Master Techniques in Surgery

Series Editor: **Josef E. Fischer**

# HERNIA

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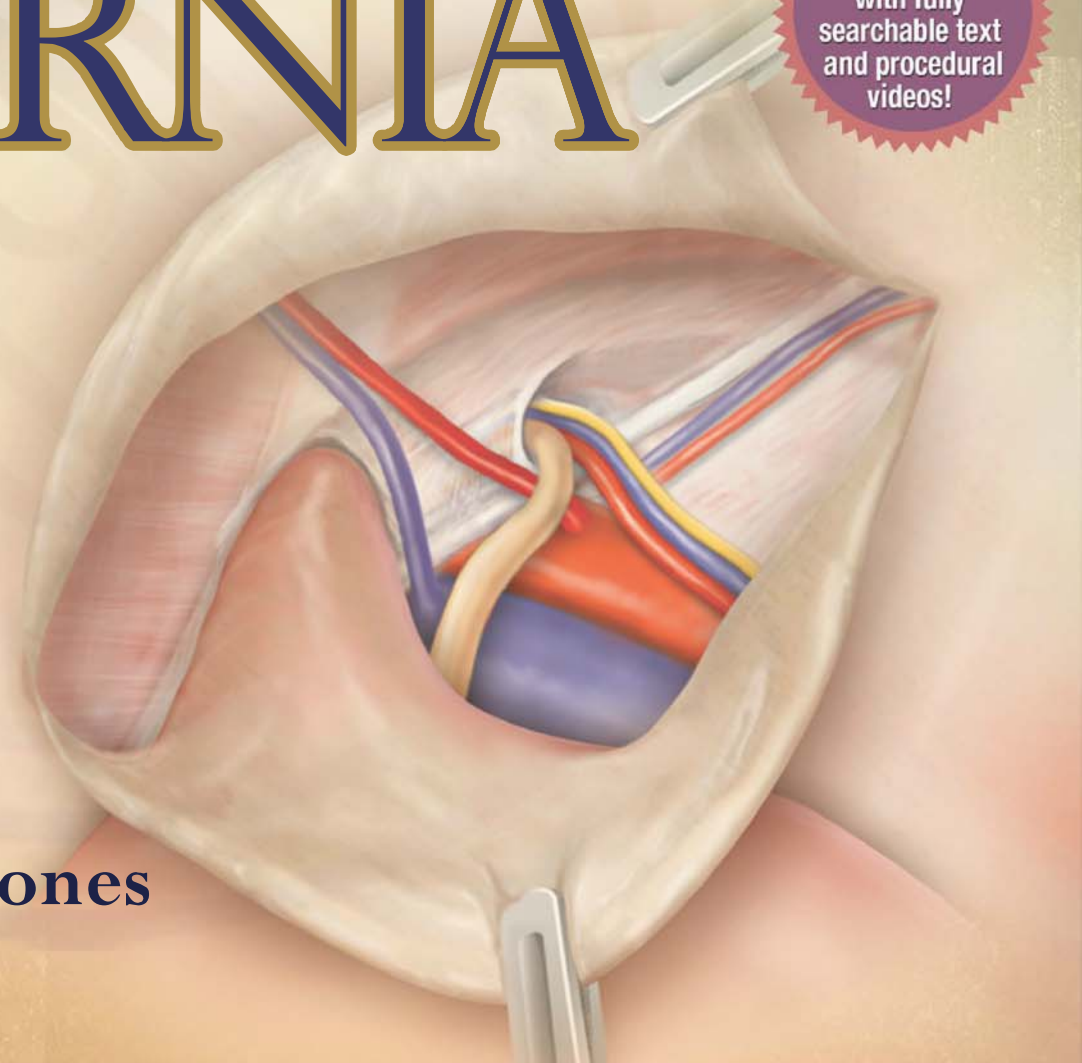
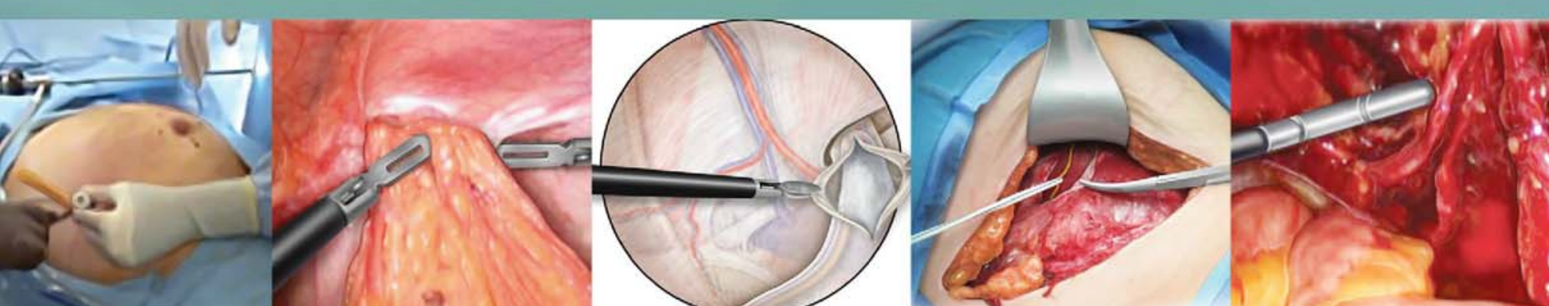


**Daniel B. Jones**



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Master Techniques in Surgery

# HERNIA

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Master Techniques in Surgery

# HERNIA

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**Two Commerce Square**
**2001 Market Street**
**Philadelphia, PA 19103 USA**
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Printed in China

**Library of Congress Cataloging-in-Publication Data**
Jones, Daniel B., 1964-
Hernia surgery / Daniel B. Jones.
p. ; cm. — (Master techniques in surgery)
Includes bibliographical references and index.
ISBN 978-1-4511-0716-6 (hardback)
I. Title. II. Series: Master techniques in surgery.
[DNLM: 1. Herniorrhaphy–methods. WI 950]
617.5′59059–dc23 2012014505



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# Series Preface

This series of mini-atlases, of which this is the fourth, is an outgrowth of Mastery of Surgery. As the series editor, I have been involved with Mastery of Surgery since the 3rd edition, when I joined two greats of American surgery Lloyd Nyhus and Robert Baker who were the editors at that time. At that time, in addition to Mastery of Surgery, which really was, almost in its entirety, an excellent atlas of how to do operations, atlases were common and some quality atlases which existed at that time by Dr. John Madden of New York, Dr. Robert Zollinger of Ohio State, and two other atlases, with which the reader may be less familiar with is a superb atlas by Professor Pietro Valdoni, Professor of Surgery at the University of Rome, who ran 10 operating rooms simultaneously, and as the Italians like to point out to me, a physician to three popes. One famous surgeon said to me, what can you say about Professor Valdoni: "Professor Valdoni said to three popes, 'take a deep breath,' and they each took a deep breath." This superb atlas, which is not well known, was translated by my partner when I was on the staff at Mass General Hospital, Dr. George Nardi from the Italian. Another superb atlas was that by Dr. Robert Ritchie Linton, an early vascular surgeon whose atlas was of very high quality.

However, atlases fell out of style, and in the 4th and 5th edition of Mastery of Surgery, we added more chapters that were "textbooky" types of chapters to increase access to the increasing knowledge base of surgery. However, atlases seem to have gone out of favor somewhat. In discussing with Brian Brown and others of Lippincott, as well as some of the editors who have taken on the responsibility of each of these mini-atlases, it seemed that we could build on our experience with Mastery of Surgery by having individual books which were atlases of 400 to 450 pages of high quality, each featuring a particular anatomical part of what was surgery and put together an atlas of operations of a sharply circumscribed area. This we have accomplished, and all of us are highly indebted to a group of high quality editors who will have created superb mini atlases in these sharply circumscribed areas.

Why the return of the atlas? Is it possible that the knowledge base is somewhat more extensive with more variations on the various types of procedures, that as we learn more about the biochemistry, physiology, genetics, and pathophysiology in these different areas, there have gotten to be a variation on the types of procedures that we do on patients in these areas. This increase in knowledge base has occurred simultaneously at a time when the amount of time available for training physicians—and especially surgeons—has been diminished time-wise and continues to do so. While I understand the hypothesis that brought the 80 hour work week upon us, and that limits the time that we have for instruction, and I believe that it is well intentioned, but I still ask the question: is the patient better served by a somewhat fatigued resident who has been at the operation, and knows what the surgeon and what he or she is worried about, or a comparatively fresh resident who has never seen the patient before?

I don't know, but I tend to come down on the side that familiarity with the patient is perhaps more important. And what about the errors of hand off, which seem to be more of an intrinsic issue with the hand off which we are not able to really remedy entirely rather than poor intentions.

This series of mini-atlases is an attempt to help fill the voids of inadequate time for training. We are indebted to the individual editors who have taken on this responsibility and to the authors who have volunteered to share their knowledge and experience in putting together what we hope will be a superb series. Inspired by their experience of teaching residents and medical students, a high calling, matched only by their devotion, and superb care they have given to thousands of patients.

It is an honor to serve as the series editor for this outstanding group of mini-atlases, which we hope will convey the experiences of an excellent group of editors and authors to the benefit of students, residents and their future patients in an era in which time for education seems to be increasingly limited.

Putting a book together, especially a series of books is not easy, and I wish to acknowledge the production staff at Lippincott, Wolters Kluwer's including Brian Brown, Julia Seto, Brendan Huffman and many others, and my personal staff in the office who include Edie Burbank-Schmitt, Ingrid Johnson, Abigail Smith, and Jere Cooper. None of this would have been possible without them.

Josef E. Fischer, MD, FACS
Boston, Massachusetts

# Foreword

This lovely atlas, expertly edited by Dr. Daniel Jones, comes at a time when I believe we must reconsider our priorities. For the past decade (or decade and a half) the emphasis has been on performing a repair with the emphasis on reducing recurrence and thus the emphasis has been on the use of some type of artificial prosthesis.

The price for artificial prosthesis has been high with pain ranging from, it seems, a minimum of 10% (with which I agree) to as high as 50% as mentioned by Bruce Ramshaw in an excellent chapter.

While triple neurectomy can relieve some (and on many occasions most) of the patient's pain, even in the hands of practiced surgeons—including myself—a stubborn residual of as many as 20% remain. Suicide, while thankfully rare, is not unknown. It is clear that we do not understand this complication in all patients. In view of this, I call for a return to open Shouldice-type of transversalis repair. Recurrence in general should be in the range of 3% to 5%.

The problem is who will instruct our residents in the open technique since many of them have never seen one. The current joke among "senior surgeons" is that we are called upon when an "old guy" is needed. I suppose this is what happens when work hours legislate that our residents finish with 500 cases instead of 900 to 1,000 and most residents report two open cholecystectomies.

If there is any solace it is that "ESO" or "excessive surgical optimism"—a category I have used in the past at M&M (morbidity & mortality), is no substitute for data.

Josef E. Fischer, MD, FACS
Boston, Massachusetts

# Preface

***Master Techniques in Surgery: Hernia*** seeks to demystify the repair of hernia and abdominal wall defects. Illustrations are depicted in color to clearly emphasize anatomical relationships. Intraoperative photographs and online video compliment the text and the illustrations. Experts, many of whom are leaders in the American Hernia Society, address the many operations which have been and are currently employed to close and patch hernias.

As a third Cornell medical student rotating on the Surgery clerkship at the New York Hospital in 1989, I would assist Dr. George Wantz, a true expert in hernia repair. With ease he would splay out anatomical structures, manipulate my hands, and voila—the hernia was fixed. All day long, direct, indirect, and femoral hernia repairs under local anesthesia were repaired in no time at all. He had dedicated the latter part of his career to inguinal hernia and he made it look deceptively easy. So it is to this giant, I dedicate ***Master Techniques in Surgery: Hernia***.

As a resident at Washington University—Barnes Hospital in the 1990s, we were trained in Bassini, Cooper, Shouldice, and then Lichtenstein repair. Every staff surgeon had a favorite repair and their own version of it. We learned the nuances of a transition stitch, releasing incision, and shutter mesh overlap. Mesh could be glued, sutured, tacked, or stapled. The laparoscopic TAPP and later TEP mesh repair became very popular, and about the same time the American College of Surgeons was studying whether "watchful waiting" was a safer option in patients with asymptomatic inguinal hernias. The great hernia debates argued learning curves, postoperative pain, seroma, neuralgia, recurrence, and cost. The merits of local and MAC versus the general anesthesia required of laparoscopy became part of the discussion.

We had solid data that recurrence rates for ventral hernia were lowest with mesh repairs compared to primary repair. Patients have been reluctant to agree to a randomized controlled trial to compare a laparoscopic ventral hernia repair to the open repair, and consequently, we have a paucity of data to advocate for laparoscopic ventral hernia repair even today. The debate most recently has focused on the types of mesh utilized, especially the value of the light weight, and biological mesh products.

I have not forgotten the folklore of a surgery chief resident from a California program, who was called upon to explain at Morbidity and Mortality Conference, "What is a hernia?" He answered confidently, "It's a protrusion through an orifice." The Chairman stuck out his tongue and challenged, "Like this?" The resident muttered, "No, that's a hemorrhoid." The resident never finished Surgery.

Sir Astley Paston Cooper in 1804 said it best, "No disease of the human body, belonging to the province of the surgeon, requires in its treatment, a better combination of accurate, anatomical knowledge with surgical skill than Hernia in all its varieties."

***Master Techniques in Surgery: Hernia*** tries to describe many of the more commonly performed hernia repairs for the groin, abdominal wall, and diaphragm. We have sought surgeon authors knowledgeable of the various techniques, and they have shared their surgical pearls. I am particularly grateful to the publishers, Brian Brown and Brendan Huffman, for the liberal use of color illustrations to elucidate important anatomical relationships and key operative steps.

I hope you find the book informative and a fun read.

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# Contents

## PART II: LAPAROSCOPIC INGUINAL HERNIA



## PART III: OPEN ABDOMINAL WALL HERNIA

## PART IV: LAPAROSCOPIC ABDOMINAL WALL HERNIA

# 1 Anatomy and Pathophysiology of Hernias

**Daniel J. Scott and Luisangel A. Rondon**

## Introduction

The repair of an abdominal wall hernia represents one of the most frequent procedures performed by general surgeons. In 2006, more than 1.1 million hernia repairs were performed in the United States.

An abdominal hernia is a defect in the wall of the abdominal cavity that allows protrusion of an organ or abdominal content through it. These defects most commonly involve the anterior abdominal wall, particularly at sites considered weak as the inguinal, femoral, and umbilical areas. The groin represents the area where the majority of abdominal wall hernias occur, totaling approximately 75% of the total incidence.

## Anterolateral Abdominal Wall

Containing most of the abdominal viscera, the abdominal wall forms a flexible and deformable girth that extends over the bony framework of the lumbar spine posteriorly, the pelvis inferiorly, and the costal margin superiorly. Though it is primarily formed by muscle and aponeurosis, the lateral abdominal wall consists of at least nine layers placed one on the other. From superficial to deep, it includes skin, Camper's fascia, Scarpa's fascia, the external oblique aponeurosis and muscle, the internal oblique aponeurosis and muscle, the transversus abdominis aponeurosis and muscle, the transversalis fascia, the preperitoneal fat, and the peritoneum (Fig. 1.1). These layers continue in the region of the groin as they form their insertions in the inguinal canal. Medially, the rectus abdominis muscle forms a major component.

The groin represents the portion of the anterolateral abdominal wall below the level of the anterior superior iliac spines formed by the inferior insertion of the lateral oblique muscles surrounding the inguinal canal on both sides of the pubis.

### Camper's Fascia

This is a thick superficial layer that contains the bulk of fat in the lower abdominal wall that blends with the reticular layer of the dermis. Its thickness varies with the body composition of the person. This layer, which is continuous with the corresponding

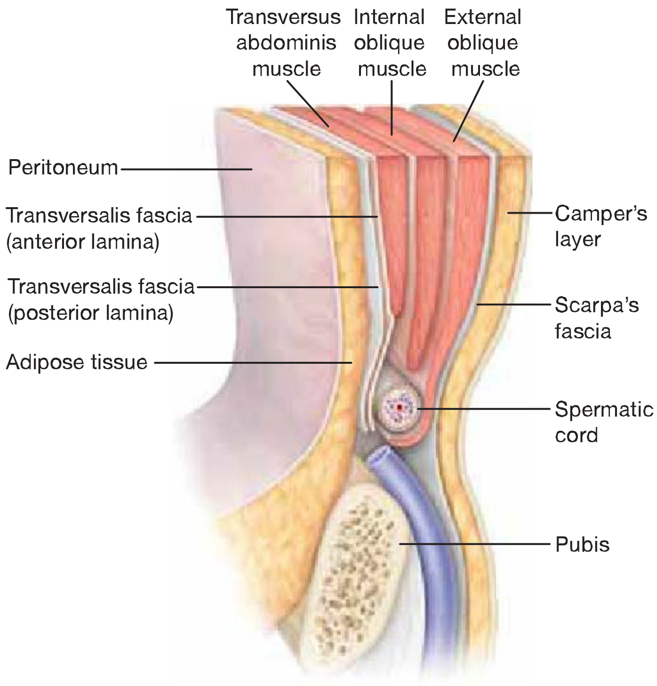


**Figure 1.1** Anterior abdominal wall: superficial layers.

layers covering the perineum and genitalia, also contains the dartos muscle fibers of the scrotum. The major blood vessels of this layer are the superficial epigastric vessels and superficial circumflex iliac vessels, tributaries of the femoral vessels.

## Scarpa's Fascia

Scarpa's fascia is a homogeneous membranous sheet of areolar tissue that forms a lamina in the depths of the subcutaneous tissues and usually is most prominent in the region of the groin. It is loosely connected to the external oblique muscle, but in the midline it is more intimately adherent to the linea alba and to the pubic symphysis, and is prolonged onto the dorsum of the penis, forming the fundiform ligament (suspensory ligament of the clitoris in females); below and laterally, it blends with the fascia lata of the thigh.

## External Oblique Muscle and Aponeurosis

The external oblique muscle is the most superficial of the three flat musculoaponeurotic layers that make up the anterolateral wall of the abdomen. It is directed inferiorly and medially extending from the posterior aspects of the lower eight ribs to the linea alba, the pubis, and the iliac crest (Fig. 1.2). Medially, the tendinous fibers pass anterior to the rectus abdominis muscle, forming the anterior layer of the rectus sheath.

Below the anterior superior iliac spine, the external oblique muscle is wholly aponeurotic and therefore, in the groin region, there is no external oblique muscle, only aponeurosis. The anteroinferior fibers of insertion of the external oblique aponeurosis fold on themselves to form the inguinal ligament. Inferiorly, the aponeurotic insertions into the body of the pubis and the pubic tubercle form the superficial or external inguinal ring, a triangular opening through which the spermatic cord or round ligament passes.

### Inguinal Ligament

The inguinal ligament is the lower, thickened portion of the external oblique aponeurosis suspended between the anterior superior iliac spine and the pubic tubercle. The fibers of the external oblique aponeurosis that form the inguinal ligament present a rounded surface toward the thigh and a hollow surface toward the inguinal canal functioning as a supporting shelf for the spermatic cord (Fig. 1.3).

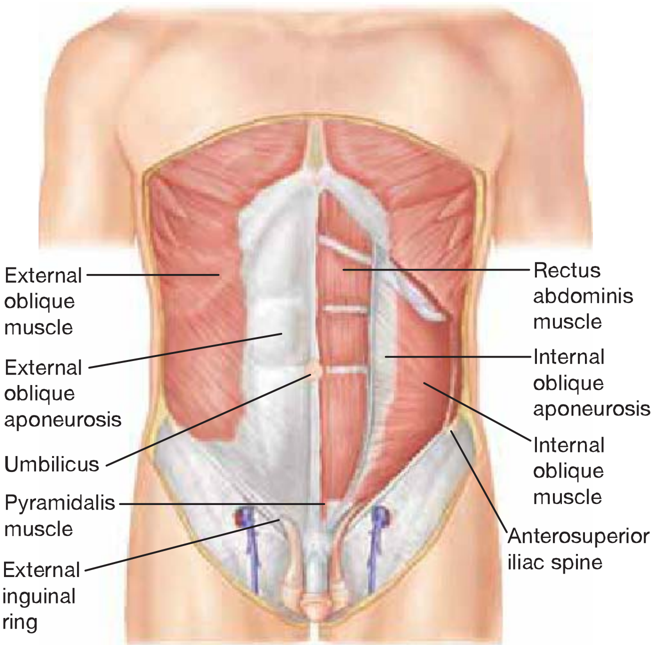


**Figure 1.2** External oblique muscle and internal oblique muscle.

### Lacunar Ligament

First described by Antonio de Gimbernat in 1793, the lacunar ligament is a triangular extension of the inguinal ligament before its insertion upon the pubic tubercle. It is inserted at the pecten pubis, and its lateral end meets the proximal end of the ligament of Cooper. It is considered the medial border of the femoral canal (Fig. 1.3).

### External Inguinal Ring

The superficial or external inguinal ring is located above the superior border of the pubis, immediately lateral to the pubic tubercle. It is a triangular opening of the aponeurosis of the external oblique, the base being part of the pubic crest with the margins formed by two crura, medial and lateral. The medial crus is formed by the aponeurosis of the external oblique itself; the lateral crus is formed by the inguinal ligament. To be more specific, the medial crus is attached to the lateral border of the rectus sheath and to the tendon of the rectus abdominis muscle. The lateral crus is attached to the pubic tubercle (Fig. 1.3).

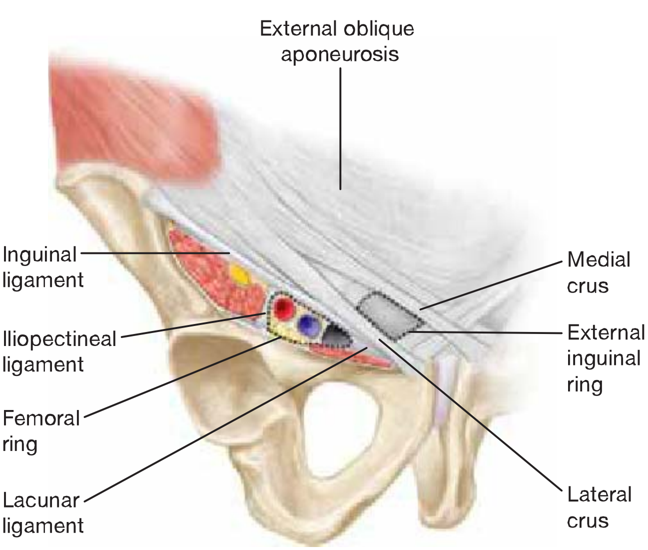


**Figure 1.3** Inguinal ligament, femoral canal combined schematic superficial ring.

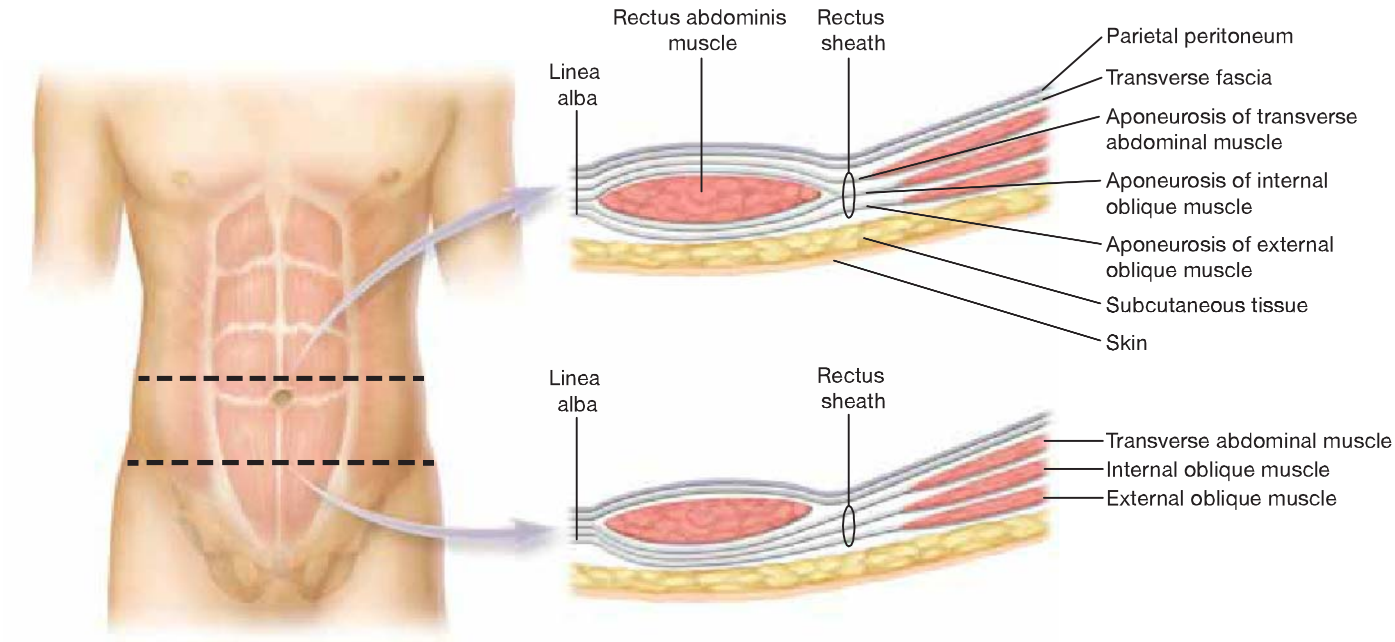


**Figure 1.4** Linea alba.

## Internal Oblique Muscle and Aponeurosis

The internal oblique muscle and aponeurosis represent the middle layer of the three flat musculoaponeurotic layers of the abdominal wall. The internal oblique muscle arises in part from the thoracolumbar fascia and the iliac crest splaying obliquely upward, forward, and medially to insert upon the inferior borders of the lower three or four ribs, the linea alba and the pubis (Fig. 1.2).

The aponeurosis of the internal oblique above the level of the umbilicus splits to envelop the rectus abdominis, re-forming in the midline to join and interweave with the fibers of the linea alba. Below the level of the umbilicus, the aponeurosis does not split but rather runs only anterior to the rectus muscle (Fig. 1.4).

The lowest fibers of the internal oblique muscle arch over the spermatic cord or the round ligament. Medially, the lower border of this muscular arch is usually at or slightly above the level of the aponeurotic arch of the underlying transversus abdominis layer. Some of the lower muscle bundles in the male form the cremaster muscle fibers that invest the spermatic cord.

The internal oblique layer is mainly muscular in the inguinal region and throughout much of its course in the groin, it is intimately attached to the underlying fibers of the transversus abdominis aponeurosis. The aponeurotic continuation of these lower bundles of the internal oblique usually is directed transversely to the linea alba and slightly more inferiorly inserted to the body of the pubis.

## Transversus Abdominis Muscle and Aponeurosis

The transversus abdominis muscle and aponeurosis are the deepest of the three flat anterior abdominal muscles layers. These layers arise from the fascia along the iliac crest, thoracolumbar fascia, iliopsoas fascia, and from the lower six costal cartilages and ribs (Fig. 1.5).

The muscle bundles of the transversus abdominis course horizontally except the inferior border of the transversus abdominis layer that forms a curved line, the transversus abdominis arch (Fig. 1.6), an important landmark for the surgeon because it represents the superior border of the direct inguinal hernia space. The area beneath the arch and the number of aponeurotic fibers and strength in this lower portion of the transversus abdominis lamina varies, having a major influence in the development of a direct inguinal hernia.

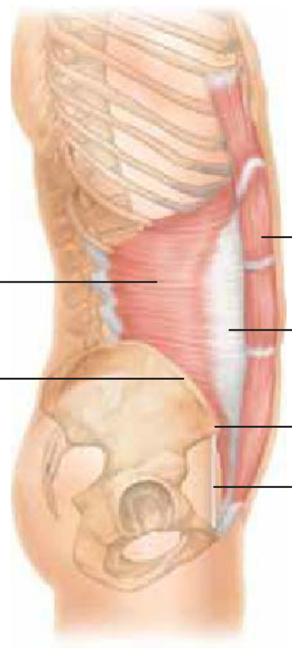


**Figure 1.5** Transversalis muscle.

The aponeurosis of the transversus abdominis joins the posterior lamina of the internal oblique forming part of the posterior rectus sheath above the umbilicus. Below the umbilicus, the transversus abdominis aponeurosis is a component of the anterior rectus sheath. The gradual termination of aponeurotic tissue on the posterior aspect of the rectus abdominis muscle forms the **arcuate line of Douglas.**

The medial aponeurotic fibers of the transversus abdominis insert on the pectin pubis and the crest of the pubis to form the **ligament of Henle** or falx inguinalis (Fig. 1.6). The falx inguinalis has an intimate relation with the rectus sheath consisting of the dense insertion of the transversus aponeurosis lateral to the tendon and muscular belly of the rectus muscle. Rarely, the fibers of the transversus abdominis aponeurosis are joined in this area by fibers from the internal oblique aponeurosis to form a true conjoined tendon.

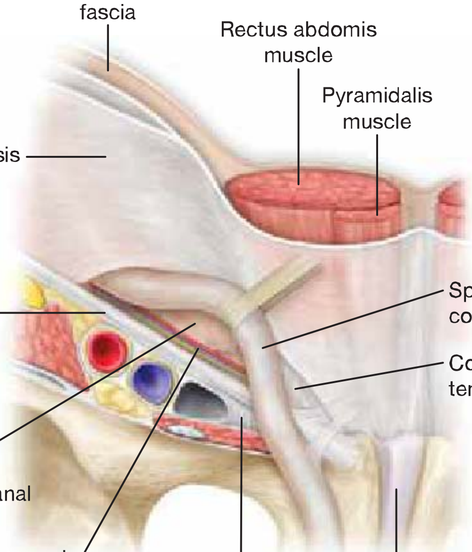


**Figure 1.6** Arch of transversus abdominis.

### Conjoined Tendon

The conjoined tendon is, by definition, the fusion of lower fibers of the internal oblique aponeurosis with similar fibers from the aponeurosis of the transversus abdominis where they insert on the pubic tubercle and superior ramus of the pubis. A true conjoined tendon is considered rare, according to Condon present in 3% of cases and believed by McVay to be only an artifact of dissection.

## Rectus Abdominis Muscle

The rectus abdominis forms the central and anchoring muscle mass of the anterior abdomen. The rectus abdominis muscle attaches to the fifth, sixth, and seventh costal cartilages and the xiphoid process above. Below, it attaches to the pubic crest, symphysis pubis, and the superior ramus of the pubis. Each rectus muscle is traversed by tendinous intersections at the level of the xiphoid process, the mid-upper abdomen, and at the umbilicus.

The rectus muscle is enclosed within a stout sheath formed by the aponeuroses of the three flat muscles that divide and pass anteriorly and posteriorly around the muscle. From the rib margin to a point midway between the umbilicus and the pubis (arcuate line of Douglas), the posterior sheath is made up of the posterior leaf of the internal oblique aponeurosis, the aponeurosis of the transversus abdominis muscle, and the transversalis fascia. Below this level, the posterior wall is formed by transversalis fascia alone, with variable contributions of aponeurotic bands from the transversus abdominis (Fig. 1.4). The deep epigastric arteries and veins course along the posterior surface of the rectus muscle, so below the arcuate line they are separated from the peritoneum only by transversalis fascia.

Medially, the two recti are separated by the linea alba, a tendinous line wherein the aponeuroses of the three flat muscles fuse with and decussate across the midline.

## Transversalis Fascia

The transversalis fascia is a portion of the continuous layer of the endoabdominal fascia that completely encloses the abdominal cavity. In various areas, the endoabdominal fascia is given particular regional designations derived from the overlying muscles, in this instance, the transversus abdominis muscle. The transversalis fascia is immediately continuous with the lumbar, iliac, psoas, and obturator fasciae. It continues medially as the rectus fascia, forming a posterior covering of the lower part of the rectus muscle.

The lower portion of the transversalis fascia between the transversus abdominis arch superiorly and Cooper's ligament and the iliopubic tract inferiorly represents the critical weak area in which inguinal hernias are found (Fig. 1.7). The transversus abdominis arch forms a relatively resistant aponeurotic superior margin that begins laterally at the iliopectineal arch and is directed medially above the deep inguinal ring and across the groin to insert into the rectus sheath or pubic bone. Similarly, the iliopubic tract and Cooper's ligament together form a resistant inferior margin that begins laterally at the iliopectineal arch and is directed medially below the deep inguinal ring and across the external femoral vessels to the superior ramus of the pubis. Between these aponeurotic margins, the continuity of the transversus abdominis layer is maintained mainly by the transversalis fascia. Hence, this layer is referred to as the floor of the inguinal canal.

### Iliopubic Tract

The iliopubic tract, described by Alexander Thomson in 1836, is an aponeurotic band within the transversus abdominis lamina that bridges across the external femoral vessels that begin near the anterior superior iliac spine and extend medially to attach to Cooper's ligament at the pubic tubercle. It forms the inferior margin of the deep musculoaponeurotic layer made up of the transversus abdominis muscle and aponeurosis and the transversalis fascia.

Laterally, the fibers of the iliopubic tract are overlapped by the inguinal ligament, which lies immediately superficial to it. However, the inguinal ligament and the

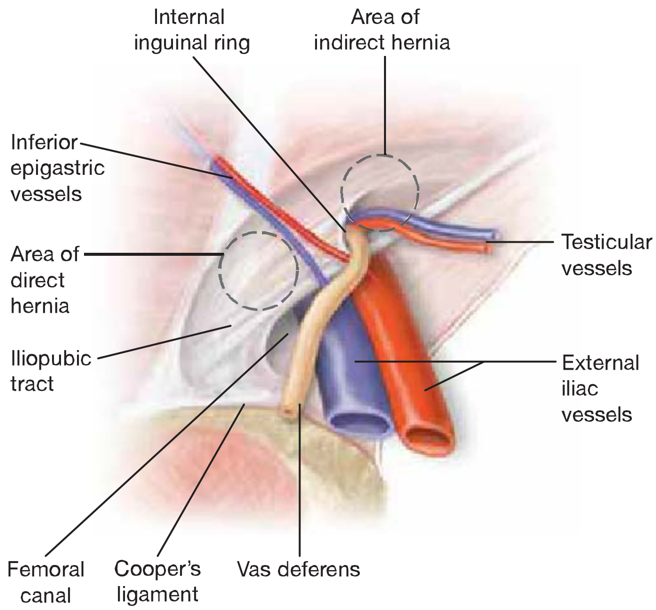


**Figure 1.7** Deep inguinal ring and transversalis fascia.



iliopubic tract are separate entities and belong to different musculoaponeurotic layers of the groin. The inguinal ligament is part of the external oblique layer; the iliopubic tract is part of the transversus abdominis layer.

The iliopubic tract as it trajects medially becomes separated from the inguinal ligament. It passes medially to form the lower border of the internal inguinal ring (Fig. 1.7). Together with the transversalis fascia, the tract crosses the femoral vessels to form the anterior margin of the femoral canal.

### Cooper's Ligament

Cooper's ligament or the pectineal ligament is a condensation of transversalis fascia and periosteum of the superior pubic ramus lateral to the pubic tubercle. It is usually several millimeters thick and densely adherent to the pubic ramus, and joins the iliopubic tract and lacunar ligaments at their medial insertions. Cooper's ligament is considered the posterior margin of the femoral canal.

### Internal Inguinal Ring

The deep or internal inguinal ring, formed mainly by aponeurotic fibers of the transversus abdominis layer, is located halfway between the pubic tubercle and the anterior superior iliac spine. At the lateral half of the area between the transversus abdominis arch above and the iliopubic tract below, the fascia transversalis thickens and forms an incomplete ring in the shape of an inverted "V", with the open end pointing laterally and superiorly (transversalis fascia crura), that supports the spermatic cord structures as they enter the inguinal canal. The inferior border is formed by the iliopubic tract. The transversus abdominis arch along with the superior crus of the transversalis fascia forms the superior border of the deep inguinal ring (Fig. 1.7).

The transversalis fascia crura provides the basis for the shutter mechanism that is thought to operate at the internal inguinal ring. During coughing or similar activities that increase the intraabdominal pressure, the transversus abdominis muscle contracts and the crura are drawn closer together and laterally. The approximation and lateral sliding motion of the crura partially closes the internal ring and flattens the cord structures against the abdominal wall respectively, thus providing additional protection to this area from forces that may lead to the formation of a hernia.

## Preperitoneal Space

The preperitoneal space is the potential space between the peritoneum posteriorly and the transversalis fascia.

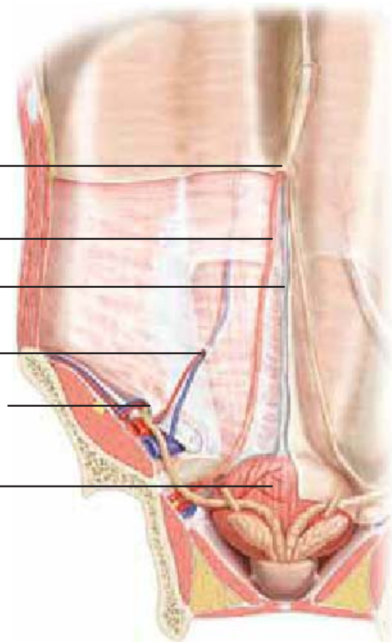


**Figure 1.8** Peritoneal folds.

Near the pubis, the peritoneum is separated from the transversalis fascia by the urachus, a fibrous remnant of the allantois that extends from the apex of the bladder to the umbilicus. In the area of the bladder, this retropubic preperitoneal space is known as the space of Retzius. The elevation of the peritoneum in the midline by the urachus forms the median umbilical fold. Just lateral to this fold, is the medial umbilical fold, which represents the obliterated portion of the fetal umbilical artery on both sides of the urachus (Fig. 1.8).

Laterally, the separation of the peritoneum from the muscle layers of the abdomen is known as the **space of Bogros.** In other words, the space of Bogros is a lateral extension of the space of Retzius. The inferior epigastric artery runs vertically upward in the space of Bogros to enter and ramify within the rectus abdominis muscle. The peritoneum underneath the inferior epigastric artery forms the lateral umbilical fold.

The inferior epigastric artery is the lateral border of Hesselbach's triangle and thus provides a useful landmark to differentiate between direct and indirect hernias. A defect medial to the inferior epigastric vessels is considered direct, whereas a lateral defect is an indirect hernia.

### Myopectineal Orifice of Fruchaud

H. Fruchaud, a French surgeon, described in 1956 an oval-shaped area in the groin protected only by the combined lamina of the aponeurosis of the transversus abdominis and the transversalis fascia where all groin hernias originate named myopectineal orifice (MPO). The MPO (Fig. 1.9) is bordered:

- Superiorly by the arching fibers of the internal oblique and transversus abdominis muscles
- Medially by the lateral border of the rectus muscle
- Inferiorly by Cooper's Ligament
- Laterally by the iliopsoas muscle

The inguinal ligament and iliopubic tract divide the MPO into two areas, both keys in the understanding of groin hernias:

- Superior compartment containing the inguinal canal. The inferior epigastric artery further divides this compartment into:
  - **Hesselbach's triangle,** medial to the inferior epigastric and weak area where direct inguinal hernias develop.

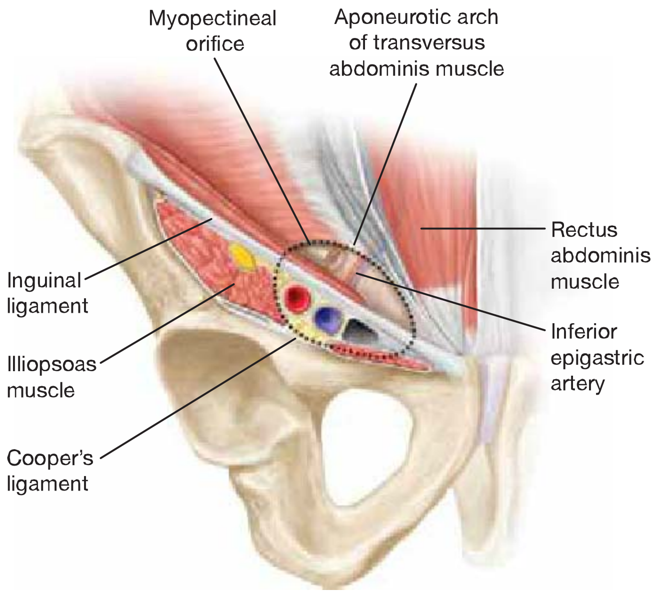


**Figure 1.9** Myopectineal orifice.

- Lateral triangle, containing the internal inguinal ring. A defect in this area is an indirect hernia.
- Inferior compartment containing the femoral canal.

## Inguinal Canal

The inguinal canal is an oblique passage directed inferiorly, anteriorly, and medially in the lower part of the anterior abdominal wall located above the medial portion of the inguinal ligament extending from a point approximately 2 cm medial to the anterior superior iliac spine laterally to the pubic tubercle medially (Fig. 1.10).

The canal begins intraabdominally on the deep aspect of the abdominal wall, where the spermatic cord in males and the round ligament in females pass through the internal inguinal ring. The canal then concludes on the superficial aspect of the abdominal wall musculature at the superficial or external inguinal ring, the point at which the spermatic

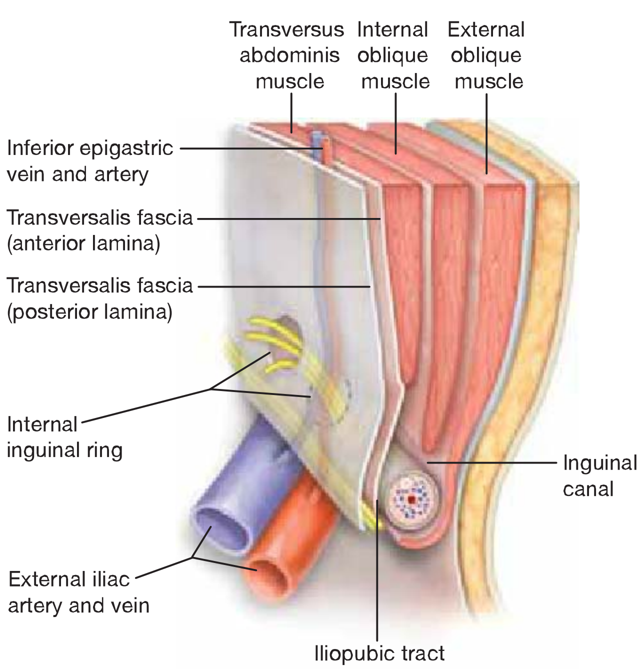


**Figure 1.10** Inguinal Canal.

cord crosses the medial defect of the external oblique aponeurosis. In the normal situation, parietal peritoneum covers the intraabdominal portion of the spermatic cord as well as the internal ring. However, when an inguinal hernia is present, the peritoneum protrudes through a defect and is considered the hernia sac. It is classic to describe four walls as the boundaries of the canal: Anterior, posterior, inferior, and superior.

***Anterior wall.*** It is formed essentially by the aponeurosis of the external oblique muscle that laterally is reinforced by the underlying muscle fibers of the internal oblique and transversus abdominis muscles.

***Inferior wall.*** The inferior wall of the canal is a narrow groove formed by the inguinal ligament.

***Superior wall.*** It is formed by the arched fibers of the lower edge of the internal oblique muscle and by the transversus abdominis muscle and aponeurosis.

***Posterior wall.*** The posterior wall is formed primarily by the aponeurosis of the transversus abdominis muscle and the transversalis fascia. The transversalis layer is reinforced, inferiorly by the iliopubic tract and Cooper's ligament. The posterior wall is the most complex and important wall of the inguinal canal as defects in this layer allow hernia formation.

## Spermatic Cord

The spermatic cord is a structure present in males that resembles a cord that suspends the testis within the scrotum. It begins in the preperitoneal space with the confluence at the deep inguinal ring of the ductus deferens and the testicular artery and vein that pass from the abdominal cavity through the inguinal canal down into the scrotum.

The spermatic cord is composed of:
Three fasciae:

- External spermatic fascia, formed from the investing fascia of the external oblique aponeurosis as the spermatic cord emerges from the superficial ring.
- Cremasteric fascia derived from the internal oblique muscle and fascia.
- Internal spermatic fascia, closely adherent to the cord structures as they pass through the deep inguinal ring. It arises from the transversalis fascia.

Three arteries:

- Testicular artery, branch of the aorta and supplies the testis.
- Cremasteric artery, branch of the inferior epigastric artery.
- Deferential artery, derived from the umbilical artery.

Three veins:

- Pampiniform plexus and testicular vein, venous drainage from the testis. On the right side they drain directly into the inferior vena cava and on the left side, into the left renal vein.
- Cremasteric vein, drains into the inferior epigastric vein.
- Deferential vein, drains into the pampiniform plexus and the vesical plexus.

Three nerves:

- Genital branch of genitofemoral nerve
- Ilioinguinal nerve
- Sympathetic nerves

Lymphatics, drain into the paraaortic nodes.

## Round Ligament

The round ligament is composed of fibrous tissue and muscle fibers. It attaches to the superoanterior aspect of the uterus and runs via the broad ligament to the lateral pelvic wall. The round ligament crosses the external iliac vessels and enters the inguinal canal, ending by inserting into the labia majora in a fanlike fashion.

### Femoral Canal

Between the inguinal ligament and the superior pubic ramus is a space organized into three compartments: Neuromuscular, vascular, and femoral canal (Fig. 1.3). The most lateral of these is the neuromuscular. It contains the iliopsoas muscle, the femoral nerve, and the lateral femoral cutaneous nerve. The middle space, the vascular compartment contains the femoral artery and vein, which continue as the external iliac artery and vein above the inguinal ligament.

The femoral canal is the most medial of the three compartments of the sheath. This location is where a femoral hernia may form. This canal is conical, approximately 1.25 to 2.0 cm in length. The boundaries are:

- Anterior: The iliopubic tract (deep layer) and the inguinal ligament (more superficial)
- Lateral: A connective tissue septum and the femoral vein
- Posterior: Cooper's ligament and iliacus fascia
- Medial: Lacunar ligament

The canal usually contains areolar connective tissue, lymph nodes, and lymphatic channels. A large node is often present at the upper end of the canal. This node is known as Cloquet's node to the French and Rosenmueller's node to the German.

## Posterolateral Abdominal Wall

The posterolateral abdominal wall is defined as the area bounded superiorly by the 12th rib, inferiorly by the iliac crest and laterally by a vertical line starting from the anterior superior iliac spine and traveling upwards. Eight muscles arrayed in three layers constitute the posterolateral or lumbar portion of the abdominal wall:

- Superficial Layer
  - External oblique muscle
  - Latissimus dorsi
- Middle Layer
  - Erector spinae (sacrospinalis muscle)
  - Internal oblique muscle
  - Serratus posterior inferior
- Deep Layer
  - Quadratus lumborum
  - Psoas major
  - Transversus abdominis

### Inferior Triangle of Petit

The inferior triangle of Petit is a weak area of the posterolateral wall present in the superficial muscle layer (Fig. 1.11). It is limited by:

- Lateral: Posterior border of the external oblique muscle
- Medial: Anterior border of the latissimus dorsi muscle
- Inferior: Iliac crest
- Floor: Internal oblique with contributions of the transversus abdominis muscle
- Roof: Superficial fascia and skin

### Superior Triangle of Grynfeltt

The middle layer of the lumbar muscle is associated with the superior lumbar triangle, a more common area of hernia than the inferior lumbar triangle (Fig. 1.11). It is bounded as follows:

- Superior: Twelfth rib and serratus posterior inferior muscle
- Lateral: Posterior border of the internal oblique muscle

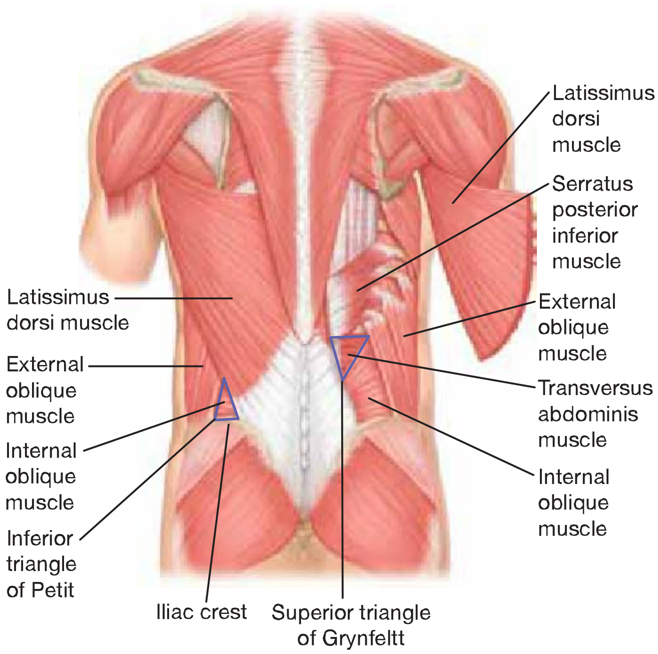


**Figure 1.11** Petit triangle and Grynfeltt triangle.

- Medial: Anterior border of sacrospinalis muscle
- Floor: Aponeurosis of the transverus abdominis muscle
- Roof: External oblique and latissimus dorsi muscles

## Nerves of the Anterior Abdominal Wall and Groin Region (Fig. 1.12)

The innervation of the anterior wall muscles is multiple. The lower intercostal and upper lumbar nerves (T7 to T12, L1, L2) contribute most of the innervation to the lateral muscles and to the rectus abdominis and overlying skin. The nerves run in a plane between the internal oblique and transversus abdominis muscles. The external oblique receives branches of the intercostal nerves. The anterior ends of the nerves form part of the cutaneous innervation of the abdominal wall.

The nerves of the inguinal region arise from the lumbar plexus, innervate the abdominal musculature, and provide sensation for the skin and parietal peritoneum.

The iliohypogastric nerves (T12, L1) emerge from the lateral edge of the psoas muscle and course within the layers of the abdominal wall. It penetrates the external oblique muscle within 1 to 2 cm of the superiomedial aspect of the external ring where it supplies the skin in the suprapubic region with sensory fibers.

The ilioinguinal nerve (L1) courses with the iliohypogastric nerve and then joins the spermatic cord or round ligament through the internal and external inguinal rings to innervate the skin of the base of the penis or mons pubis, the scrotum or labia majora, and the medial aspect of the thigh.

The genitofemoral nerves (L1, L2) run along the anterior aspect of the psoas muscle and divide before reaching the internal inguinal ring. The genital branch penetrates the iliopubic tract lateral to the internal inguinal ring and then enters the ring to join the cord. It supplies the anterior scrotum with sensory fibers, the cremaster muscle with motor fibers, and is the efferent limb for the cremasteric reflex (stroking the inner thigh produces contraction of the cremaster muscle and elevation of the ipsilateral testicle). The femoral branch courses beneath the inguinal ligament to provide sensation to the anteriomedial thigh and is the afferent limb for the cremasteric reflex.

The lateral femoral cutaneous nerves (L2, L3) emerge at the lateral edge of the psoas muscle, course along the iliac fossa, lateral to the iliac vessels, and beneath the iliopubic tract and inguinal ligament to provide sensation to the lateral thigh.

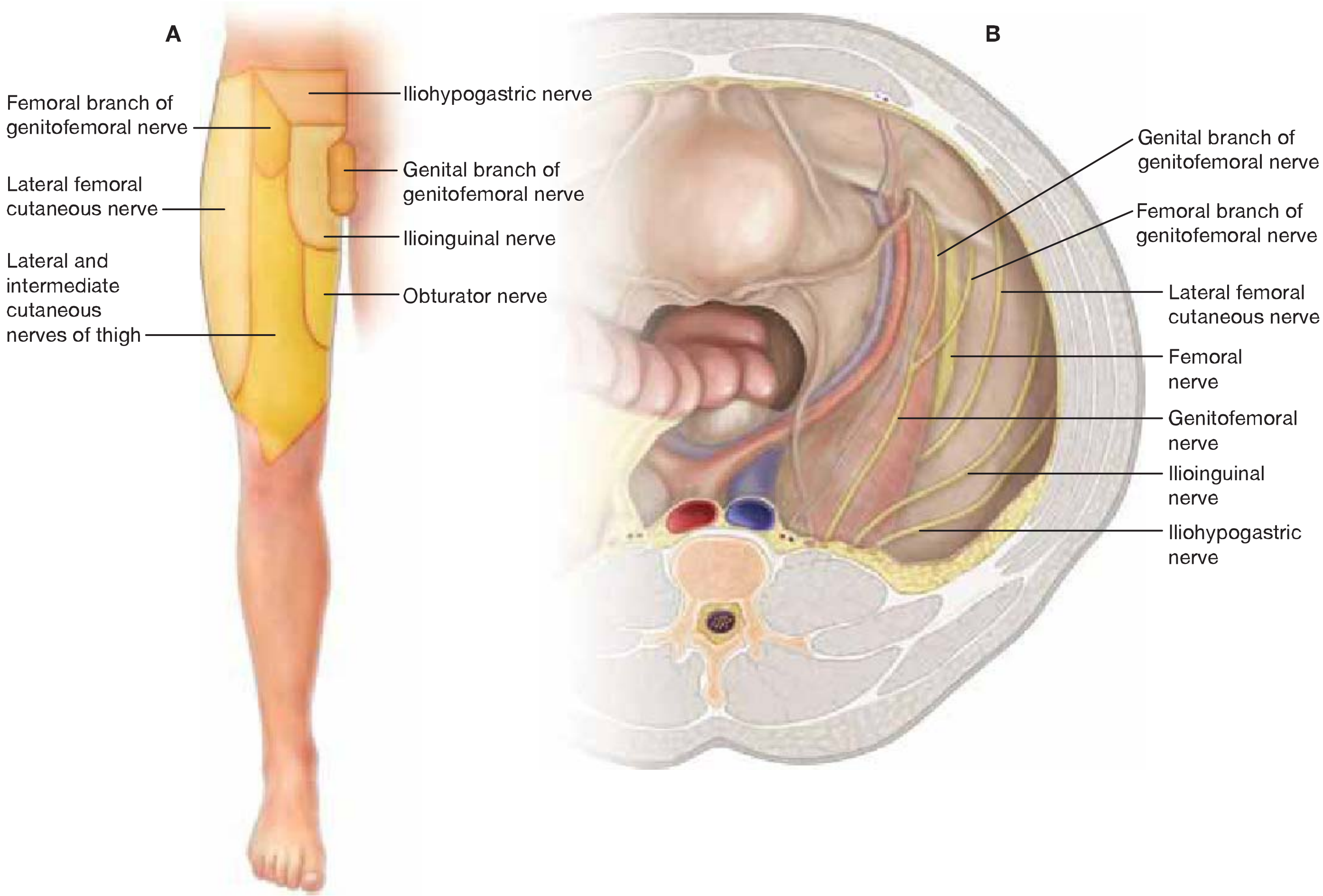


**Figure 1.12** Schematic nerves of groin.

The femoral nerves (L2 to L4) emerge from the lateral aspect of the psoas muscle and course beneath the inguinal ligament lateral to the femoral vessels and outside of the femoral sheath to provide motor and sensory innervation for the thigh.

## Vasculature of the Abdominal Wall and Groin Region

The blood supply of the lateral muscles of the anterior abdominal wall is primarily from the lower three or four intercostal arteries, the deep circumflex iliac artery, and the lumbar arteries. The rectus abdominis has a complicated blood supply derived from the superior epigastric artery (a terminal branch of the internal mammary artery), the inferior epigastric artery (a branch of the external iliac artery), and the lower intercostal arteries. The superior and inferior epigastric arteries enter the rectus sheath and anastomose near the umbilicus.

The inferior epigastric artery and vein cross over the iliopubic tract at the medial aspect of the internal ring and ascend along the posterior surface of the rectus muscles, invested in a fold of peritoneum called lateral umbilical ligament. Near its takeoff the inferior epigastric artery gives off two branches, the cremasteric and the pubic. The cremasteric branch penetrates the transversalis fascia and joins the spermatic cord. The pubic branch courses in a vertical fashion inferiorly, crossing Cooper's ligament, and anastomoses with the obturator artery forming a circle—**the corona mortis**—before entering the obturator foramen (Fig. 1.13). Injury to the circle, usually sustained while working in the area of Cooper's ligament, may cause copious bleeding.

The testicular vessels follow the ureter into the pelvis on its lateral border, and then course along the lateral edge of the external iliac artery, cross the iliopubic tract, and

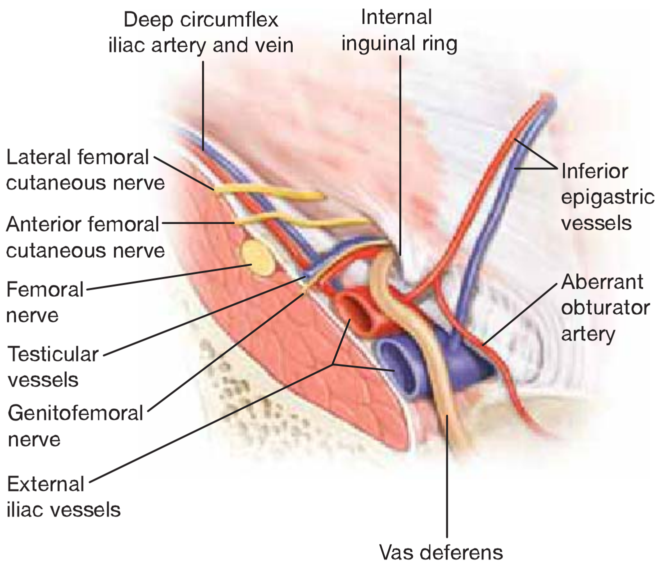


**Figure 1.13** Corona mortis (aberrant obturator).

join the spermatic cord at the lateral aspect of the internal ring. The testicular or internal spermatic artery arises from the aorta just below the renal arteries. Anastomoses between the testicular, deferential, and cremasteric arteries supply the testicle with rich collateral circulation. The testicular veins drain into the inferior vena cava on the right and the renal vein on the left.

The deferential artery arises from the inferior vesicle artery, forming a microvascular network with the adventitia of the vas deferens. The deferential vein drains into the pampiniform plexus and the vesical plexus. The pampiniform plexus drains into testicular veins that course with the testicular artery.

The cremasteric or external spermatic artery arises from the inferior epigastric artery. The cremasteric vein drains into the inferior epigastric vein.

# Pathophysiology of Abdominal Wall Hernias

The most common hernias develop at sites where the abdominal wall strength to withstand the intraabdominal pressure is lower, such as the internal inguinal ring, the umbilicus, esophageal hiatus, and previous surgical entry sites. The cause of abdominal wall hernias is probably multifactorial, with one or more factors applying in any particular case.

## Raised Intraabdominal Pressure

Factors that increase the pressure in the abdominal cavity, such as obesity, coughing with chronic lung disease, straining, and ascites have traditionally been considered important in the etiology of abdominal hernias; however, recent work suggests that these conditions do not cause hernias on their own but may be additional facilitating factors. Several studies have documented strenuous physical activity as a predisposing risk factor to acquiring an inguinal hernia. Repeated physical exertion may increase intraabdominal pressure; however, whether this process occurs in combination with a patent processus vaginalis or through age-related weakness of abdominal wall musculature is unknown.

Interestingly, several studies have noted a protective effect of obesity. In a large, population-based prospective study of American individuals (First National Health and Nutrition Examination Survey), the risk of inguinal hernia development in obese men was only 50% that of normal-weight males, while the risk in overweight males was 80% that of nonobese men. A possible explanation is the increased difficulty in detecting inguinal hernias in obese individuals.

## Integrity of the Abdominal Wall

### Collagen

The ability of the abdominal wall to withstand physiologic and pathologic elevations in the intraabdominal pressure is dependent on the state of the collagen fibers that make up its tissues and give its strength. Type I collagen represents the mature and most stable collagen form; type III collagen is an immature isoform, which is present at a greater concentration in the extracellular matrix of patients with incisional and inguinal hernias. The decreased type I/type III collagen ratio in the connective tissue of patients with abdominal wall hernia can be attributed to either a primary defect in collagen synthesis as found in various connective tissue disorders such as osteogenesis imperfecta, Marfan syndrome, or Ehlers–Danlos syndrome; or an altered collagen expression caused by inordinate extracellular matrix degradation mainly by matrix metalloproteinases (MMPs). MMPs are mainly extracellular proteins with zinc-dependent endopeptidase activity. The association between MMP overexpression and abdominal wall hernia was initially demonstrated by Bellon et al., who found an MMP-2 overexpression in fibroblasts of patients with direct inguinal hernias.

### Cigarette Smoking

Read et al. found that substances in cigarette smoke inactivate antiproteases that lead to an increase in the level of circulating proteases and elastases causing destruction of the extracellular matrix of the rectus sheath and fascia transversalis thus predisposing to herniation. The level of circulating serum elastolytic and protease substances is higher in the blood of patients with hernias than in controls, in those with direct compared with indirect hernias, and still higher in those with bilateral direct inguinal hernias.

An increase in the level of circulating proteases and elastases also occurs in stress situations and systemic illnesses product of an enhanced leukocyte response leading to a relative decrease in antiprotease activity. These mechanisms may be partly responsible for attenuation of the abdominal wall fascia and hernia formation in nonsmokers, in a fashion similar to smokers.

### General Factors

The ability of the abdominal wall to withstand the forces in favor of herniation may be reduced by the weakening of the muscles and fasciae with advancing age, lack of physical exercise, multiple pregnancies, and loss of weight and body fitness as may occur after illness, operation, or prolonged bedrest.

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# 2 Lichtenstein-based Groin Hernia Repair

**Steven D. Schwaitzberg**

## Introduction

There are a variety of open hernia repair techniques that the surgeon can choose from today. For the last 20 years the majority of surgeons have employed some form of mesh augmented repair for the reconstruction of the groin. One of the key early adopters of mesh augmented hernia repair was Irving Lichtenstein who along with Alex Shulman and Parviz Amid developed this method of hernia repair. This technique followed in the footsteps of the earliest mesh augmented repairs performed by Francis Usher who used a piece of polypropylene mesh to create a cuff around the conjoined tendon before suturing it to the inguinal ligament. The Lichtenstein repair came into existence with the recognition that classic Bassini or McVay (Cooper's ligament) type procedures were associated with higher than acceptable long-term recurrence rates even when relaxing incisions in the anterior rectus fascia were employed. This repair requires the surgeon to define precise anatomic landmarks. A tension-free repair is then created utilizing a modest size polypropylene mesh to reconstruct the floor of the inguinal canal which continues laterally with a keyhole in the mesh to accommodate this spermatic cord thus reconstructing the internal ring. This repair can be mastered with a relatively shallow learning curve and is associated with low recurrence rates and complications.

## INDICATIONS

The Lichtenstein hernia repair is indicated for initial mild to moderate, direct or indirect inguinal as well as femoral hernias in both men and women. It can also be deployed in patients with recurrent groin hernias particularly when an alternate technique was used at the initial repair. Surgeons who choose this technique should be prepared to make the appropriate technique modifications that are based on the specific type of hernia encountered.

# PREOPERATIVE PLANNING

## Patient Preparation

This technique can be performed under local, regional, or general anesthesia. One cited advantage of performing this technique in awake patients is the opportunity to ask the patient to cough and assess the repair for weakness. The arms may remain outstretched or can be tucked on the basis of the patient's body habitus and the surgeon's preference. In routine cases, a urinary catheter is not necessary. Sufficient bladder decompression is achieved if the patient is able to urinate immediately prior to the procedure and a consensus is reached with anesthesia that minimal amounts of intravenous fluids will be administered intraoperatively. The lower abdomen and groin are prepped consistent with the surgeon's preference. Many surgeons prefer the use of a plastic barrier draped over the skin to prevent contact of the mesh with the skin. Unless the patient has a large intrascrotal hernia, the scrotum does not need to be draped into the operative field. The use of the plastic barrier drape makes it possible to easily include the umbilicus, the anterior superior iliac spine (ASIS), and the pubic tubercles into the operative field. A single dose of first generation cephalosporin is commonly administered for prophylaxis.

# SURGERY

## Incision

For most patients, a properly placed incision need not be much larger than 5 cm. There are two basic incision types for this procedure, transverse or oblique (Fig. 2.1). Transverse incisions have the advantage of being made in the lines of Langer which imparts a theoretical cosmetic advantage. The oblique incision is essentially made over the distance from the internal to the external ring which in theory allows for the smallest length of incision needed. The oblique incision is prepared by marking a line from the ASIS to the pubic tubercle. A 5 to 7 cm incision is then made parallel 1 cm cephalad to the previously marked line which begins medially 2 cm lateral to the pubic tubercle and continued for the selected distance. Given the general laxity of the skin in this region it can easily be shifted in order to visualize all of the required structures to be dissected. Once the skin is incised, the incision is carried down to the external oblique fascia sharply or by cautery. It is common to encounter a subcutaneous vein requiring ligation in the lateral aspect of the wound. The external oblique should be exposed from the external ring 10 cm laterally and at least 5 cm in width. This will facilitate closure at the end of the case.

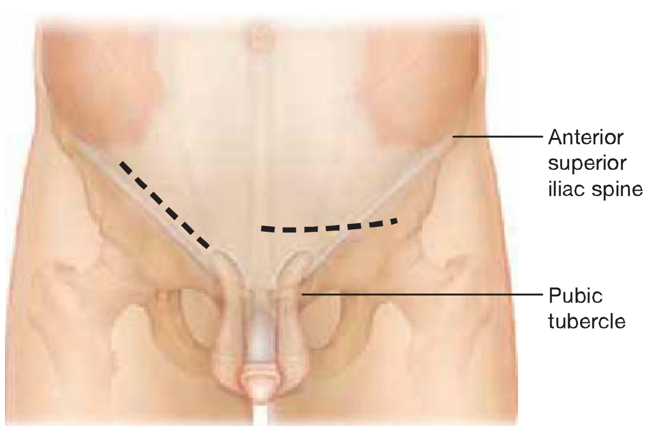


**Figure 2.1** Either a transverse or inguinal incision may be used for this procedure.

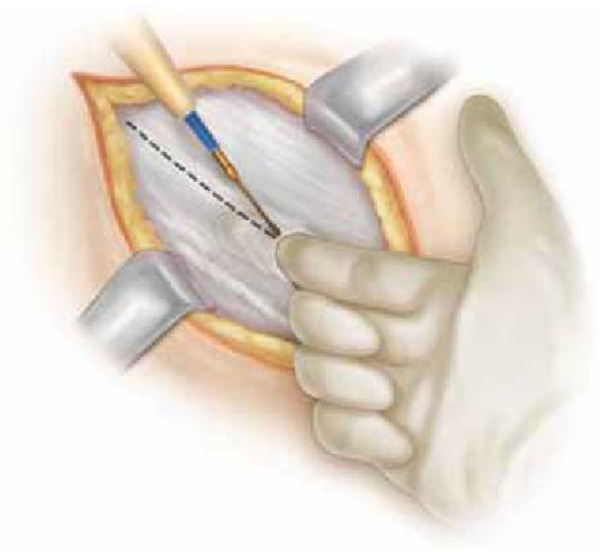

Figure 2.2 A finger is placed through the external ring protecting the spermatic cord as the external oblique is opened in line with its fibers.



## Dissection

The true dissection commences at opening the external oblique fascia in line with its fibers (Fig. 2.2). After identifying the pubic tubercle the surgeon or assistant can place their finger into the external ring just under the external oblique fascia. The fascia is then opened medially to laterally with electrocautery using the surgeon's finger to protect the underlying structures. Alternatively, one blade of the Metzenbaum scissors is placed under the external oblique aponeurosis and the scissors are "pushed" in the direction of the fibers opening the layer. This guarantees that the external ring will be completely opened which is a requirement for adequate exposure. The external oblique should be open for at least 10 cm which will allow for complete exposure of the internal ring as well as a few centimeters laterally. Cephalad and caudad flaps of the external oblique aponeurosis are developed from the pubic tubercle for the entire length of the incision. The cephalad extent of the dissection should expose the conjoined tendon and rectus sheath. The caudad flap dissection should be continued until the inguinal ligament (Poupart) is clearly demonstrated. Self-retaining retractors are used to maintain the exposure. At this point the course of the ilioinguinal nerve should be discerned. At this point either the nerve is carefully mobilized and retracted behind the cephalad flap of the external oblique aponeurosis or some surgeons prefer to resect the nerve and allow the proximal end to retract into the internal oblique muscle fiber. The second option is more commonly employed in older patients. Not all patients experienced numbness when this resection maneuver is performed because of overlapping innervation. If the nerve is resected, neuroma is possible, inguinodynia is avoided.

The spermatic cord is then mobilized. It is elevated off the pubic tubercle in its entirety along with its cremasteric fibers. A Penrose type drain is then secured around it. The spermatic cord must be carefully elevated from 2 cm distal to the pubic tubercle all the way to the internal ring. There are often cremasteric fibers that are lateral and medial to the spermatic cord that require division in order to achieve full mobilization. Moderate to large direct hernias may present as a structure adherent to the undersurface of the spermatic cord. These hernias are easily separated and diagnosed by elevating the spermatic cord anteriorly and sweeping the direct hernia posteriorly without violating the plane of the cremasteric muscle. The spermatic cord is then mobilized laterally. The anterior and medial portion of the cremasteric envelope of the spermatic cord is opened for 3 to 4 cm in the line of its fibers. The hernia sac associated with an indirect hernia is located in this portion of the spermatic cord. If a peritoneal sac is identified, it is mobilized by retracting a hernia sac cephalad and laterally while mobilizing the spermatic cord structures medially (Fig. 2.3A). The process is likened to opening a book with the spine of the book centered in the internal ring. This process should be continued

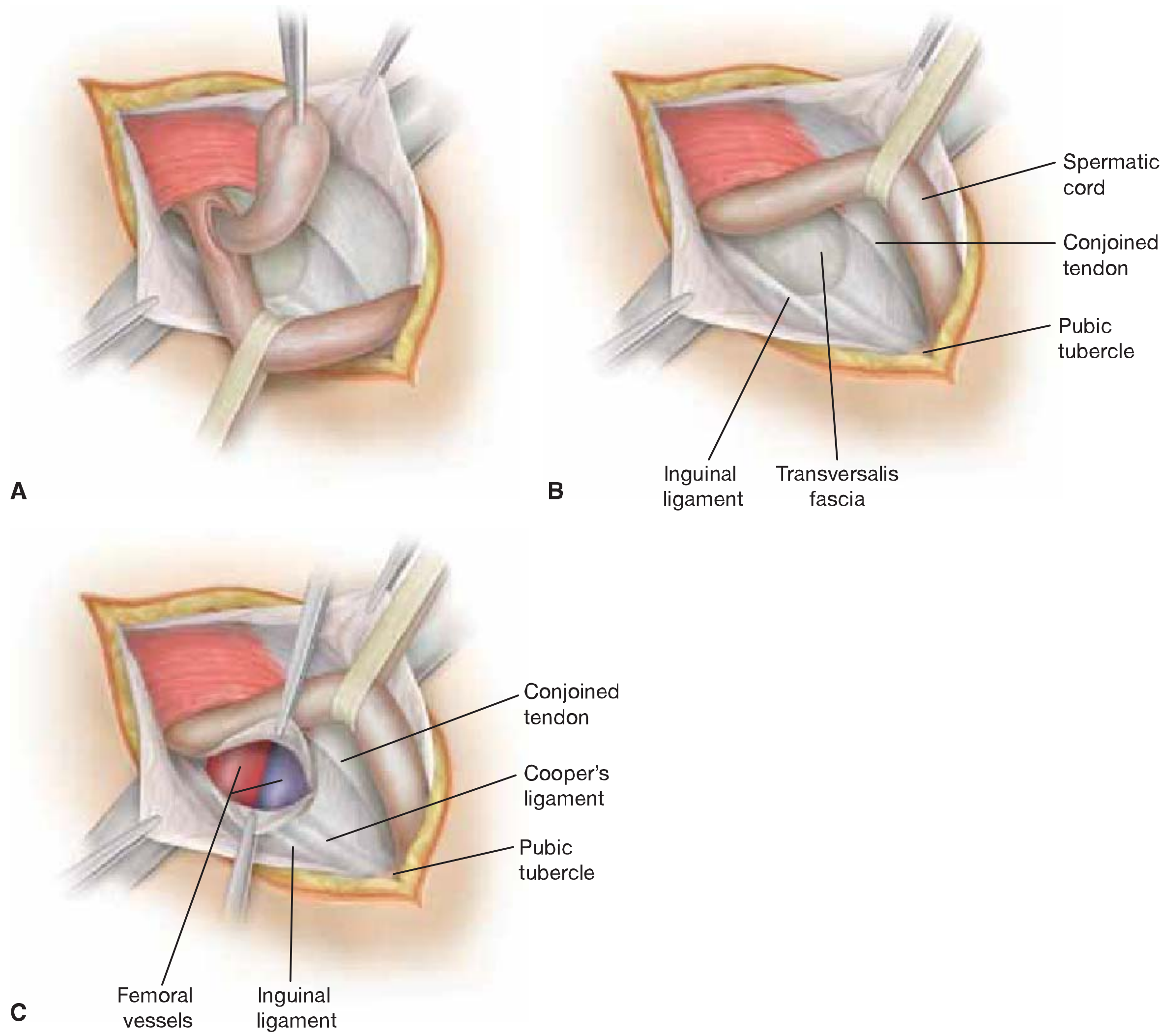


**Figure 2.3** **A:** The hernia sac is teased out from the anteromedial portion of the spermatic cord after incising the cremasteric fibers. **B:** After removing the indirect sac (if present) the spermatic cord is encircled with a penrose drain. **C:** The trasversalis fascia can be open to explore for a femoral hernia which would be found medial to the femoral vein and just anterior to Cooper's ligament.

until the vas deferens and cord vessels are seen entering into the internal ring and completely separated from the peritoneal sac. Lipomata of the spermatic cord are mobilized in a similar fashion. Once these structures are mobilized, they are either ligated and excised or mobilized back into the retroperitoneum.

After the completion of the exploration of the spermatic cord, the floor of the inguinal canal is assessed by examining the transversalis fascia. If the integrity of the floor of the inguinal canal is intact, then the transversalis fascia does not need to be opened unless a femoral hernia is suspected (Fig. 2.3B). These suspicions can be confirmed by examining the region outside of the external oblique just medial to the femoral vein and palpitating for any suspicious masses suggesting femoral hernia. If either a direct hernia or femoral hernia exists, then the transversalis fascia should be opened in its medial portion near the pubic tubercle at its juncture with the inguinal ligament. By doing so, Cooper's ligament in the femoral canal can be exposed (Fig. 2.3C). Femoral hernias are then reduced and Cooper's ligament is cleared off from the femoral vein to the pubic tubercle with care to avoid injury to the rectal vein which can run parallel to Cooper's ligament. The ligament is identified as a firm but slightly spongy structure lying over the pubic ramus.

The final portion of the dissection is an examination of the conjoined tendon. The structure represents the fusion of the internal oblique and transversus abdominis aponeurosis. In many cases, these layers of aponeurosis are incompletely fused and examination reveals that the internal oblique layer is primarily muscle. In this setting surgeon should dissect more posteriorly reflecting back the internal oblique muscle in order to demonstrate the transversus abdominis aponeurosis which is generally a consistent structure. The dissection is now complete.

## Reconstruction

The precise reconstruction should be dictated by the pathology encountered as a result of the careful examination of the direct, indirect, and femoral spaces. The principle behind all of the choices and variants is the use of a flat polypropylene mesh that has a keyhole laterally to accommodate the spermatic cord. This mesh must extend medially for at least 2 cm past the pubic tubercle in order to avoid a medial recurrence through the direct space and a result of mesh shifting or shrinkage. In cases where only a small or moderate indirect hernia is encountered, a 1 inch × 4 inch mesh can be tailored for the repair. Larger patients or larger hernias will require using a somewhat bigger piece of polypropylene. It is critical to avoid tension on the mesh. Later variants from the Lichtenstein group included mesh configurations with a dome in the medial portion to accommodate mesh shrinkage. The internal ring is assessed in order to determine if there is risk of herniation through an unduly large orifice that would reside posterior to the anticipated mesh placement. The internal ring can be tightened to an appropriate size by imbricating the transversalis fascia medial to the exit of the spermatic cord/using 2–0 absorbable suture(s).

The mesh placement begins with fixation at the pubic tubercle. A mattress suture is initiated 2 cm from the medial end of the mesh in order to create the overlap of mesh well past the pubic tubercle. The suture is placed into the periostium and brought back through the mesh but not tied at this point. The caudad mesh fixation present two major options of the surgeon. Either the mesh is sewn to the inguinal ligament from the pubic tubercle to 2 cm past the internal ring (Fig. 2.4A) or the mesh is sewn to Cooper’s ligament medially and transitioned to the inguinal ligament laterally (Fig. 2.4B). Simple indirect hernias do not require opening the transversalis fascia and the caudad mesh fixation is the “shelving edge” of the inguinal (Poupart’s) ligament. The choice of running suture line or interrupted suture line is by surgeon’s preference. I usually prefer to place the first 3 or 4 sutures individually using 0 polypropylene suture into the pubic tubercle and inguinal ligament and secure them with hemostats in order to properly gauge the mesh alignment before tying these first 4 sutures. Choice of suture varies amongst operators, though most prefer some type of permanent suture. The key technical point is to be careful to only suture the inguinal ligament and not the structures such as the femoral artery vein or nerve underneath. Instructors are often heard telling trainees to “skive” the shelving of the inguinal ligament with a bite of tissue 2 to 3 mm wide and not deeper than the ligament itself. If a suture is placed in the vein or artery, obvious bleeding may ensue. In this case, the suture should NOT be tied. It should be removed and firm direct pressure should be held for 10 minutes and reassessed. Persistent bleeding should be treated with dissection, exposure, and suture repair of the injury. The individual sutures should be placed approximately 7 to 10 mm apart. Once the suture line joining the mesh to the inguinal ligament is mostly completed, it is convenient to join the two tails of the keyhole in the mesh together around the spermatic cord with a permanent suture. The key technical point for this step of the procedure is to splay out the external oblique aponeurosis as the sutures are placed by placing tension on the cut edge of the caudal flap. This avoids bunching the external oblique which would leave the surgeon potentially without much tissue to work with at the time of closure of this layer. Attention is then turned back to the medial portion of the reconstruction. The cephalad suture line is made by joining the conjoined tendon (or the aponeurosis of the transversus abdominis) to the mesh in interrupted fashion. The two suture lines are carried laterally until at least 1 to 2 cm past the lateral aspect of the exit of the spermatic cord out of the internal ring.

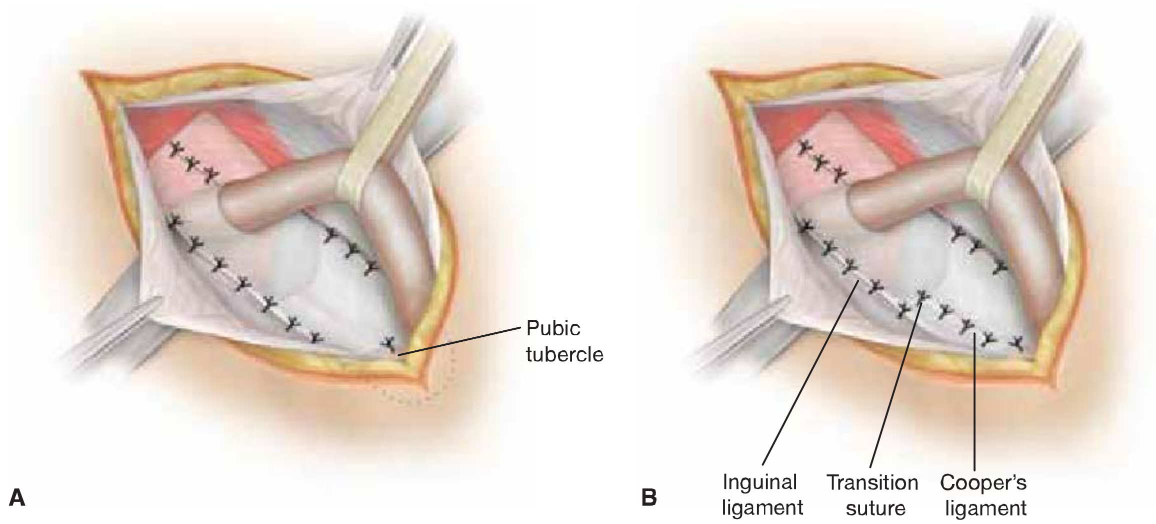


**Figure 2.4** **A:** For an indirect or small direct hernia: The mesh is sewn onto place with a series of interrupted sutures. The medial suture is in the pubic tubercle. The caudal sutures are in the inguinal ligament and the cephalad sutures are in the conjoined tendon. The tail of the mesh are joined together laterally allowing the tip of the surgeon's finger to enter the neo-internal ring. **B:** The large direct defects are repaired by sewing the mesial mesh to Cooper's ligament instead of the inguinal ligament. When the femoral vessels are encountered, a "transition" stitched is placed in both Cooper's and inguinal ligaments sealing the femoral canal.

The neo-internal ring is now assessed. It should be wide enough to admit just the tip of the surgeon's index finger through the hole in the mesh. If the hole is too tight, a small slit is cut on the medial side. If the hole is too loose, then an additional suture is placed until the proper spacing is achieved.

If the patient's pathology demonstrates the presence of a femoral hernia, then the repair is modified to bring the medial—caudad mesh down on to Cooper's ligament instead of the inguinal ligament (Fig. 2.4B). Clearly, it is not possible to close the femoral space by suturing the mesh to the inguinal ligament which is anterior to the femoral canal. The idea of placing sutures through an intact transversalis fascia on to Cooper's ligament should be avoided in favor of clearly identifying Cooper's ligament and inspecting the femoral canal. Interrupted sutures are placed first in the mesh, then in Cooper's ligament until the femoral vein is reached. The shape of the mesh can be modified to leave a larger portion medially to simply tension-free coverage of the femoral space. This final stitch on Cooper's ligament is known as the "transition stitch" since a second bite is also placed on the inguinal ligament more anteriorly. This is what closes the femoral space. Since Cooper's ligament run more deeply than the inguinal ligament, it is convenient to place these sutures without tying them until the inguinal ligament is reached and then "parachute" them into place and tie them. The remainder of the repair is performed in the same fashion as above. Large direct hernias should also be repaired in this fashion.

## Technique Variations in Women

As in men, direct and indirect inguinal hernias are more common than femoral hernias in women; however, the incidence of femoral hernias are higher in women than in men. This should alert the surgeon to be vigilant for this possibility and have a low threshold to open the transversalis fascia layer to inspect the femoral space. The presence of the round ligament in place of the spermatic cord requires some consideration as well. Some surgeons prefer to ligate the round ligament in the preperitoneum with the idea that future indirect hernia recurrence risk is lessened by closing the entire floor of the (inguinal) canal of Nook. In younger women, this could reduce the support to the uterus and may not be advisable. In the event that the round ligament is preserved it is handled in a fashion analogous to the spermatic cord in males using a somewhat smaller keyhole in the mesh.

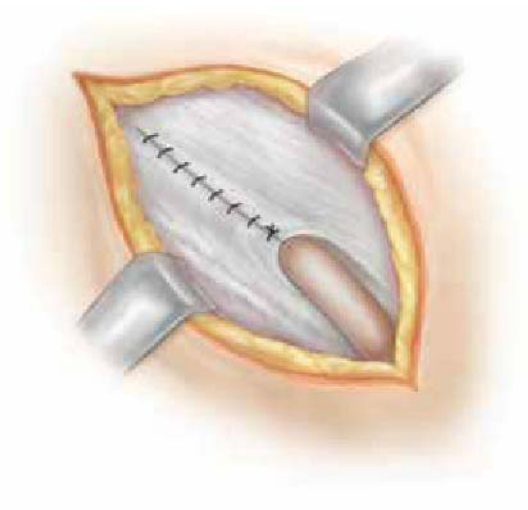

**Figure 2.5** The external oblique fascia is closed with a continuous absorbable suture with care not to incorporate a nerve into the suture line or make the external ring too tight.

## Wound Closure

If preserved the ilioinguinal nerve is returned to its normal position. Irrigation is used consistent with the surgeon's preference. The penrose drain around the spermatic cord is removed and the dissection of the spermatic cord is inspected for bleeding. Since this technique does not depend on extensive distal mobilization of the spermatic cord, the testicle should be in a relatively normal position. This is confirmed after the drapes are removed and the scrotum is inspected at the end of the case. The external oblique layer is closed by identifying the new location of the external ring and suturing the aponeurosis together at this point with care not to make the ring too tight or catch a portion of the spermatic cord or ilioinguinal nerve into the closure. Since this layer does not contribute strength to the hernia repair, this layer can be approximated with a running 2–0 absorbable suture (Figure 2.5). Scarpa's layer is closed with three interrupted 3–0 absorbable sutures and the skin is closed by the surgeon's preferred choice.

# POSTOPERATIVE MANAGEMENT

An ice pack is used for 24 hours on the wound to minimize swelling. Male patients should wear scrotal support for at least a week. This reduces tension on the testicle and increases comfort in the postoperative period. Patients are given oral narcotic pain medication and non-steroidal anti-inflammatory agents for pain. Most patients can return to work depending on the physical requirements in 1 to 2 weeks, but there is a wide variation on the basis of patient motivation and the extent of physical activity required. Patients are advised to avoid truly strenuous lifting for 6 weeks postoperatively.

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# 3 Plug and Patch Inguinal Hernia Repair

**Jonathan F. Critchlow**

## Introduction

Inguinal hernia repair is one of the most common operations performed by general surgeons, with approximately 750,000 operations done per year in the United States by surgeons who incorporate it as a part of their varied practices. Conventional open repairs without prosthetics are most often successful for small hernias. However, they are plagued in general by a high recurrence rates except in specialized centers. This has prompted most surgeons in the United States to turn to prosthetics which have the following advantages:

- Less tension
- Utility in areas where there is poor tissue strength
- Strengthening other weak areas of the floor at the time of operation
- Coverage of the areas which may deteriorate over time

Attention to all of the above have led to lower recurrence rates with the use of grafts. The quest has continued for a prosthetic repair which is rapid, safe, versatile, and easily taught. The patch/plug repair has thus been embraced by a large number of surgeons as their procedure of choice.

The open preperitoneal approach described by Stoppa is quite effective but involves extensive dissection in often somewhat unfamiliar anatomy. It is now relegated to complex hernias and recurrences. The anterior approach was addressed by Lichtenstein, whose work revolutionized herniorrhaphy in the United States. However, this technique, which reinforces the entire floor of the inguinal canal without directly addressing the defect, requires a meticulous closure with continuous sutures, and does expose the patient to some risk of recurrence through small gaps in the external repair, or because the primary defect has not been bridged.

Gilbert described the "sutureless" repair which was preperitoneal placement of a mesh patch to close the defect of an indirect hernia with an overlay similar to that of Lichtenstein, but without sutures as the original defect had been addressed. Direct hernia defects were bridged with a round plug followed by an overlay to reinforce the floor and help to hold the plug in place. Rutkow and Robbins developed an approach to repair the primary defect with a prosthetic material ("plug") and resurfacing the entire floor with mesh to prevent recurrence and to help hold the plug in place. This approach is applicable to direct and indirect hernias and has enjoyed tremendous success and is arguably the most common repair done in the United States. It can be done quickly and efficiently under local anesthesia with or without sedation, allowing for safe repair in high risk patients with low recurrence rates. This is a very versatile technique and is adaptable to most all types of hernias including the findings of an unsuspected femoral hernia or Pantaloon hernias. It is rapid and can most often be done as an outpatient without general anesthesia. Some have argued that this is a more "minimally invasive" approach to hernia repair than laparoscopy as it can be done without general anesthesia, bladder catheterization, or extensive dissection violating the space of Retzius around the bladder and prostate which could complicate subsequent prostatectomy. Some surgical educators bemoan the fact that this relatively simple technique does not require the more extensive skill and understanding of complex anatomy on the part of the trainee to complete a successful repair as compared to tissue repairs and that future surgeons are not as prepared to handle the unusual contaminated case. This can be considered, but countered by excellent patient outcomes and that the fine points of anatomy are often lost on the most junior trainees who do the majority of these operations during residency. This technique has allowed hernia repair to truly become an "intern-case".

## INDICATIONS

- Elective repair of most all indirect and direct hernias
- Emergent repair of most all indirect and direct hernias without contamination
- Hernia repair in patients unable to tolerate general anesthesia
- Bilateral inguinal hernia repairs—patient preference

## CONTRAINDICATIONS

- Strangulated hernias with gangrene
- Wound contamination
- Asymptomatic hernias in very high risk patients
- Multiple recurrent hernias previously repaired via an anterior approach

## PREOPERATIVE PLANNING

If possible, antiplatelet medications and anticoagulants should be held. Aspirin should be stopped 10 days prior to the date of operation unless essential for prevention of serious coronary or vascular events. Non-steroidal anti-inflammatory drugs should be discontinued 24 to 48 hours prior to operation. Warfarin is held in patients who are at low to moderate risk for thromboembolism. It may be continued at a lower dose to effect an international normalized ratio (INR) of approximately 2.0 in patients of moderate risk, and most often the operation may be performed easily without the need for a heparin "bridge". Prophylaxis for deep venous thrombosis is generally not necessary as most patients are done under sedation with local anesthesia unless general anesthesia is used in a patient at very high risk. These repairs are generally done under local anesthesia with sedation delivered by an anesthesiologist. Repair of hernias which are very large, recurrent or those in uncooperative patients are done under general anesthesia. Intravenous antibiotics with good gram-positive coverage are administered, as graft material is implanted. An alcohol-based antiseptic (e.g., chlorhexidine) is used to prepare the skin as it is more bacteriocidal than povidone-iodine.

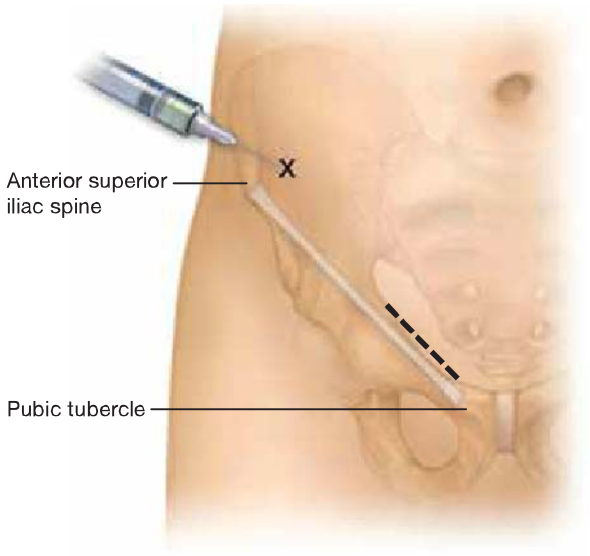


**Figure 3.1** Incision and site of nerve block: x = injection site; — = incision.



A mixture of 0.5% xylocaine and 0.5% bupivacaine is infiltrated locally. This is used throughout the procedure prior to incision of each fascial layer. A nerve block is also helpful for intraoperative anesthesia and postoperative analgesia. This is placed 2 cm medially and superior to the anterior superior iliac spine. A blunted 22 gauge needle is used so that a "pop" can be felt as the needle penetrates through the external oblique fascia thus delivering the solution in the appropriate layer (Fig. 3.1).

## SURGICAL TECHNIQUE

A 4 to 6 cm oblique incision is made beginning at the pubic tubercle and extending toward the internal ring (Fig. 3.1). This allows for exposure both the pubic tubercle and the ring through a very short incision, which is hidden in the hairline. Undermining of the subcutaneous tissue greatly facilitates exposure through a small skin incision. Hand-held retractors offer excellent exposure in all areas of dissection and repair. The external oblique aponeurosis is opened down to the external ring. Blunt dissection is used to dissect the tissues away from the external oblique laterally and inferiorly. The cord is then blunted dissected off of the aponeurosis at the level of the pubic tubercle under direct vision. Medial dissection is then done in a similar fashion coming down to the pubic tubercle and clearing this area off as well. The cord can then be easily encircled at the level of the pubic tubercle passing a right-angled clamp and encircling it with a Penrose drain under direct vision in most cases. This obviates the possibility of leaving tissue behind or entering an attenuated floor if blind digital dissection is carried out cephalad to the tubercle. The ilioinguinal nerve is preserved and generally not dissected away from the surrounding tissues to avoid injury. The cord is then mobilized off the floor up to the level of the internal ring. The cord is then carefully explored by separating the cremasteric fibers.

Indirect hernia sacs are dissected well up into the retroperitoneum to the level of the internal ring. This dissection should be carried out quite high and the sac should be separated from the cord structures. "High ligation" is unnecessary in most cases and the sac can be allowed to fall back into the retroperitoneum. Ligation is sometimes required for large scrotal hernias where the sac is dissected down to the level of the pubic tubercle and then divided with the proximal portion being closed with absorbable sutures, leaving the distal end open to prevent a hydrocele. Lipomas of the cord are similarly dissected back to the retroperitoneum and can either be resected or left *in situ* and allowed to fall back into the retroperitoneum.

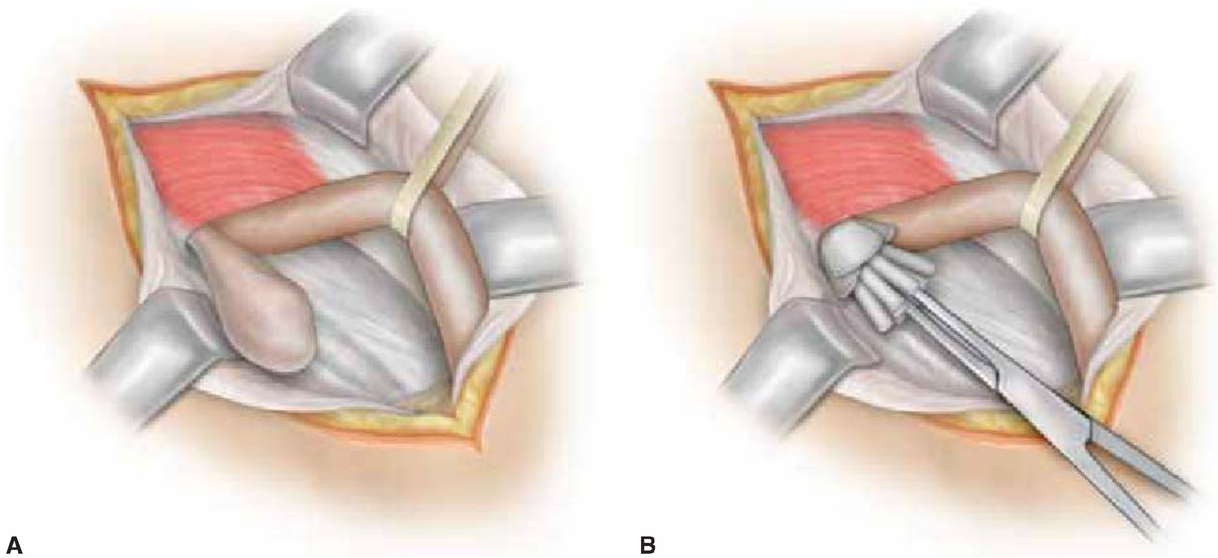


**Figure 3.2** (**A**) Dissection of the cord and indirect sac. (**B**) Plug placement into internal ring.

The plug is then placed to the internal ring and held in placed with sutures, either absorbable or permanent (Fig. 3.2). The number of sutures will depend on the size of the defect and the amount of "underlay" coverage afforded by the prosthesis. Gilbert described the suture placement of a flat sheet of mesh which is unfurled in the retro-peritoneum, while most surgeons now use a preformed prosthesis and attach them in several locations around the fascial defect.

An ever increasing array of plugs are now available. Small defects and some femoral hernias can be repaired with a cone created by folding a triangular piece of flat mesh several times into a cone shape and then fixing it with the suture (Fig. 3.3A). The Perfix® Mesh Plug is popular, containing an outer layer with multiple inner "petals" which can be trimmed to accommodate smaller defects or used to attach the mesh to the fascia affording more underlay coverage (Fig. 3.3B). Absorbable or semi-absorbable plugs address concerns about deformation, shrinkage, and potential adherence to underlying structures which have been reported, though rarely, with permanent materials. The Gore Bio/A® Plug absorbs over months and becomes collagen and scar. As all repairs require the placement of a permanent overlay, which incorporates quickly, there is little concern as to the ultimate strength of the resulting tissue of the defect. This device supports relatively wide underlay afforded by the four flat vanes which are deployed under the

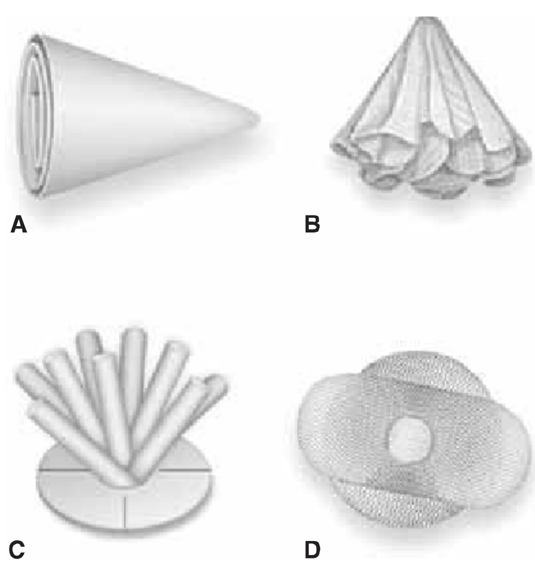


**Figure 3.3** Types of plugs: (**A**) handmade "cone," (**B**) Perfix® Plug, (**C**) Gore Bio/A® Plug, (**D**) Prolene Hernia System®.

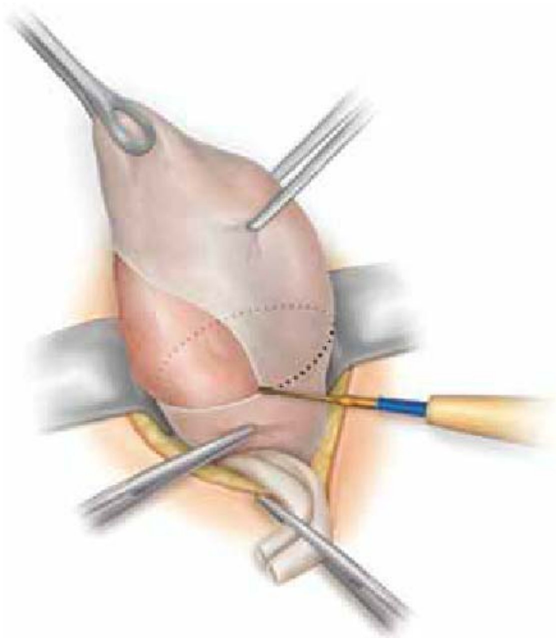

Figure 3.4 Opening of direct hernia to the retroperitoneum.

defect as well as a trimmable external component, and has at least a theoretical advantage of being absorbed if a preperitoneal approach is needed for repair of a recurrence, either open or laparoscopic (Fig. 3.3C). The Prolene Mesh System® which affords even more underlay, is a double sheet of mesh designed to cover the internal ring or direct defect as well as provide the overlay in one piece. This does have the advantages of more "underlay" coverage. However, it is a permanent prosthesis and also is not as versatile for use especially with direct hernias (Fig. 3.3D).

Direct hernias are approached by circumferential excision of a portion of the attenuated transversalis fascia of the sac (Fig. 3.4). The edges are grasped with clamps, and in larger defects the retroperitoneal space is developed by packing a $4 \times 4$ gauze sponge through the defect and then removing it. A plug is then placed and secured with multiple sutures around the defect. My personal preference is the Gore Bio/A Plug®, which should be placed inside of the defect, assuring that all four of the flat vanes are deployed against the abdominal wall for maximum coverage of the defect rather than using this as simply as space occupying mass (Fig. 3.5).

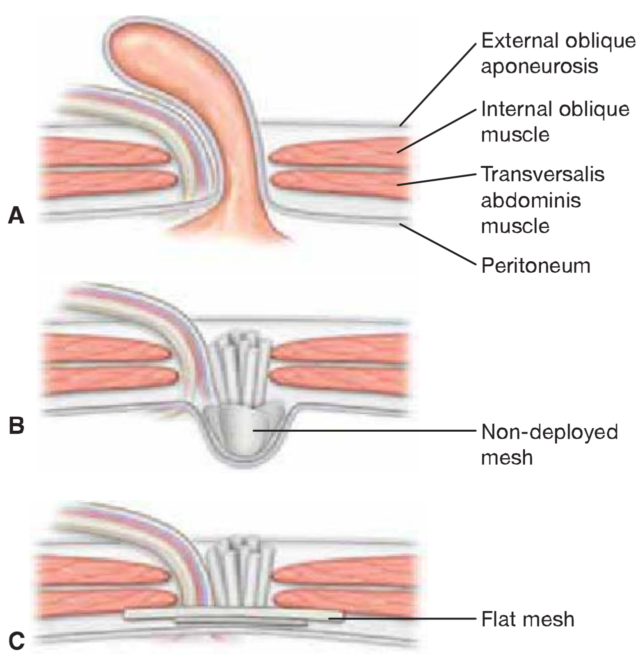


Figure 3.5 Placement of gore Bio/A® Plug: (**A**) Before repair, (**B**) correct, (**C**) incorrect.

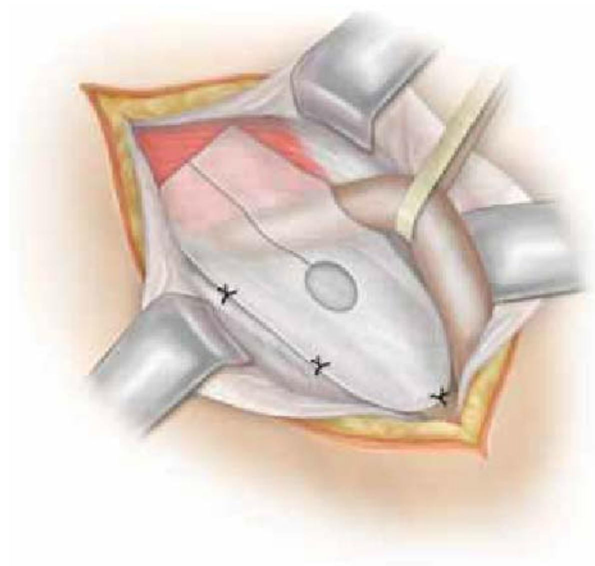

**Figure 3.6** Suture placement—pubic tubercle and inguinal ligament.

Large defects may require more than one plug and these can often be sutured together. Pantaloon hernias also require multiple plugs.

All initial inguinal hernia repairs require placement of an onlay graft to resurface the entire floor to prevent future hernias, and to help to keep the plug in place. Commercial systems are available, or this can be fashioned from a flat sheet of mesh cut to approximately 8 cm × 14 cm with a slit cut laterally to accommodate the cord. The graft is positioned and sutured to the aponeurosis over the pubic tubercle (Fig. 3.6). In most hernias, absorbable sutures can be used as they may obviate the potential of a painful reaction if permanent sutures are placed too deeply. In larger direct defects, a permanent suture such as Prolene® may be more appropriate. A number of mesh choices are available. Permanent material is recommended for elective repairs. I prefer polypropylene as it is easy to handle, inexpensive, and has a very good chance of healing even in cases of infection. Expanded polytetrafluoroethylene (PTFE) is more expensive, more difficult to handle, and must be removed if the field becomes infected as there is minimal porosity which could allow any granulation tissue to develop. Lightweight meshes are available; however, I find them more difficult to handle and great care must be taken to place the sutures far away from cut edges to assure that the mesh does not fray or pull through.

Gilbert's "sutureless herniorrhaphy" and Rutkow and Robbins patch–plug technique describe placement of the overlay graft without sutures. This should be adequate for small, indirect hernia defects but probably not for all. I do have some concerns over possible medial recurrences and larger direct hernias or slippage of the graft material and reports of delayed lateral recurrences have also been reported. Therefore, I prefer to suture the graft to the shelving edge of the inguinal ligament to assure that it sits properly (Fig. 3.6). Larger defects may require more sutures. The cord is placed between the two "pant legs" which are then sutured together or crossed over. A tacking suture or two on the rectus sheath also will assure full coverage by the graft, especially infero-medially. Care must be taken to assure that a branch of the ilioinguinal or iliohypogastric nerve is not incorporated in these sutures. Absorbable sutures are probably adequate, except in cases of larger direct hernias (Fig. 3.7).

The external oblique is then closed with a running absorbable suture taking care not to incorporate the ilioinguinal nerve. Scarpa's fascia is closed with interrupted absorbable sutures and the skin with a running absorbable suture.

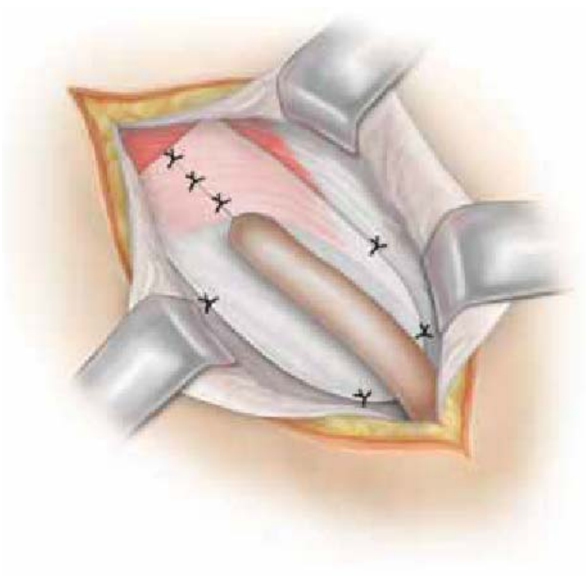

Figure 3.7 Suture placement—rectus sheath.



## POSTOPERATIVE MANAGEMENT

Patients are transferred to the post-anesthetic care unit and are usually ready for discharge when the effects of the short acting sedatives have dissipated. Unless there is a significant history of urinary dysfunction, patients may be discharged home without voiding. Patients are discharged home to do normal activities. They may drive when able to react quickly and press quickly on the brake. Activities requiring marked Valsalva are discouraged (in the absence of any good data) for 2 to 3 weeks. Patients are given prescriptions for non-steroidal anti-inflammatory drugs, unless contraindicated, and opioids if required for breakthrough pain. Patients with very large scrotal hernias requiring more dissection may benefit from scrotal support.

## COMPLICATIONS

### Recurrence

Recurrence rates for several variations of this technique run between 1% and 3% in large series. This is quite similar to results from other "tension-free" techniques, laparoscopic repairs, and results from the Shouldice Clinic.

### Infections

Infections occur in less than 1% of procedures. Permanent woven mesh (e.g., Marlex®, Prolene®) will most often eventually incorporate and does not require immediate removal. Use of mesh with small pore size such as PTFE will not support granulation tissue and should be excised.

### Ischemic Orchitis

The development of ischemic orchitis is less than 1%. This may be diminished by not completely dissecting a large sac out of the scrotum but instead by dividing it and not interfering with the arterial and venous plexi that adhere directly to the sac distally.

## Persistent Pain/Neuralgia

Three to thirty percent of patients may have persistent pain/neuralgia. Significant chronic pain after hernia repairs is a relatively rare complication. Most patients have mild symptoms but a few complain bitterly. Although sometimes called "mesh inguinodynia", a randomized trial of Shouldice, Lichtenstein, and laparoscopic TAPP repairs demonstrated less persistent pain with the TAPP repair, but essentially equivalence between the mesh and the non-mesh open repair. This supports the contention that excessive handling of the cord and partial injuries to the nerve during manipulation are most likely to blame in the few severe cases rather than adherence to the mesh itself. Avoidance of the nerves or even division of the nerves rather than excessive handling may well result in a lower incidence of this problem. Occasionally, these patients may require nerve blocks, ablation, or rarely exploration and resection.

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# 4 Prolene Hernia System

**David C. Treen, Jr.**

## INDICATIONS/CONTRAINDICATIONS

Prerequisite for the performance of any surgical procedure, and as important as technique, is a thorough working knowledge and understanding of the anatomy involved. Robert Condon said, "The anatomy of the inguinal region is misunderstood by some surgeons of all levels of seniority." Appreciation of the complexity of groin anatomy eludes most surgical residents, and argues that groin hernia repair by surgical residents should be in the hands of the more senior trainees under supervision of expert attendings. The understanding of the pathology of hernia formation in this region is still evolving, and humbles us with each new discovery. The pursuit of the ideal solution for groin hernia repair therefore necessarily incorporates as a foundational cornerstone knowledge of the anatomy and pathology affecting the pelvic floor. Prosthetic devices whose design processes begin with these foundations will lead the way toward the ultimate goal.

Fruchaud described the myopectineal orifice (MPO) (Fig. 4.1), as the area at risk for the development of groin hernia. This area of the MPO has been subdivided into three component triangles: medial, lateral, and femoral.

The integrity or vulnerability of the tissue within each triangle is dependent upon multiple variables, and can be enhanced or diminished by the introduction of mesh prosthetics in the repair of groin hernias. In the pre-mesh era of groin herniorraphy, prior to the introduction of the Lichtenstein onlay mesh technique, failures occurred predominantly in the medial triangle of the inguinal region, often adjacent to the pubic tubercle. Eventually, the reason generally accepted for these failures was the degree of tension created with the mobilization and suturing of tissues adjacent to the original defect. Following the adoption of tension-free methods employing various mesh materials and techniques, medial triangle recurrences became rare while recurrent hernias presenting through the lateral triangle became more common. This suggested that incomplete mesh coverage of all three triangles of the MPO at the original operation predisposed patients to recurrences in unprotected, more vulnerable locations.

The Prolene Hernia System® (PHS) (Ethicon, Inc., Somerville, NJ) (Fig. 4.2) was developed by Dr. Arthur Gilbert and colleagues at the Hernia Institute of Florida, and was introduced in 1999. As described by Gilbert, the PHS is "a bilayer polypropylene (mesh) device" (PPM) intended for use in the repair of groin hernia including inguinal (direct, indirect, and recurrent) and femoral hernias. The impetus for the design of the PHS was to achieve positioning of a flat mesh inside the preperitoneal space (PPS) of the groin via a conventional anterior surgical approach. The goal of the technique

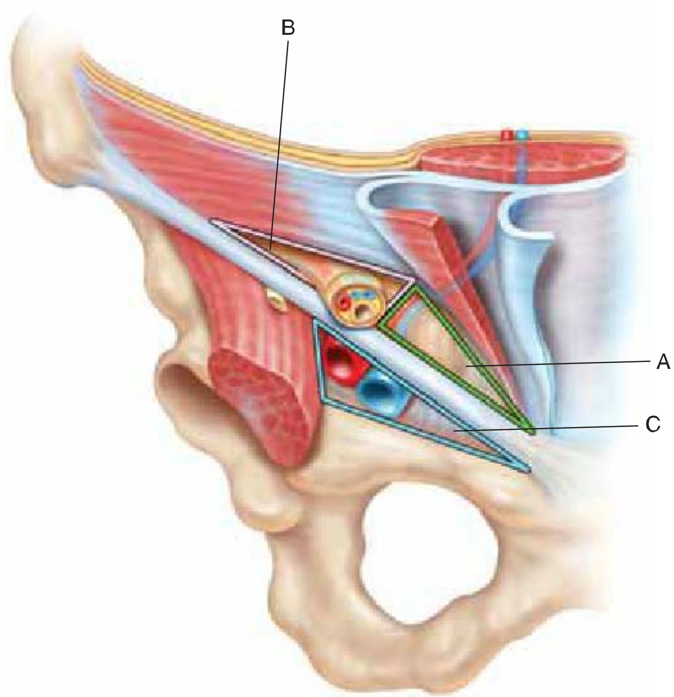


**Figure 4.1** Myopectineal Orifice with medial (**A**), lateral (**B**), and femoral (**C**) triangles.

is to cover and protect the entirety of the myopectoneal orifice (MPO) within this PPS with the "underlay" mesh component, augmented by the addition of the second mesh layer in the floor of the inguinal canal. Use of the PHS has also been found to be efficacious in the repair of umbilical, epigastric, spigelian, and small incisional hernias, provided that protection of viscera is achievable with either preperitoneal placement of the underlay component, or by positioning the omentum immediately adjacent to the intraabdominal mesh. Recently developed similar devices, which employ tissue separating visceral protection components, have replaced the use of the PHS in many of these applications beyond the groin area. While our use of the PHS has been applicable to virtually any primary or recurrent groin hernia, including those with previous mesh, alternative techniques and materials should be considered in circumstances where the PPS is either inaccessible or obliterated by previous surgery or irradiation. It has been suggested that the use of mesh in the inguinal PPS should be avoided in patients at risk for future radical pelvic surgery such as prostatectomy;

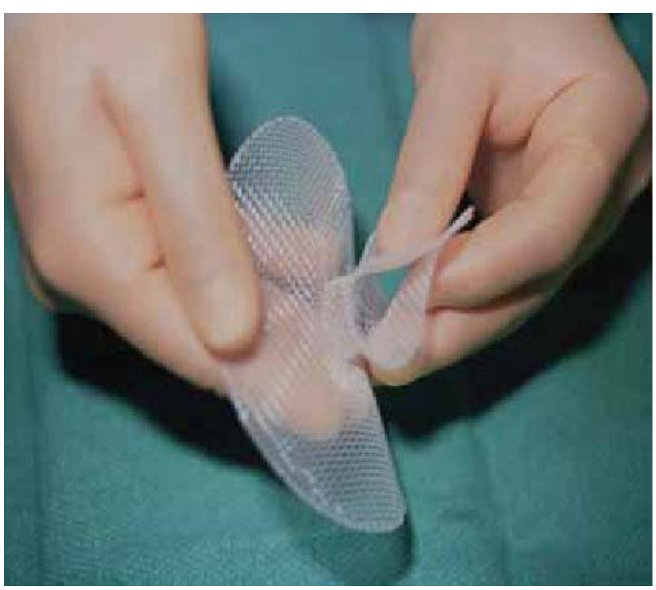

**Figure 4.2** Prolene Hernia System®.

however, reports have been published which refute this concern, and it is our belief that choice of technique and materials should not be limited by potential future pathology. Questions have also been raised about the potential adverse effect of mesh devices, particularly polypropylene, upon the integrity of the iliac vessels and the patency of the vas deferens. In our experience, and based upon other published reports, these concerns are unwarranted. Finally, hypersensitivity to polypropylene has been reported rarely, but remains an obvious contraindication to use of the PHS.

## PREOPERATIVE PLANNING

As in any surgical procedure, careful history and physical examination is essential. Assessment of the patient's body habitus is important particularly in the case of severely obese individuals; as such anatomic obstacles may cause significant challenges to the performance of groin hernia repair. Accurate documentation of any previous abdominal, pelvic, vascular, or groin surgery can lead to the selection of an alternant approach to preperitoneal mesh placement for groin herniorraphy.

Skin infection or other conditions which could lead to poor healing or potential complications should be resolved when possible prior to implantation of any foreign body, particularly synthetic mesh. The use of enteral or parenteral perioperative antibiotics, and the practice of antibiotic irrigation during mesh herniorraphy have been debated for years. Most authors conclude that there is no statistically significant advantage to the use of antibiotic prophylaxis in the performance of routine inguinal hernia repair with or without synthetic mesh prosthesis. Nevertheless, many surgeons argue that antibiotic prophylaxis is both inexpensive and safe, and that such practice should not be considered inappropriate.

Anesthesia options for PHS repair include general, spinal, epidural, or local–regional anesthetic.

We have found that groin hernia repair with PHS using local anesthesia with regional infiltration is well tolerated; however, such is not the case in the repair of umbilical hernias with PHS or other preperitoneal or intraperitoneal devices, and our preference for umbilical hernia repair is general anesthesia.

## SURGERY

Operative technique of initial dissection and exposure for the Prolene Hernia System repair is similar to standard methods of anterior approach to the inguinal region. Refer to the accompanying videos for all technique steps.

- Skin preparation with clipping rather than shaving is preferred.
- Gel prep cleansers reduce the incidence of caustic chemical skin irritation in the dependent skin folds near the thigh and perineum.
- Surgical exposure of the inguinal region is accomplished through a 3 inch oblique incision minimizing dissection where possible. Appropriate retractors are placed, and stretching and pressure on the skin is avoided. In obese patients, Trendelenburg position can be advantageous.
- The external oblique aponeurosis is opened in the direction of its fibers, and medial and lateral flaps of this layer are minimally mobilized and retracted.
- Care is taken to preserve the ilioinguinal nerve, the iliohypogastric nerve, and the genital branch of the genitofemoral nerve (GFN). In cases where a bifurcated nerve hinders necessary dissection, the minor branch is sacrificed sharply and ligated with fine, absorbable suture. It is widely agreed that an injured nerve is more problematic than a divided nerve; therefore, suspected injury warrants division and ligation.
- The spermatic cord (SC) is encircled with a ¼ inch penrose drain, and gently retracted, allowing inspection of the inguinal floor. A direct hernia, if present, is separated from its attachments to the under surface of the cord structures.

- The cremasteric muscle fibers are separated on the anteromedial aspect of the proximal SC, and careful search for an indirect hernia sac is completed. This is particularly important in cases of obvious direct hernia, as occult indirect hernias can be missed without diligent and careful dissection of the proximal SC as it exits the deep (internal) inguinal ring.

### 1. Indirect Inguinal Hernia Repair

- The indirect hernia sac is carefully separated from the other structures within the interior of the SC, identifying and preserving the blood supply to the testis and the delicate investments and vessels attached to the vas deferens.
- The hernia sac is separated from the vas deferens deep into the PPS most often with gentle blunt dissection using the tip of a finger or the back of a Debakey forcep. Rarely is sharp dissection necessary for this maneuver.
- Attachments of the internal oblique and transversus abdominis muscles to the neck of the hernia sac are released where these layers overlap the internal ring. This is particularly important to ensure that the hernia sac will be freed from the lateral triangle in order to permit separation of the peritoneum lateral to the internal ring.
- The deep epigastric vessels are identified in the medial rim of the internal ring, and are encircled with an Allis forcep, permitting medial retraction of the vessels while the hernia sac is retracted laterally (Fig. 4.3).
- The tissue bridging between the deep epigastric vessels and the hernia sac is transversalis fascia (TF), and cutting through this TF affords entry into the PPS. The TF can be bi-laminate in this area, and in such cases may require deeper dissection to gain entry to the PPS. The fat within the PPS is readily identifiable, and palpation of Cooper's ligament with the index finger through this internal ring confirms PPS access.
- Blunt separation of the abundant fat in the PPS beneath the inguinal floor and along Cooper's ligament with index finger and dry gauze clears the medial and femoral triangles of the MPO.
- Continue the blunt finger dissection cephalad, beneath the deep epigastric vessels, and toward the lateral triangle. *As the dissection proceeds laterally, the PPS will no longer contain fat, requiring attention to peel the peritoneum away from the overlying TF in order to create the lateral triangle space for optimal mesh deployment* (Fig. 4.4).
- The peritoneum is intimately applied over the iliac vessels and retroperitoneal segment of the vas deferens.

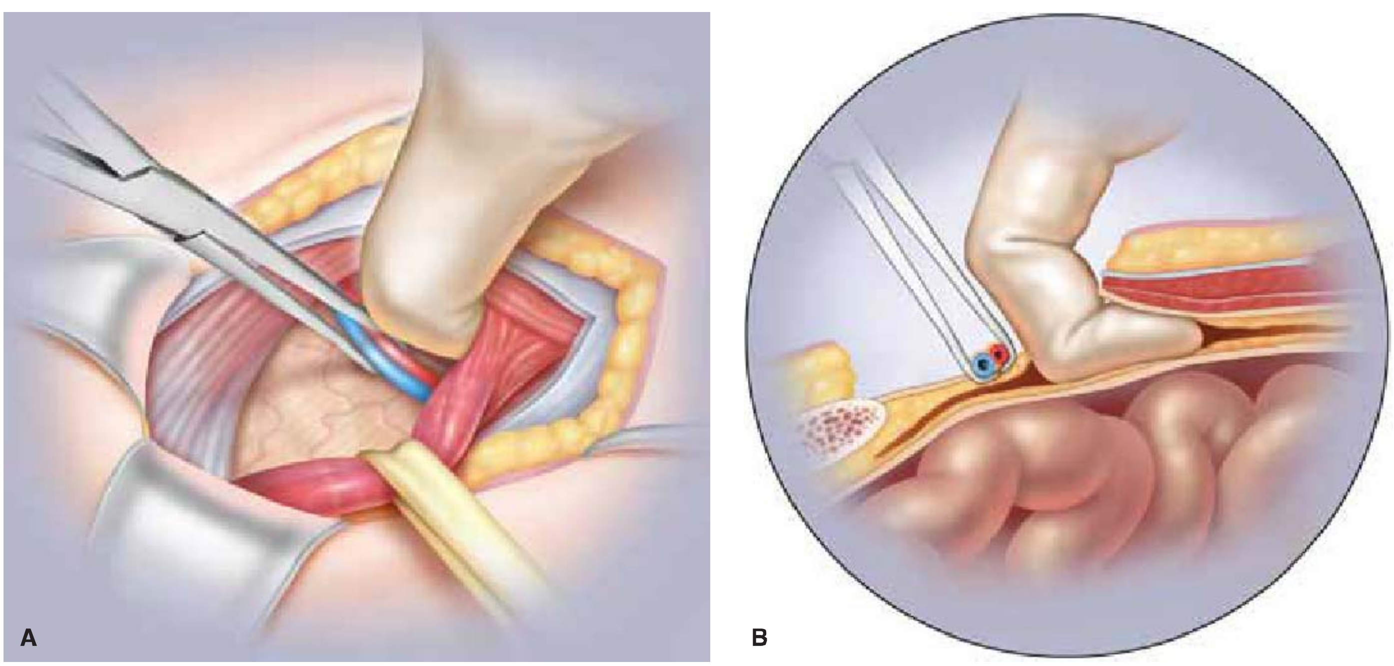


**Figure 4.3** Parts (**A**) and (**B**): Dissection of the PPS (indirect hernia sac is omitted in illustration to avoid complexity).

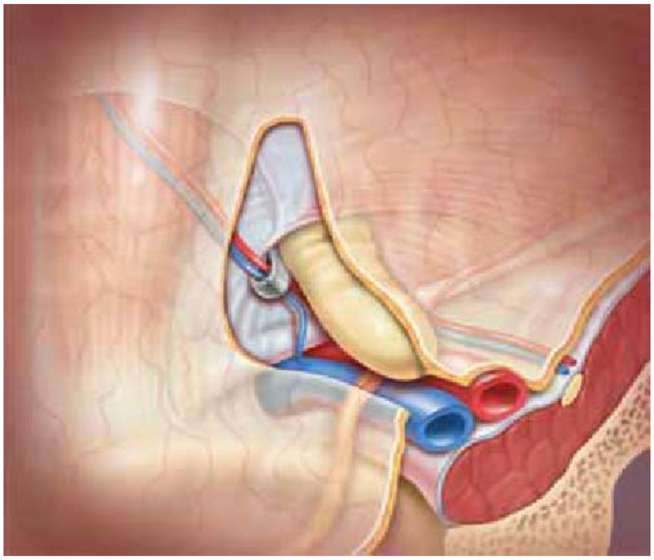

Figure 4.4 Manual dissection of the PPS.

- Retracting the hernia sac cephalad, exposing the iliac vessels, and gently dissecting the peritoneum off the iliac vein completes the PPS dissection. There are several lymph nodes between the peritoneum and the iliac vein, which may or may not require dissection; however, surgeons who are new to this procedure are advised to exercise great care in separating these lymph nodes, and optimal mesh deployment overlying the iliac veins does not necessarily require this lymph node dissection.
- Dissection of the PPS should be essentially bloodless, as no significant vessels traverse the PPS; however, previous pelvic surgery can alter the PPS significantly, and care is advised in these cases.
- The hernia sac is not ligated unless the sac extends into the scrotum and contains the testicle. Otherwise, the sac is inverted laterally and in a cephalad direction.
- The PHS mesh is prepared for insertion by folding the oblong mesh layer into thirds, grasping the folded mesh with a ring forcep, and collapsing the mesh into a cone similar to closing an umbrella (Fig. 4.5 A–D).
- The mesh is moistened with saline.
- Insert the mesh umbrella fully into the PPS through the internal ring, ensuring that the hernia sac is fully inverted.
- While stabilizing the folded onlay mesh with the ring forcep, deploy the underlay umbrella by grasping the medial leaflet of mesh with a Debakey forceps, and push the edge of mesh beneath the inguinal floor toward the undersurface of the pubic tubercle.
- Deploy the cephalad leaflet of the underlay mesh similarly, pushing the edge of mesh beneath the aponeurotic arch and deep epigastric vessels.
- Deploy the caudad leaflet of the underlay mesh by grasping similarly and rolling the mesh down into the PPS between the peritoneum and Cooper's ligament and iliac vessels. This maneuver is safely facilitated using the back end of the Debakey forcep to unroll this leaflet into position, draping over the retroperitoneal structures.
- The lateral leaflet of the underlay mesh is deployed into the lateral triangle with forceps.
- Confirm proper deployment with gentle palpation of the relationship of the mesh to the abdominal wall and pelvic structures. The mesh should now be in the shape of a taco shell, curving posteriorly as it drapes over Cooper's ligament and the iliac vessels. It is common for the mesh to have minor wrinkles, which are typically flattened as the patient's intraabdominal pressure is applied against the mesh.
- The ring forcep is removed, unfolding the onlay mesh into the inguinal floor.
- An absorbable suture is used to loosely tack the medial edge of the onlay mesh to the rectus tendon just above its insertion into the pubic tubercle.
- A slit is cut in the edge of the onlay mesh to allow passage of the SC through the mesh, and this cut edge is similarly sutured to the inguinal ligament adjacent to the internal ring, avoiding injury to the genital branch of the GFN (Fig. 4.6).

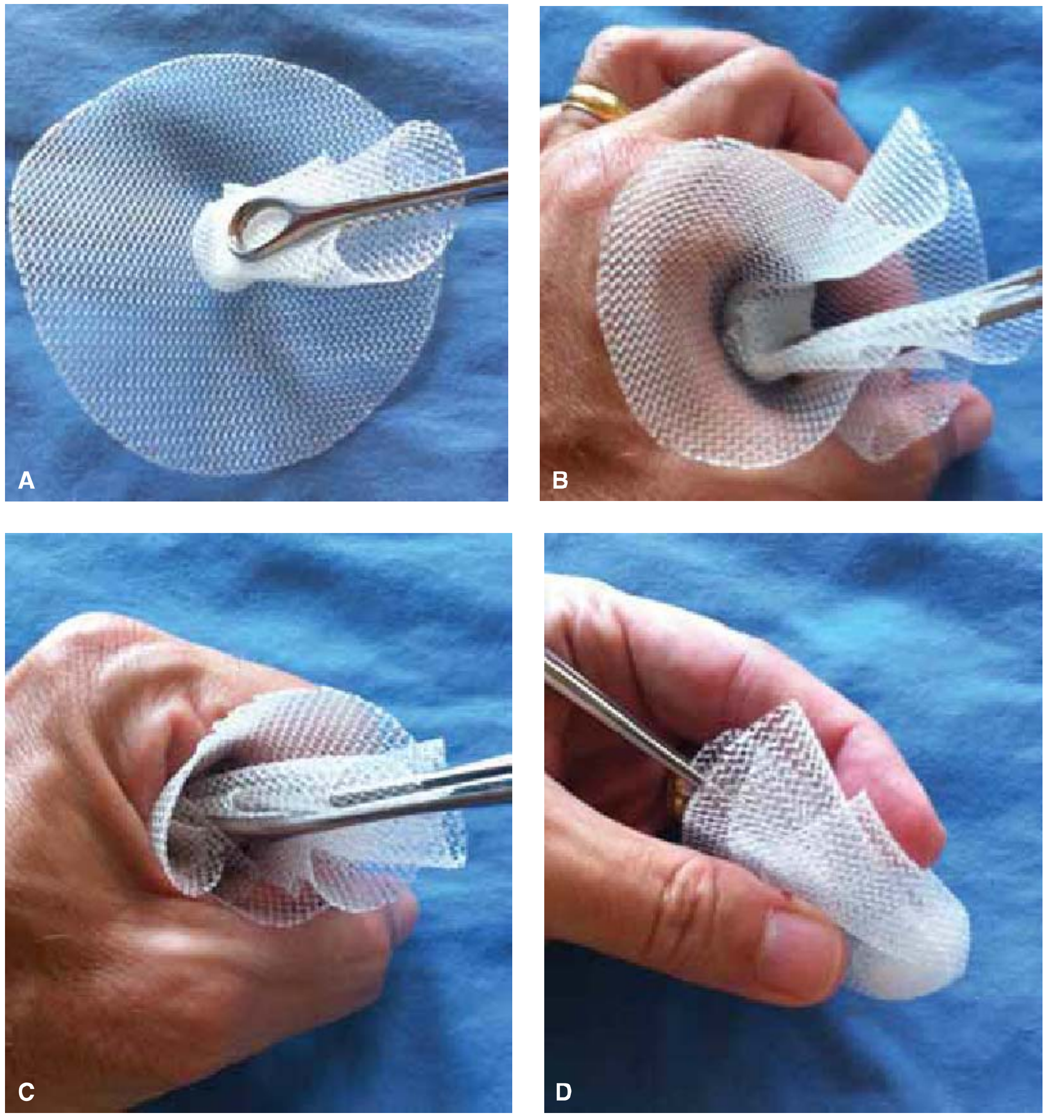


**Figure 4.5** Preparation of the PHS (**A–D**).

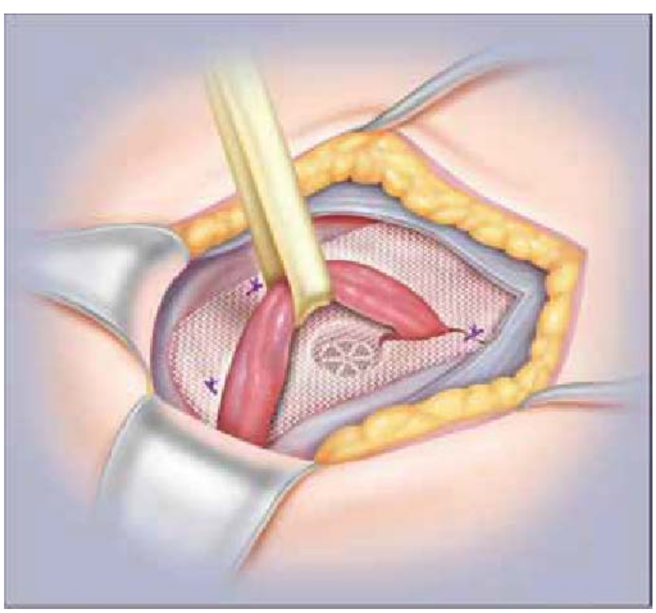

**Figure 4.6** Slit in PHS onlay component and location of sutures.



**Figure 4.7** **A:** Laparoscopic view of right inguinal hernia repair with PHS (2 years post-op). Note folded lateral edge on the right side. **B**. Optimal deployment of PHS.

- The caudal edge of the onlay mesh may be trimmed slightly between the two previously placed sutures, allowing enough residual mesh overlap of the inguinal ligament and placement of the third suture midway between the other sutures.
- It is extremely uncommon to require any additional sutures to anchor the mesh.
- Closure of the external oblique, recreating the superficial inguinal ring is accomplished with continuous absorbable suture. Closure of Scarpa's fascia and skin approximation complete the operation.

### 2. Direct Inguinal Hernia Repair

- The classic technique for PHS placement for direct inguinal hernias is to enter the PPS through the floor defect. This is acceptable provided the dissection of the lateral triangle is not impeded by the adherence of the peritoneum to the undersurface of the internal ring. Many surgeons fail to recognize the incompleteness of the lateral triangle dissection in such cases, and thereby obtain sub-optimal deployment of the underlay mesh in this critical area of the MPO (Fig. 4.7 A, B).
- Following blunt separation of the PPS around the MPO using finger and gauze dissection, PHS deployment through the direct defect is accomplished in a manner similar to the steps defined above for indirect hernia repair (Fig. 4.8).
- The margins of the direct defect can be tightened around the connector portion of the PHS, which affords enhanced stability of the mesh in the inguinal floor.
- As a result of the central portion of the mesh device being positioned medial to the deep epigastric vessels and the internal ring, many surgeons choose the extended version of the PHS, which has added length of onlay mesh to compensate for the slight medial relocation of the device.
- The slit in the onlay mesh should be positioned where the SC will comfortably pass through the mesh. Do not force the SC to exit the onlay mesh adjacent to the central connector if this position appears inappropriate.
- In the case of complete destruction of the floor, stabilization of the mesh can be achieved using continuous absorbable sutures along the inguinal ligament and the aponeurotic arch similar to any other onlay mesh technique.

### 3. Alternant approach for Direct Hernia Repair (refer to video)

- It has become our preference and practice to approach direct hernia repair with the same internal ring access as in an indirect hernia repair.

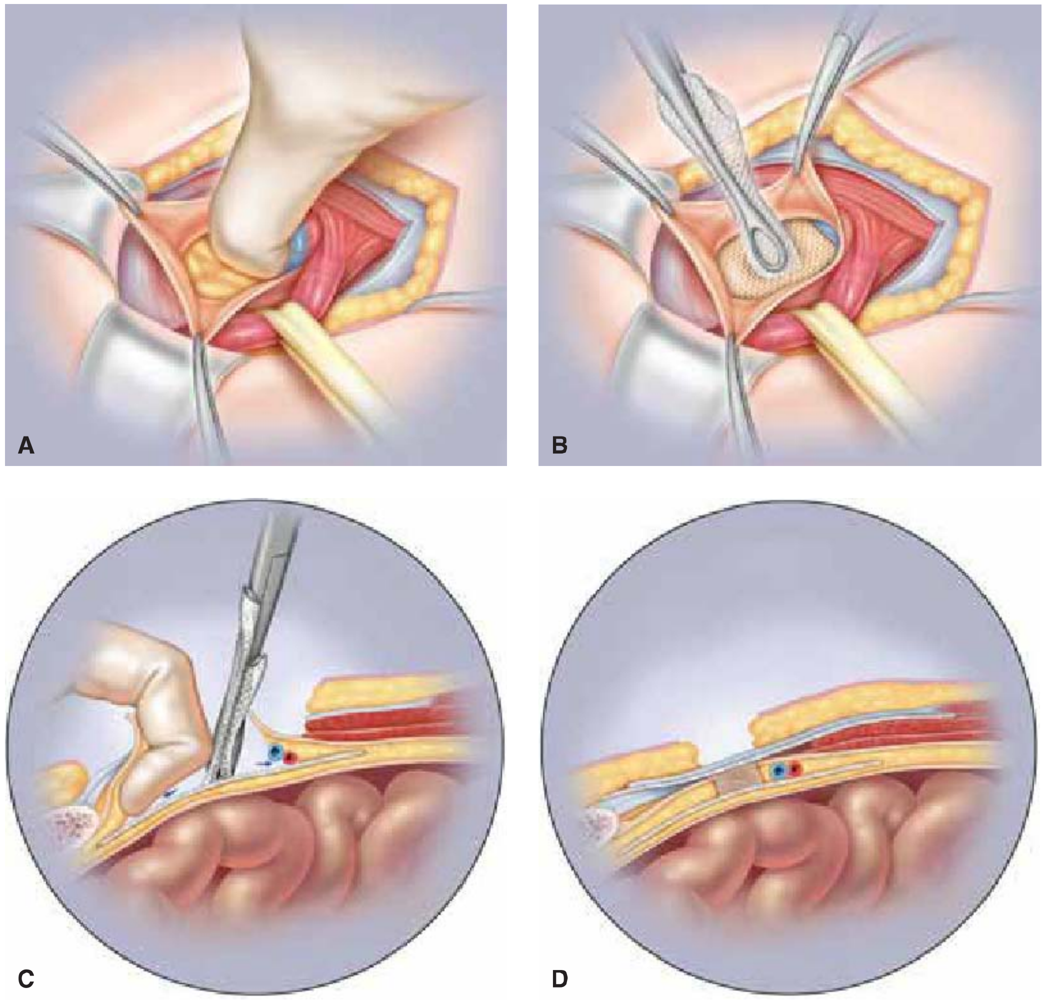


**Figure 4.8** Direct hernia repair dissection and mesh placement (**A–D**).

- The major advantage of this approach is to directly visualize the retroperitoneal structures including the vas deferens and iliac vessels through the internal ring, confirming the separation of the peritoneal sac from the internal ring and lateral triangle, and to position the central connector of the device in the internal ring.
- Through the internal ring, the contents of the direct defect are evacuated, separating the preperitoneal fat from the attenuated TF.
- The remaining steps of the procedure are identical.

### 4. UltraPro Hernia System Repair

- The UltraPro Hernia System® (UHS) (Fig. 4.9) (Ethicon, Inc. Somerville, NJ) is a lightweight polypropylene mesh version of the PHS. Its permanent PPM construction is augmented with absorbable monofilament fiber and film (Monocryl® poliglecaprone 25) in order to provide temporary enhancement of lightweight mesh handling qualities. Following absorption of the Monocryl elements, the remaining mesh affords sufficient strength of repair with the reported advantages of lightweight mesh.
- The handling characteristics of UHS differ from PHS in that the latter behaves and unfolds with fabric-like qualities; whereas the Monocryl film on the underlay component of UHS renders a more plastic quality, which can result in challenges when folding and deploying UHS in the same manner as PHS.
- Suboptimal mesh deployment in the repair of a groin hernia can lead to a higher risk of hernia recurrence if vulnerable areas of the MPO remain unprotected. Our solution to the challenges of these handling characteristics includes an alternant method of mesh preparation and insertion, which takes advantage of the plastic quality of the Monocryl components.

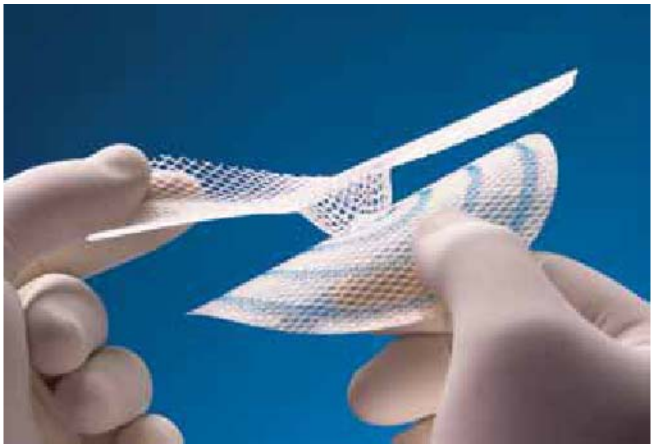

Figure 4.9 UltraPro Hernia System®.

### 5. Modified Preparation and Insertion Technique for UltraPro Hernia System Repair

- The onlay portion of the mesh is folded into the center in thirds (Fig. 4.10 A, B). The medial end then is folded onto the lateral end (Fig. 4.10 C). The underlay portion of the mesh is rolled from its "cephalad" and "caudad" edges toward the central connector into a scroll-like arrangement (Fig. 4.10 C). A suture is employed to temporarily maintain the scroll in this configuration during initial implantation and positioning (Fig. 4.10D).

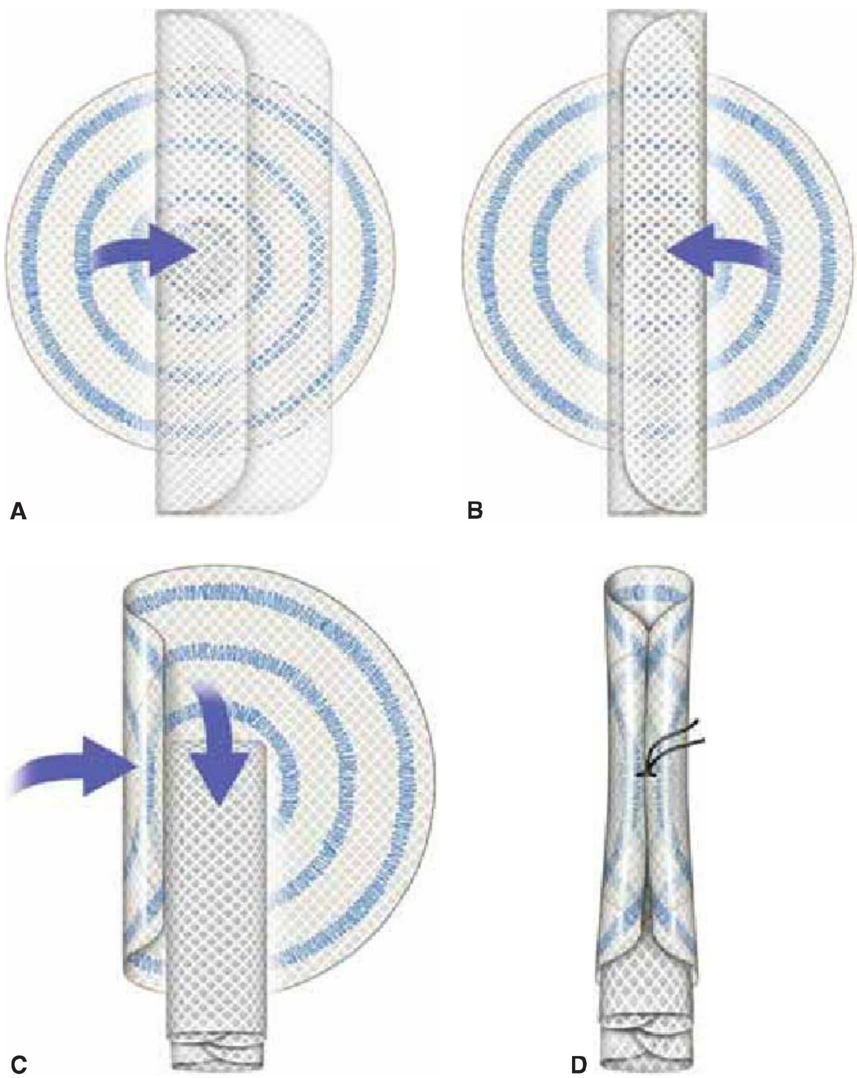


Figure 4.10 UHS Scroll configuration.

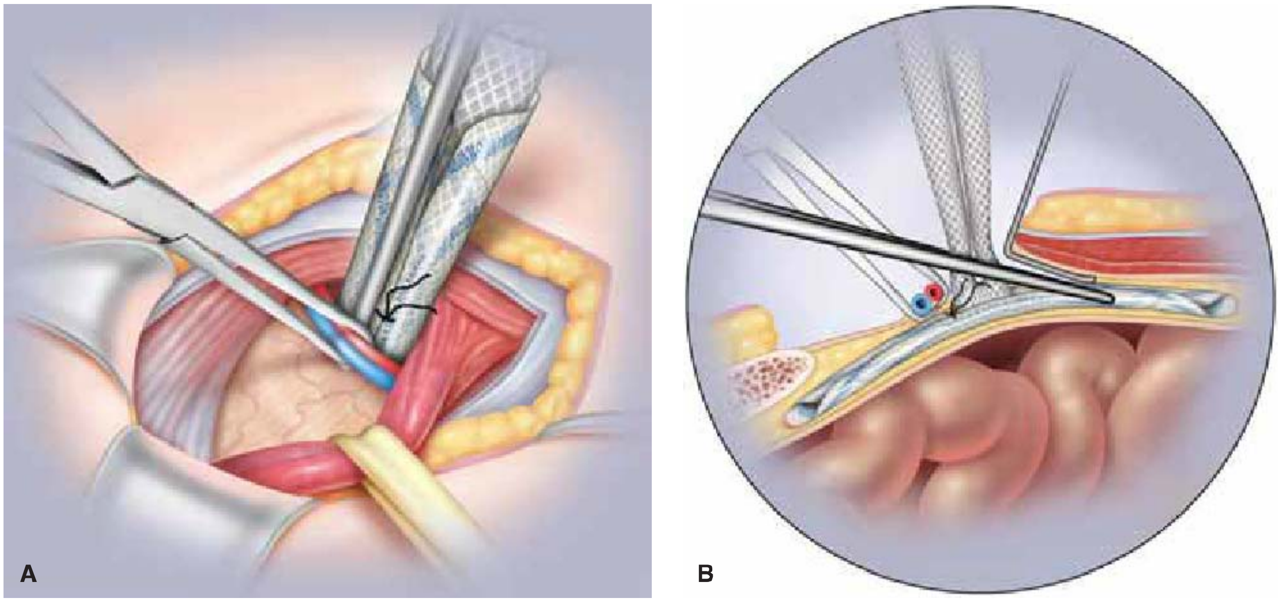


Figure 4.11 A: Insertion of UHS; B: UHS scroll into medial and lateral triangles of MPO.

- The medial end of the scrolled mesh is grasped and directed into the internal ring and advanced toward the pubic tubercle in the PPS (Fig. 4.11 A). The lateral margin of the internal ring is elevated upward with a retractor to allow the lateral end of the scrolled mesh to be inserted and advanced into the lateral triangle (Fig. 4.11 B). The retractor is then removed.
- The temporary suture is cut and removed. The index finger or back end of a Debakey forcep is used to unroll the cephalad scroll into position under the aponeurotic arch and beneath the deep epigastric vessels (Fig. 4.12). The caudad scroll is similarly unrolled against Cooper's ligament and draped over the iliac vessels (Fig. 4.13). The underlay mesh deployment is completed, establishing a mesh roof superficial to the preperitoneal fat medially, and the peritoneum laterally.
- The light weight on lay mesh component does not employ the absorbable monocryl film, and typically requires 3 or 4 interrupted, absorbable sutures to ensure that the

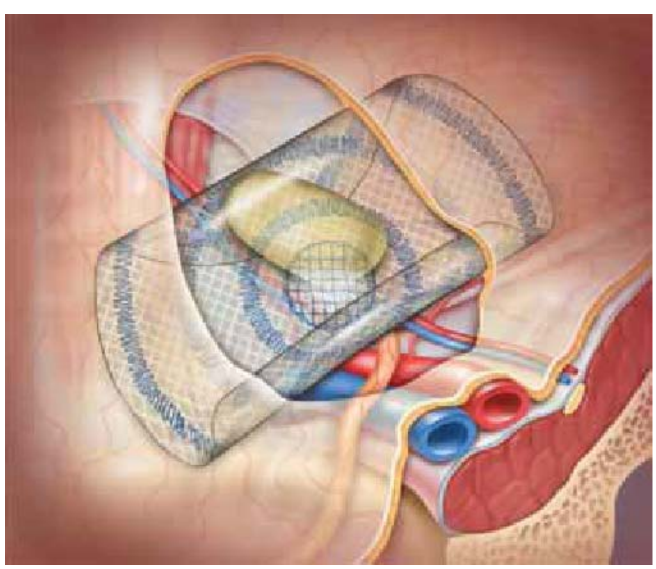

Figure 4.12 Un-scrolling UHS beneath aponeurotic arch.

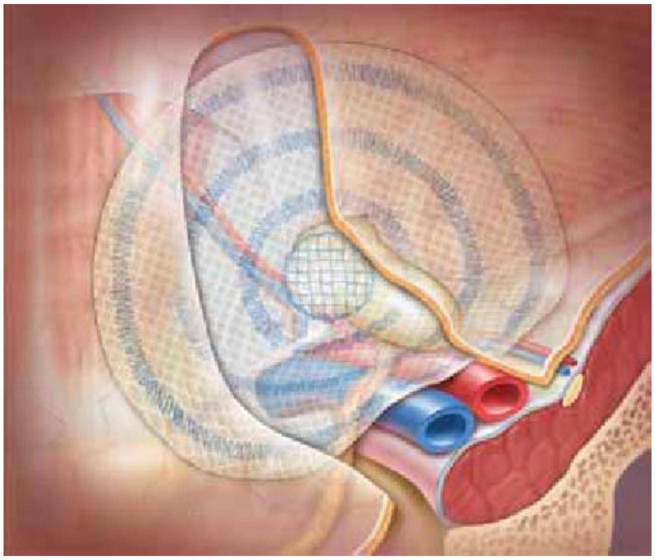

**Figure 4.13** Un-scrolling UHS onto iliac vessels and femoral triangle.

final position of the on lay mesh is maintained through the tissue in-growth period (Fig. 4.14 A, B) (Fig. 4.15).

## POSTOPERATIVE MANAGEMENT

Care of the hernia patient is generally not different where the PHS or the UHS have been employed compared to other repair methods. However, since these methods involve the use of broad preperitoneal mesh stabilized over the defect(s) in the PPS, mobility and activity restrictions are minimal and patients are allowed to return to activity or work-related obligations as soon as their minimal postoperative discomfort has resolved.

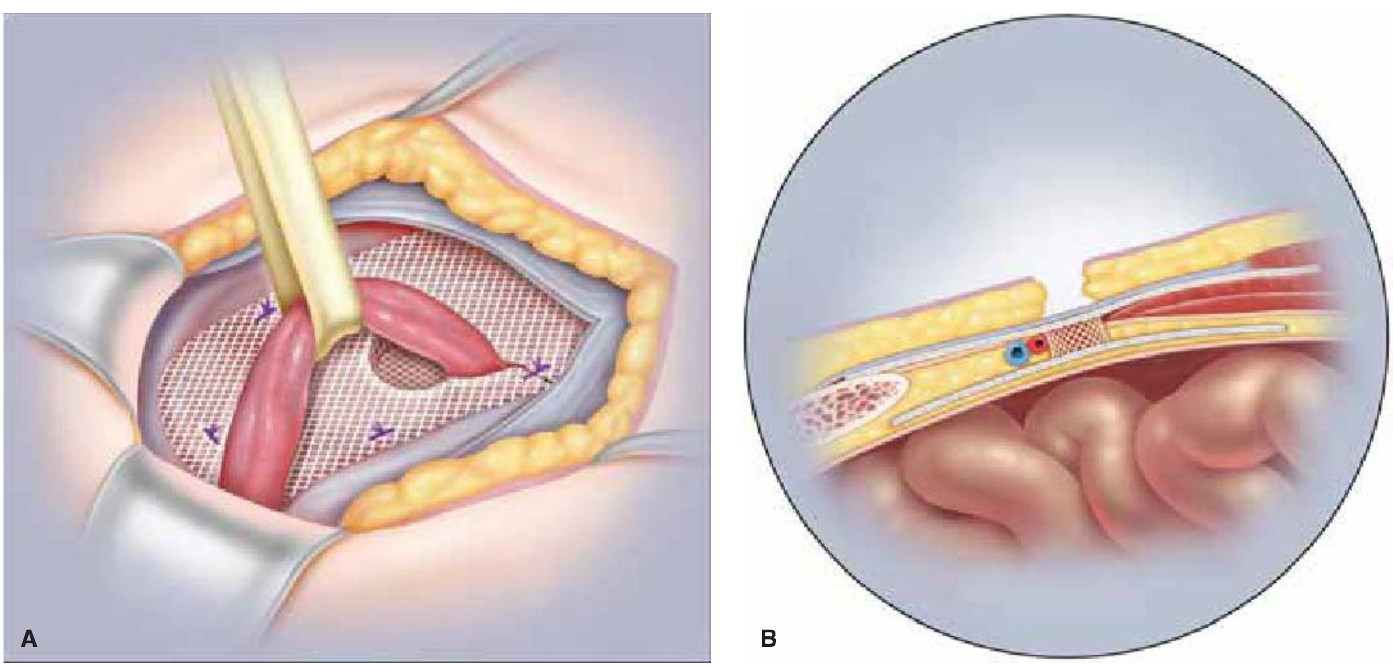


**Figure 4.14** **A**: UHS onlay sutures; **B**: UHS bilayer endpoint position, side view.

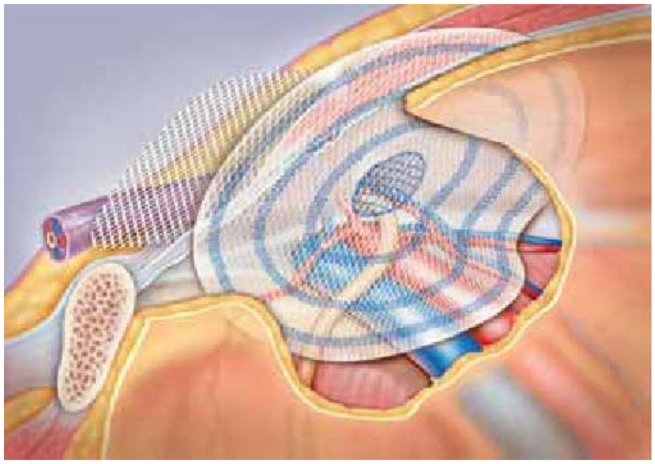

**Figure 4.15** UHS bilayer endpoint position, 3D view.

## COMPLICATIONS

As with any technique for the repair of groin hernias, complications are fortunately uncommon. Particularly significant is the fact that recurrences following the adoption of tension-free techniques employing various forms of mesh have diminished to rates typically below 1% to 2% among non-laparoscopic techniques. Specific data and discussion on recurrence rates will be addressed in the next section on results. In our experience, complications with the use of the PHS or the UHS are also quite rare.

- Wound infection, in reported studies, occurs in less than 1% of cases, and is most often minor, superficial, and effectively treated with local care and antibiotics. Rare infections involving polypropylene mesh, regardless of density and weight, are usually effectively treated without the requirement of mesh removal.
- Seroma formation is also rare and occurs in patients having large hernias extending into the scrotum leaving significant dead space.
- Hematoma has been seen also in the postoperative period following repair of scrotal hernias, and are treated most often with conservative observation, typically requiring weeks to resolve. Retroperitoneal hematoma can occur if operative injury to the deep epigastric vessels or their branches are unrecognized, or from injury to the iliac, obturator, or testicular vessels. Careful dissection in the PPS makes this exceedingly rare.
- Nerve injury is rare in primary repairs, but can be more common in the repair of recurrent hernias, particularly where previous mesh contributes to scar-related obscurity of the nerves or entrapment. Management of the nerves during dissection of the groin has been debated for years, with those who advocate routine severance of the nerves on the one hand, to those who prefer preservation and minimal nerve manipulation. Our approach is the latter where possible.
- Chronic pain is also rare in the use of the PHS and the UHS partly due to the use of absorbable suture in limited number. Patients with chronic postoperative groin pain are managed conservatively, referring to pain management in persistent cases, and rarely require surgical neurectomy.
- Hypersensitivity or allergic reaction to polypropylene mesh has been reported in case studies and are quite rare, usually in applications for uro-gynecologic procedures.

## RESULTS

Outcomes have been widely published comparing PHS with other methods of inguinal herniorraphy. The rate of recurrence following inguinal hernia repair has long been considered the defining quality of any repair method or technique. Gilbert's initial report of 759 cases in 1999 revealed no recurrences. In a follow-up report by Gilbert in 2004, three recurrences were known among 4,801 repairs, for a rate of 0.18%. In this same report, results submitted by trained preceptors for the PHS repair, and other general surgeons trained in the use of PHS revealed recurrence rates of 0.15% and 0.16%, respectively. Subsequent reviews of outcomes among general surgeons trained in the PHS technique duplicated the results of hernia specialists.

Comparing PHS to the Lichtenstein technique, Kingsnorth reported less postoperative pain, earlier return to normal activities, shorter duration of operation, and fewer recurrences in the PHS group.

## CONCLUSIONS

- PHS and UHS provide a reliable repair of groin hernias.
- Surgical technique of preperitoneal and onlay mesh deployment via the anterior approach is safe, results in rare complications, and is applicable to the overwhelming majority of groin hernias.
- Results among general surgeons utilizing the PHS are equivalent to those of hernia specialists.

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# 5 The Bassini Operation

**Oreste Terranova and Luigi De Santis**

## Introduction

Edoardo Bassini was an eminent teacher and surgeon at the University of Padua, School of Medicine and Surgery, where he was head of surgical pathology from 1882 to 1888 when he was appointed Chair of Clinical Surgery, a post he held until 1919.

Following extensive study of the anatomy of the inguinal region, he devised a revolutionary method for the surgical treatment of inguinal hernia: The Bassini operation (Fig. 5.1).

Resting on firm anatomic and pathophysiologic foundations, his technique improved on previous empirical methods. And with time, it was proved correct in theory and effective in practice. Much has been said spoken and written on such matters as perhaps on any other. Nonetheless, there is a need to keep abreast of new developments as surgical techniques continue to evolve. In 1986, on the centennial of the publication of Bassini's article reporting a new approach to inguinal hernia repair, and in homage to Bassini's work, the Paduan School of Surgery celebrated the occasion with a scientific meeting that gathered such renowned international experts in surgery as Stoppa R, Bendavid R, Nyhus LM, Chevrel JP, and Wantz GE, in which a further contribution to the path pioneered by Bassini was added. At this meeting, the state of the art was defined and the figure of this illustrious physician commemorated.

### Biography of Edoardo Bassini

Edoardo Bassini was born into a family of wealthy landowners and patriots in Pavia in 1844. He studied medicine at the University of Pavia, graduating in 1866 at the age of only 22 years.

It is unknown whether he had originally intended to become a surgeon. What is certain is that from an early age he was fascinated by the movement for Italian unification. A friend of the Cairoli brothers, prominent figures in the Italian *Risorgimento*, he joined the unification movement as an infantry soldier during the third war of independence.

In June 1867, together with the Cairoli brothers, he fought in the battle of Villa Glori near Terni. Numerous historical accounts describe the bayonet assault of 78 men against a troop of 1,000 soldiers. During the battle, Bassini was wounded by a Zouave who took him by surprise and planted a bayonet in his abdomen.

After the battle, Bassini was brought by the few remaining survivors in a cart to the Holy Spirit Hospital, where he was nursed for several months because of a fecal fistula and stercoraceous peritonitis resulting from the bayonet wound to the iliac right fossa

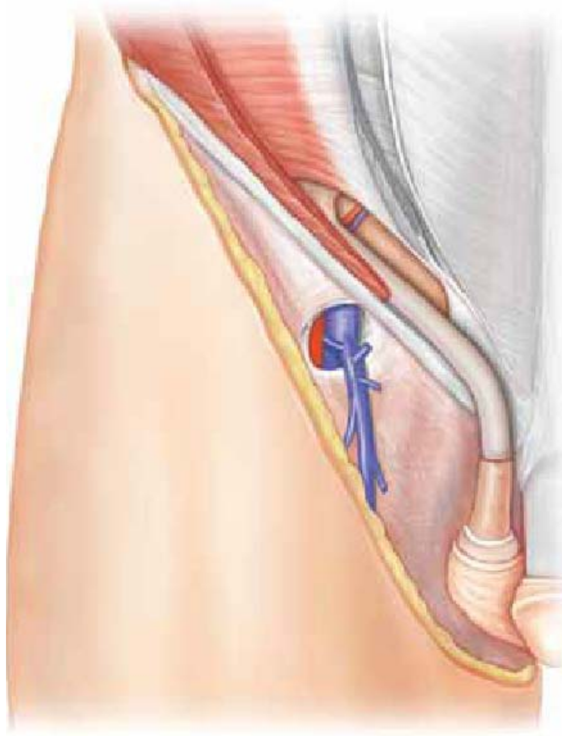


**Figure 5.1** The Inguinal Canal.

that had pierced the abdominal wall and the intestine. The wounded did not receive particular care because the hospital surgeons believed them inoperable.

Thanks to his extraordinary physical resistance, he recovered from the peritonitis but remained stercoraceous probably because of the fecal fistula. He was transferred to Pavia where was placed in the care of Luigi Porta, a great clinical surgeon of that time. During his long stay in the clinic, he gained the friendship and esteem of Porta, who urged Bassini to become a surgeon.

Porta's encouragement was decisive; he recognized Bassini's talent for the surgical art and the ingeniousness and the intuition he was beginning to demonstrate in surgical practice.

It was already then, perhaps, that the young student Bassini had begun to think about how best to reconstruct the inguinal canal and restore the anatomy. These experiences, his background, and character would prepare him for a brilliant surgical career.

Descending from a long lineage of farmers, he grew up in an agrarian community, living among men who worked the fields. His family led a comfortable life without luxury. Since his youth he admired the hard work of common laborers, who were poorly paid for the hardships they endured. His love of the land and farming people remained in his heart, though he would later have little contact with rural life.

Accustomed to hard work and sacrifice, he acquired a rigid character, yet earned the respect and admiration of his collaborators. An operating room nurse once said of him, without a grudge but with much pride, that he was a very good person, while he was showing him the shin scars the teacher had given him.

He was surely a generous man; while still alive, gave his farms to his laborers and willed everything he had to the Milan Institute for the Poor which bears his name today. In a few words, he did shun the city's fashionable salons. Yet he was known as a protagonist and a great admirer of the surgical art. He showed determination when he declined a professorship at the University Parma because the competition was irregular, preferring to remain in La Spezia, where his mentor Porta had found him a temporary post so that he could gain experience.

After attaining a professorship in Padua, he devoted himself to the study of inguinal and crural hernia, reviewing descriptive anatomy and applied anatomy and conducting cadaver studies in which he tested his operating techniques.

On Christmas Eve of 1884, he carried out an operation for inguinal hernia for the first time using the method he had devised and which he would repeat in 1885 and 1886. In 1887, he published his "*Nuovo metodo operative per la cura dell'ernia inguinale*" in which he reported 262 cases: 251 of which were inguinal hernias including free and persistent hernias, and 11 strangulated hernias, with low mortality, plus 5 recurrences, a surprising result considering that in those days the recurrence rate with any method was over 30%. On the 50th of the operation, his students Fasiani and Catterina wrote: "*Half a century has passed and the Bassini method remains a conquest that has survived all criticisms, all attempts at change and daily verification countless times the world over.*"

In addition to the original Bassini operation for inguinal hernia, Bassini should also be remembered for having developed other fundamental surgical techniques, including nephropexy, subtotal hysterectomy, ileocolostomy, the cravat incision of the neck for thyroid operations (usually called Kocher's incision), suprapubic cystostomy, hip disarticulation, intrascapular–thoracic amputation, and a technique for crural hernia.

In 1904, he was appointed senator for life to the Italian parliament. On seeing that his career as teacher and surgeon had ended it course, he said good-bye to his first assistant Mario Donati, who was waiting at the clinic door, and retired to his house in Vigasio. Bassini left to posterity the rational dexterity of his hands and the principle of restoring a diseased organ to its original anatomy and function.

Widely regarded as a meticulous and careful operator, he was considered a great man, teacher, and surgeon in the noblest sense.

## SURGERY

### The Bassini Operation for Inguinal Hernia

The Bassini operation for the treatment of inguinal hernia entails the reconstruction (Fig. 5.2) of the abdominal wall with a suture that includes three layers (Fig. 5.3) comprising the transversalis fascia, the transversus and the internal oblique muscles superiorly, and the inguinal ligament inferiorly. The method can be easily performed under local anesthesia.

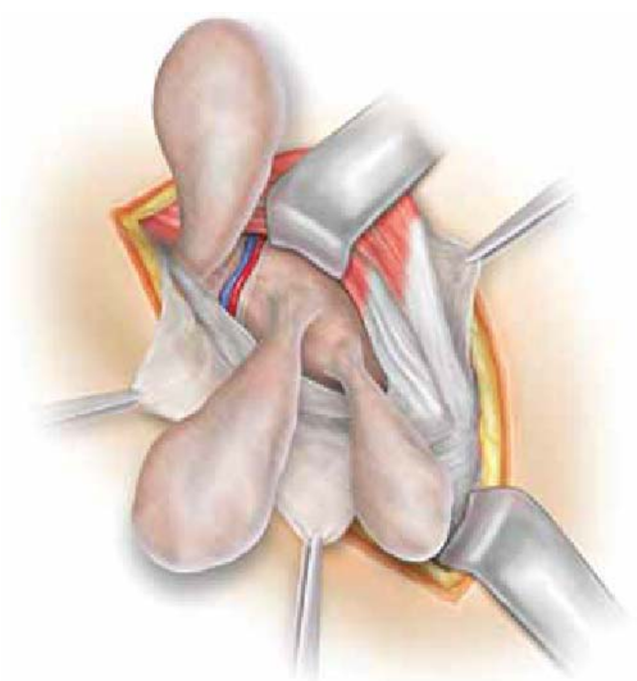


**Figure 5.2** Inguinal Hernia.

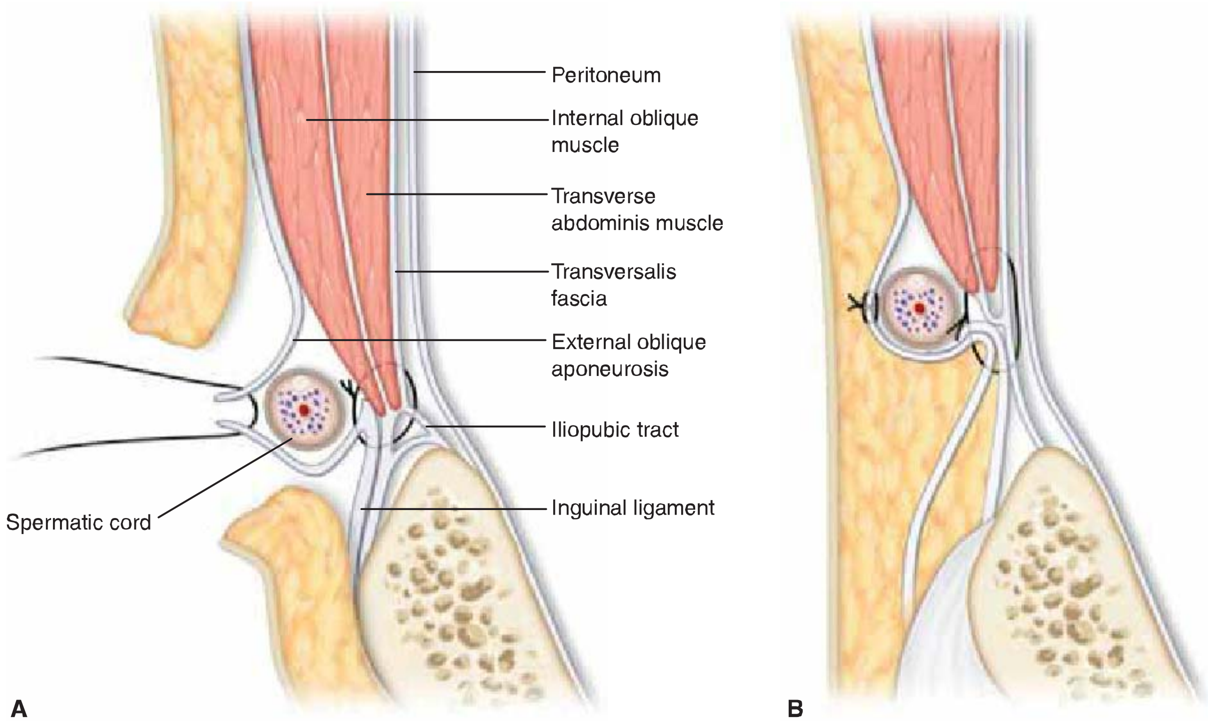



**Figure 5.3** Reconstruction of the posterior wall of the inguinal canal with interrupted sutures placed in the triple layer (comprising the transversalis fascia, the transverse abdominis, and the internal oblique muscles) superiorly and the iliopubic and inguinal ligament inferiorly. The spermatic cord lies under the external oblique aponeurosis.

## Technique

1. **Incision of the Skin and the Subcutaneous Planes**

The cutaneous incision starts at the pubic tubercle, placed laterally to the pubic symphysis, and runs for 8 to 12 cm to the anterior superior iliac spine (Fig. 5.4).

Identified in the subcutaneous adipose tissue, the superficial epigastric vessels are tied and dissected.

The superficial abdominal fascia (Scarpa's fascia) is then divided.

Release of the external oblique aponeurosis muscle from the innominate fascia (which connects into the spermatic fascia composed of loose cellular tissue), exposes the superficial inguinal ring.

2. **Incision of the External Oblique Aponeurosis**

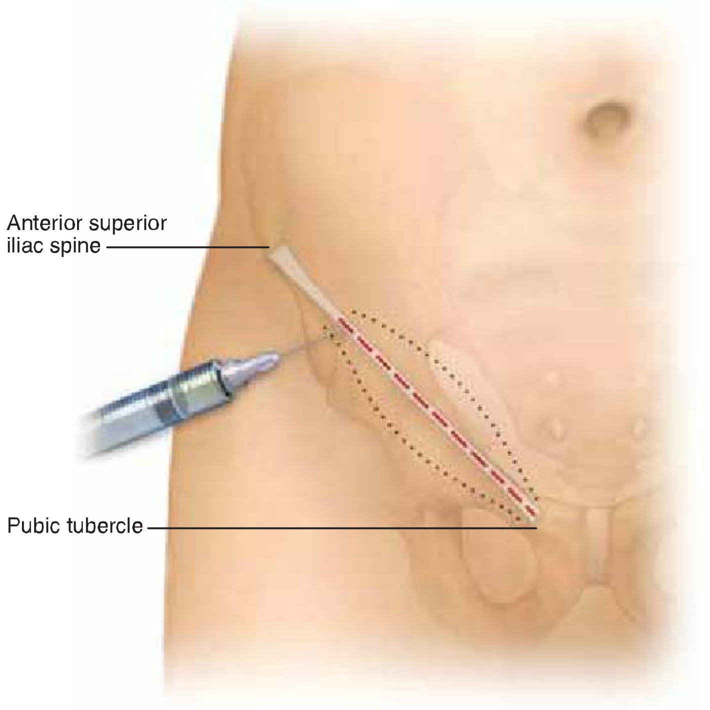
The external oblique aponeurosis muscle runs along the course of its fibers; an incision of the aponeurosis is placed on the upper rim of the superficial inguinal ring to expose the inguinal canal (Fig. 5.5).

The upper leaf of the external oblique aponeurosis is released with scissors from the internal oblique muscle, while the lower leaf is separated from the spermatic cord or round ligament in the male and the female, respectively.

This exposes the genital branches of the iliohypogastric and the ilioinguinal nerve (Fig. 5.6).

The iliohypogastric nerve lies on the internal oblique muscle, parallel and superior to the spermatic cord; a superior terminal branch leaves the inguinal canal through a small orifice medially and superior to the superficial inguinal ring.

The ilioinguinal nerve runs anterior to the inferior spermatic cord. Both nerves must be identified for selective block with local anesthetic and to prevent inadvertent injury or entrapment while placing the suture.



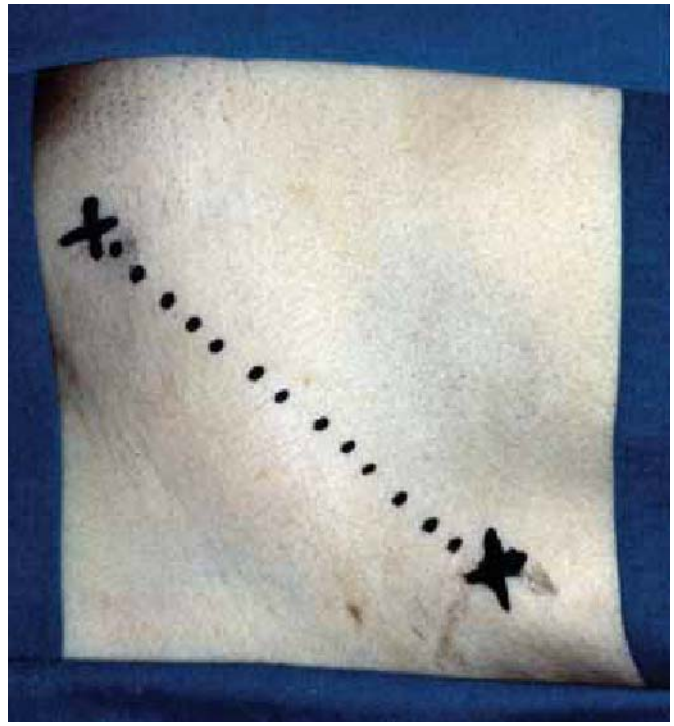



**Figure 5.4** Infiltration of the skin with a local anesthetic solution (8 to 10 mL) along the incision line parallel to the inguinal ligament for 8 to 10 cm, starting from the anterior superior iliac spine to the pubic tubercle.

**3. Isolation of the Spermatic Cord**

The spermatic cord is isolated from the posterior wall of the inguinal canal. Isolation starts near the pubic tubercle, which is easier by first sliding a finger down over the groove formed by the inguinal ligament, and then high, above the edge of the internal oblique muscle (Fig. 5.7A, B).

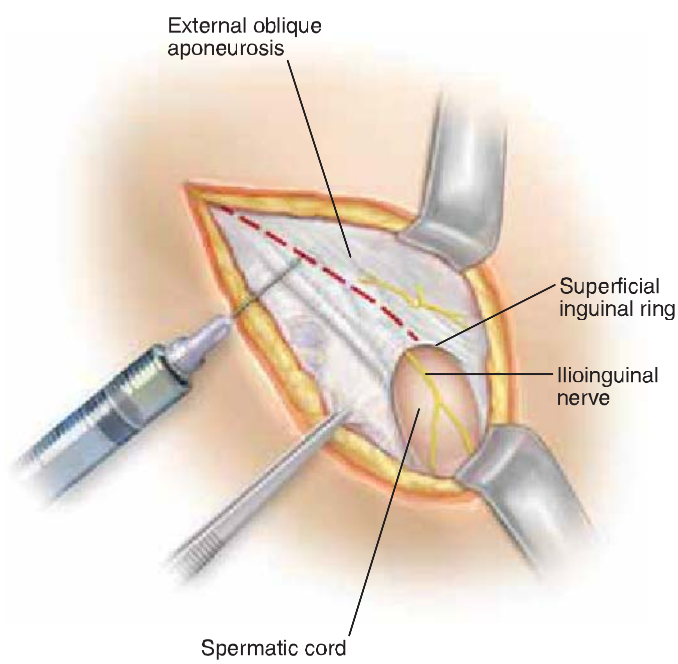



**Figure 5.5** Infiltration of the external oblique aponeurosis after dissection of subcutaneous tissue. The aponeurosis is then incised in the direction of its fibers to the superficial inguinal ring, thus providing wide exposure of the inguinal canal.

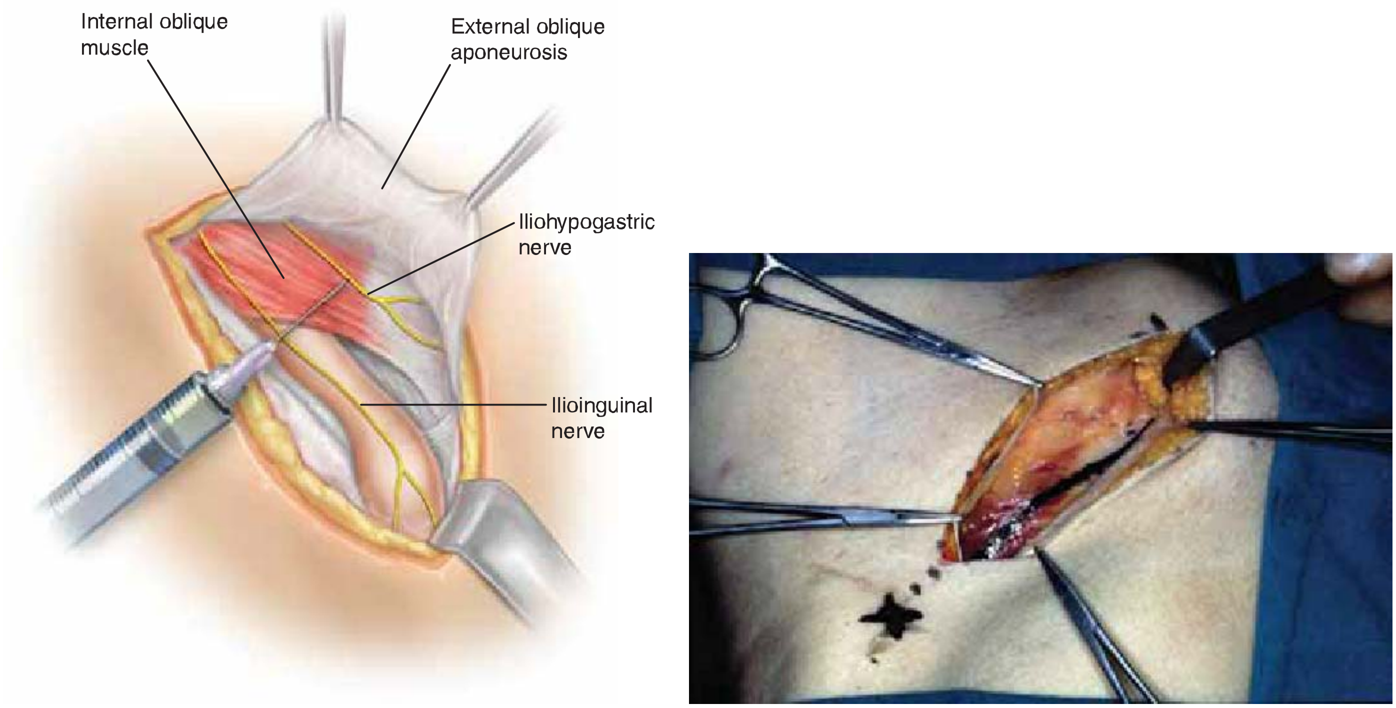



**Figure 5.6** Selective blocking of the ilioinguinal and iliohypogastric nerves.

Completely freed, the spermatic cord is encircled with a Penrose drain and pulled forward so that it can be detached from the posterior wall of the inguinal canal, consisting of the transversalis fascia. The spermatic cord is thus completely freed from the deep inguinal ring until the pubic tubercle. The internal oblique muscle is visible superiorly, the transversalis fascia deeply, and the inguinal ligament inferiorly.

4. **Resection of the Cremaster Muscle**
The cremaster muscle is elevated with two forceps and resected longitudinally to divide it into two flaps: An upper and a lower flap (Fig. 5.8A, B).

The thinner upper flap is coagulated and sectioned. The lower flap, which contains the cremasteric vessels, is grasped with two small Klemmer forceps, ligated and sectioned.

The genital branch of the genitofemoral nerve entering the inguinal canal at the deep inguinal ring is identified and then placed on the posterior aspect of the spermatic cord (Fig. 5.9).

5. **Treatment of an External Oblique Sac**
An indirect inguinal hernia, if present, will be isolated and separated from the surrounding structures (seminal vessel and spermatic vessels) as high as possible.

Once open, the sac and any adhesions are resected and the content in the abdominal cavity reduced; the sac is then ligated with suture material to slow absorption at the neck; its distal part is resected.

If the sac has been sufficiently freed from surrounding adhesions, the stump re-enters and disappears easily into the preperitoneal space (Fig. 5.10A, B).

A pre-hernial lipoma must be isolated from the spermatic cord, ligated and sectioned at the deep inguinal ring.

A different approach is required for treating sliding hernias, which are large hernias often of long duration. The hernia contains the hernia sac formed by the peritoneum, in addition to intraperitoneal and partly extraperitoneal organs that, accompanying the hernia sac, slips down. The bladder and the cecum can be found on the right and the pelvic colon on the left.

Preoperative diagnosis may be difficult, as a sliding hernia is usually incidentally discovered during surgery.

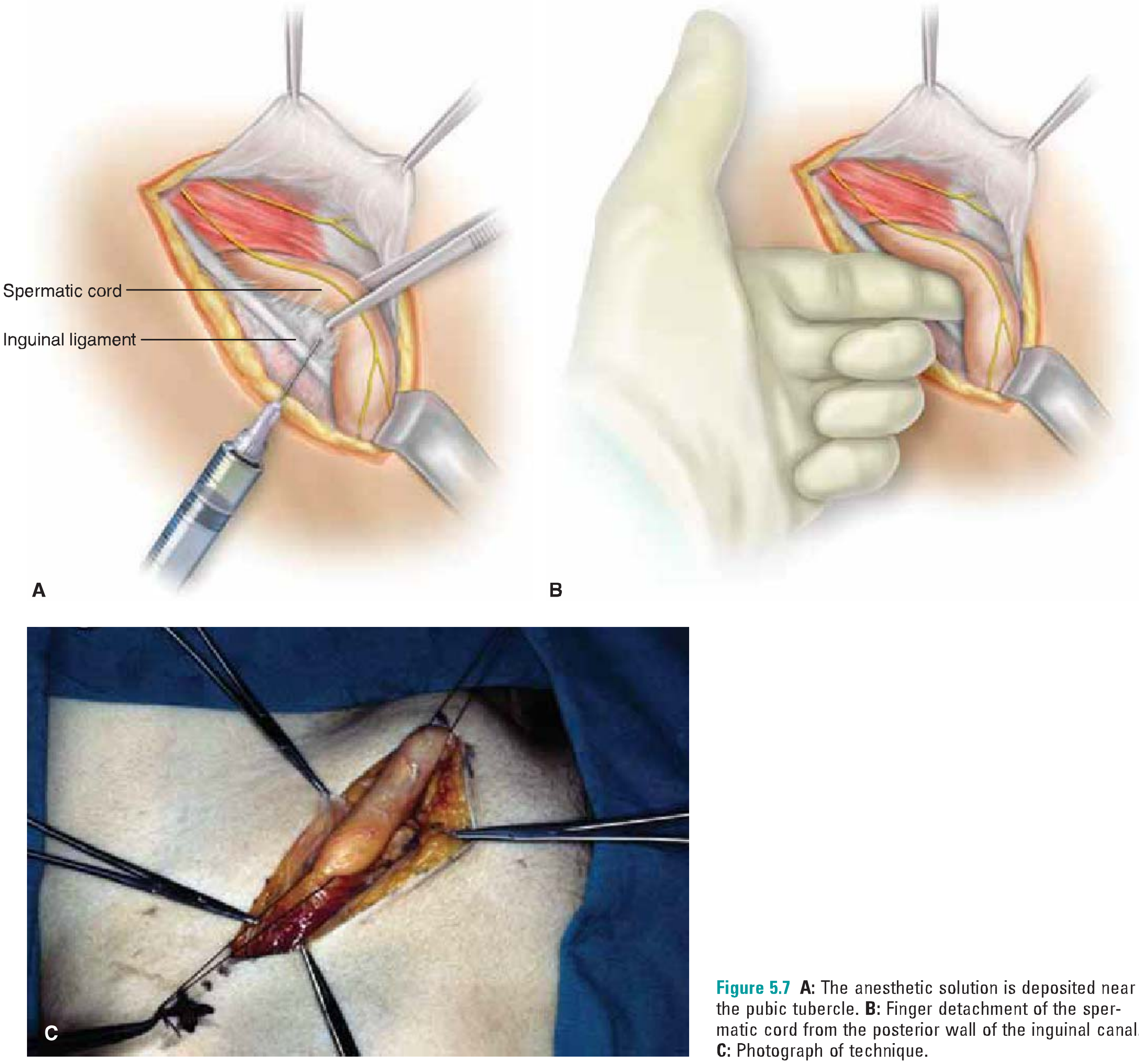



**Figure 5.7** **A:** The anesthetic solution is deposited near the pubic tubercle. **B:** Finger detachment of the spermatic cord from the posterior wall of the inguinal canal. **C:** Photograph of technique.

Unwary isolation and opening of the hernia sac can increase the risk of inadvertent injury to the intestine or bladder.

The best treatment is resection of the excess peritoneum of the sac, without removing the visceral adhesions.

The serosa is closed with a continuous suture and the adherent herniated bowel is freed from adhesions to the parietal structures and reduced into the abdominal cavity.

The cord, put on two laces, is moved down, two Klemmer forceps grasp the extremity medial and lateral to the inferior edge of the external oblique fascia above the spermatic cord.

6. **Opening of the Transversalis Fascia**

The transversalis fascia is incised parallel to the inguinal ligament (Fig. 5.11A, B).

The fascia is lifted by two forceps and opened beginning at the medial aspect of the deep inguinal ring, while holding the tip of the scissors towards the pubic crest;

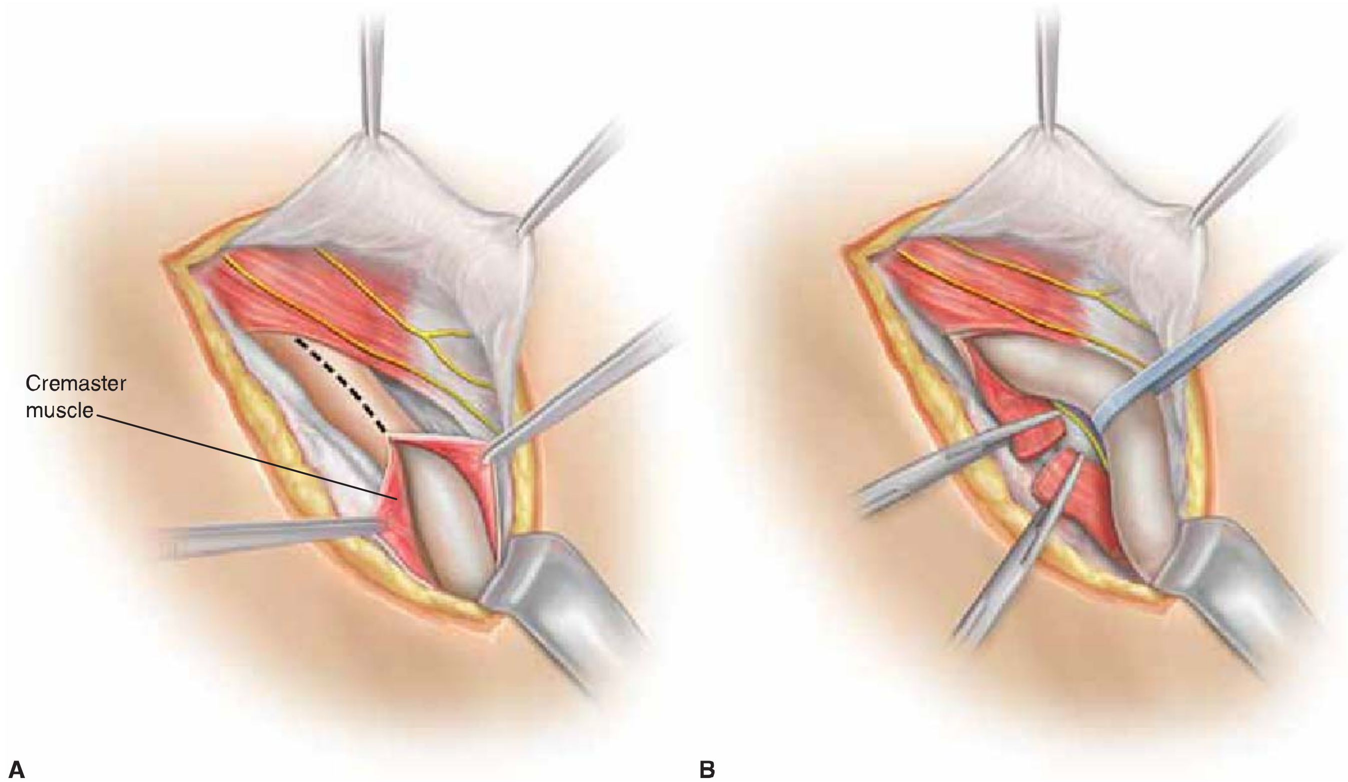
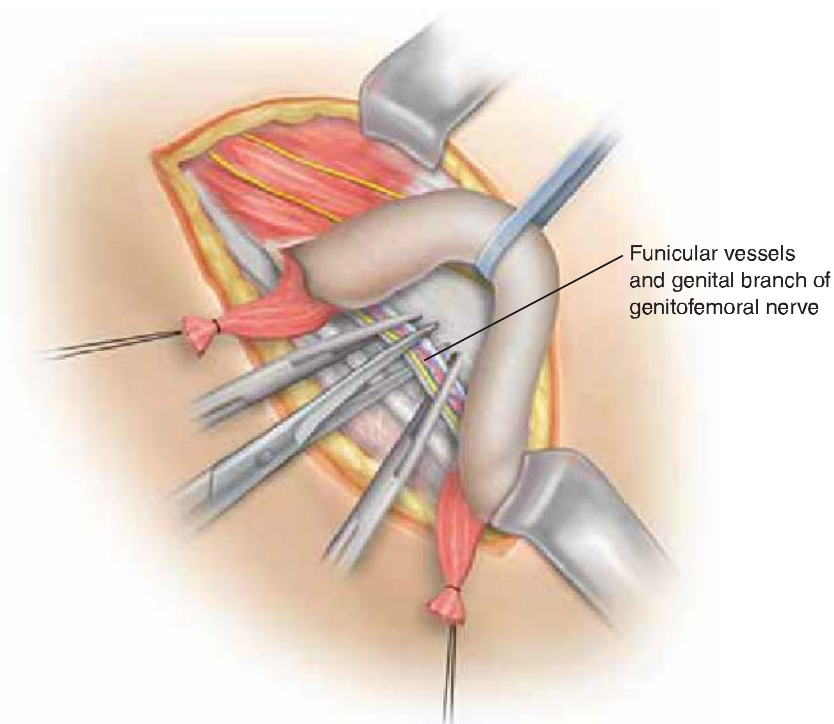



**Figure 5.8** **A:** Opening the cremaster muscle. **B:** Ligature and dissection of the inferior flap of the cremaster muscle.

**Figure 5.9** Ligature and dissection of the cord vessels and the genital branch of the genitofemoral nerve.



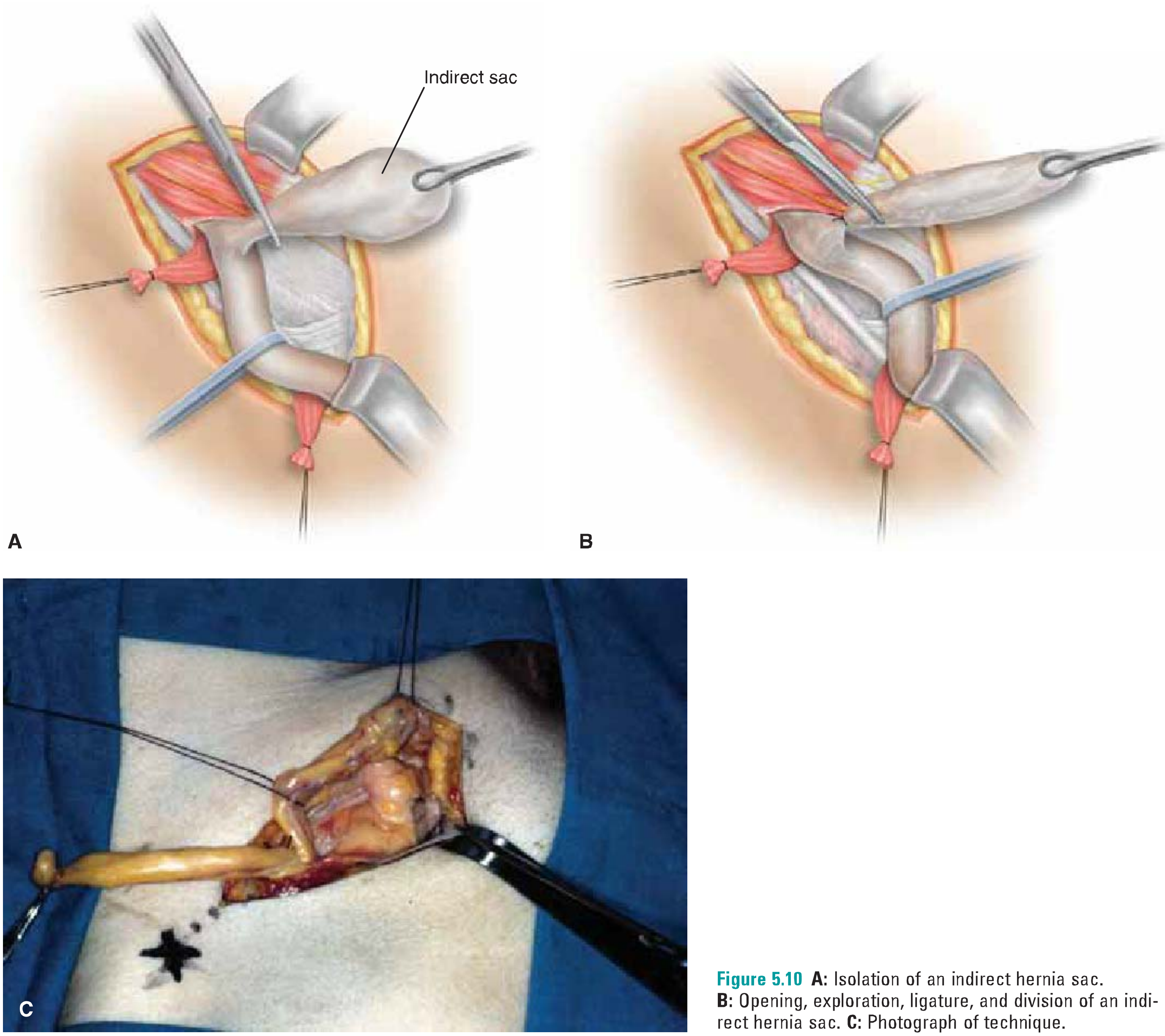



**Figure 5.10** **A:** Isolation of an indirect hernia sac. **B:** Opening, exploration, ligature, and division of an indirect hernia sac. **C:** Photograph of technique.

particular care must be taken to avoid injuring the epigastric vessels just below the transversalis fascia.

The transversalis fascia is incised to the pubic tubercle.

The preperitoneal fat is pushed away from the transversalis fascia to move the peritoneum and the bladder, displaying the rectus abdominis and the aponeurosis of the transversus muscle superiorly and Cooper's ligament inferiorly.

In cases of direct inguinal hernia, the sac can be dissected after opening the fascia transversalis.

Typically, direct hernias consist primarily of preperitoneal fat and sometimes the vesical horn. In such cases, it is unnecessary to treat the peritoneal sac; instead, it is sufficient to remove the fat from the posterior aspect of the fascia transversalis and push it down deeply (Fig. 5.12).

The redundant and weakened part of the transversalis fascia is resected at the lower edge of the transverse and internal oblique muscles.

The lower edge of the transversalis fascia almost always shows a marginal vein internally that should be tied or cauterized to avoid troublesome bleeding.

Blunt finger dissection is performed to search for associated femoral hernia.

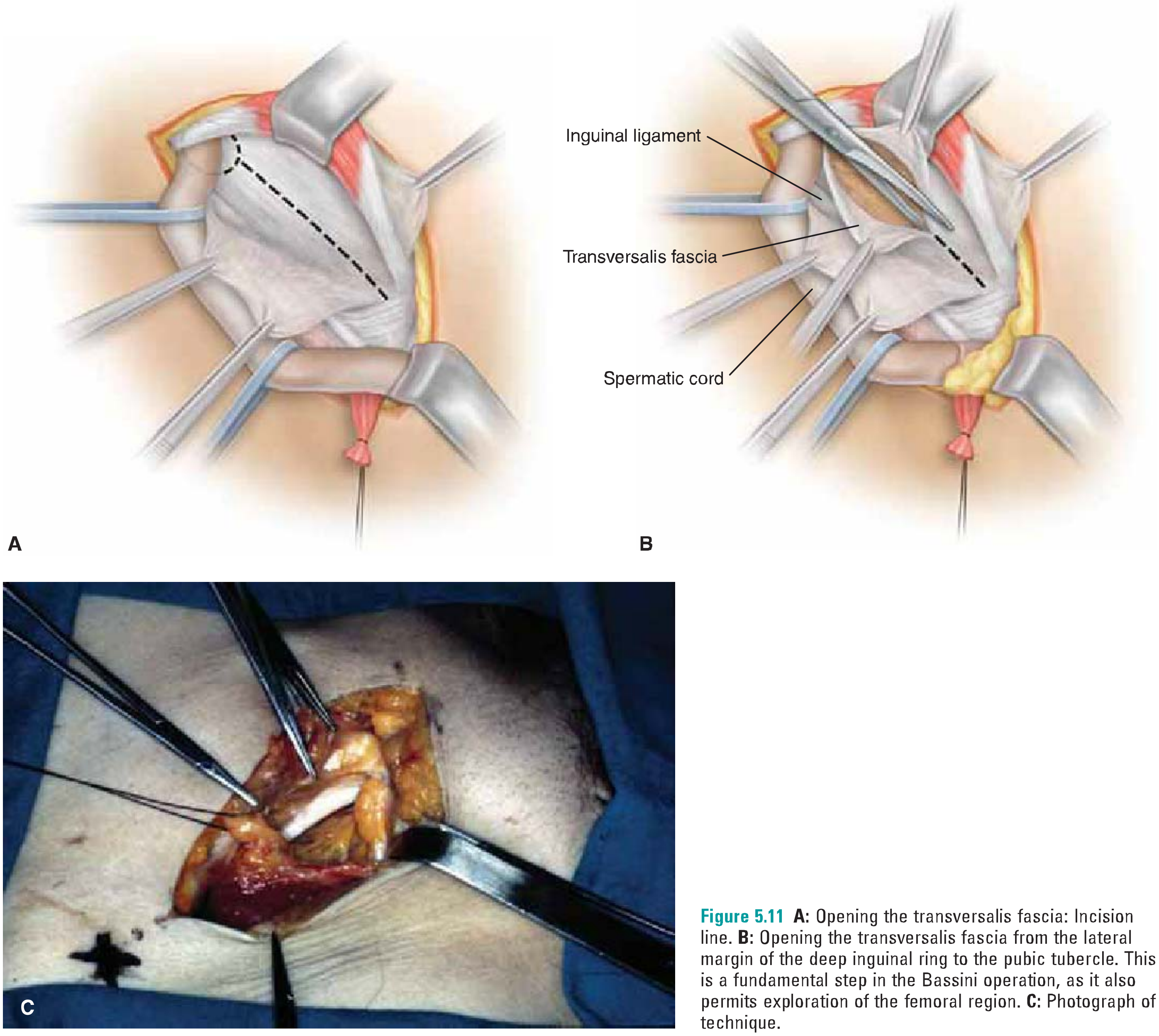



**Figure 5.11** **A:** Opening the transversalis fascia: Incision line. **B:** Opening the transversalis fascia from the lateral margin of the deep inguinal ring to the pubic tubercle. This is a fundamental step in the Bassini operation, as it also permits exploration of the femoral region. **C:** Photograph of technique.

7. **Deep Parietal Suture**

Hernia repair starts with the first suture placed medially and superiorly which encompasses the sheath of the rectus abdominis muscle; the handle of the forceps is inserted under the transversalis fascia to move away the preperitoneal fat protecting the peritoneum and the bladder.

A Farabeuf retractor holds the triple layer and the underlying structures superiorly, making it easy to place the first suture below the tubercle, the pubic periosteum and the inguinal ligament. Subsequent sutures include the triple layer superiorly, about 3 cm from its lower edge, and staggered 1 cm apart from each other to avoid involvement of the iliohypogastric nerve (Fig. 5.13).

Below, the second or third stitch includes the transversalis fascia, the inguinal ligament and Cooper's ligament; this prevents the development of crural hernia. Subsequent stitches are passed only through the transversalis fascia and the inguinal ligament.

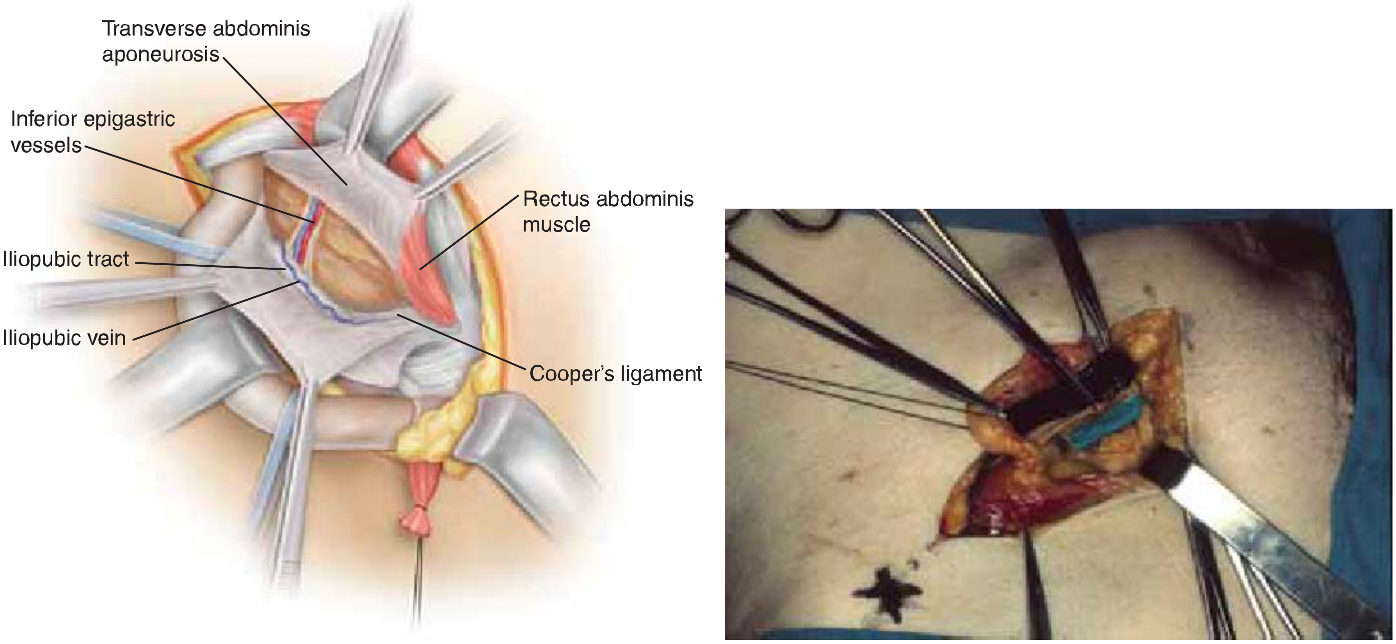



**Figure 5.12** The inguinal region after clearing of the preperitoneal fat of Bogros's space.

The sutures are tied without excessive traction; the triple layer is simply apposed with the inguinal ligament; sutures tied too tightly can cause ischemia and cut the affected tissues (Fig. 5.14).

With the last stitch the deep inguinal ring is rebuilt, which must not be tied too tight, otherwise it will compress the cord vessels.

The tip of the finger should be able to commit at this level and the axial mobility of the cord contents checked by traction using forceps after having tied the last suture.

**8. Reconstruction of the Superficial Planes**

The cord is replaced into the inguinal canal, and the external oblique fascia is rebuilt.

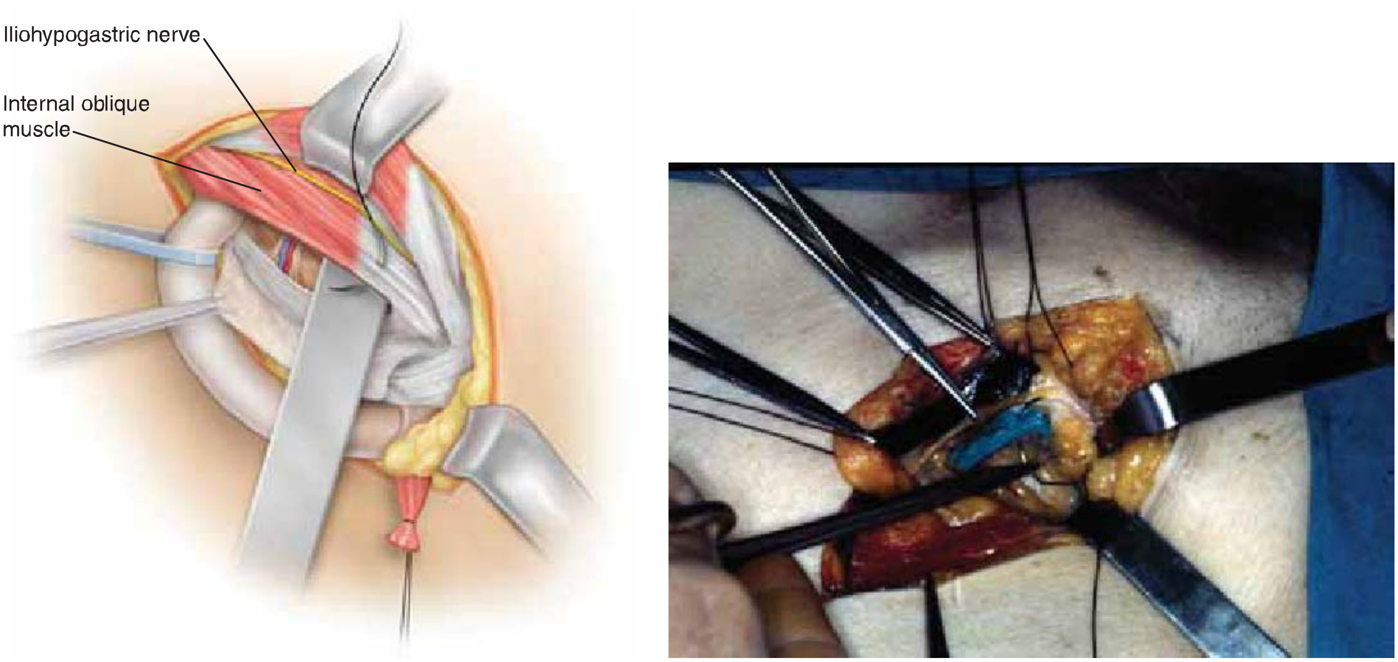



**Figure 5.13** The first suture of the deep plane. It is passed through the triple layer and part of the rectus abdominis muscle superiorly and inferiorly through the pubic periosteum and the inguinal ligament.

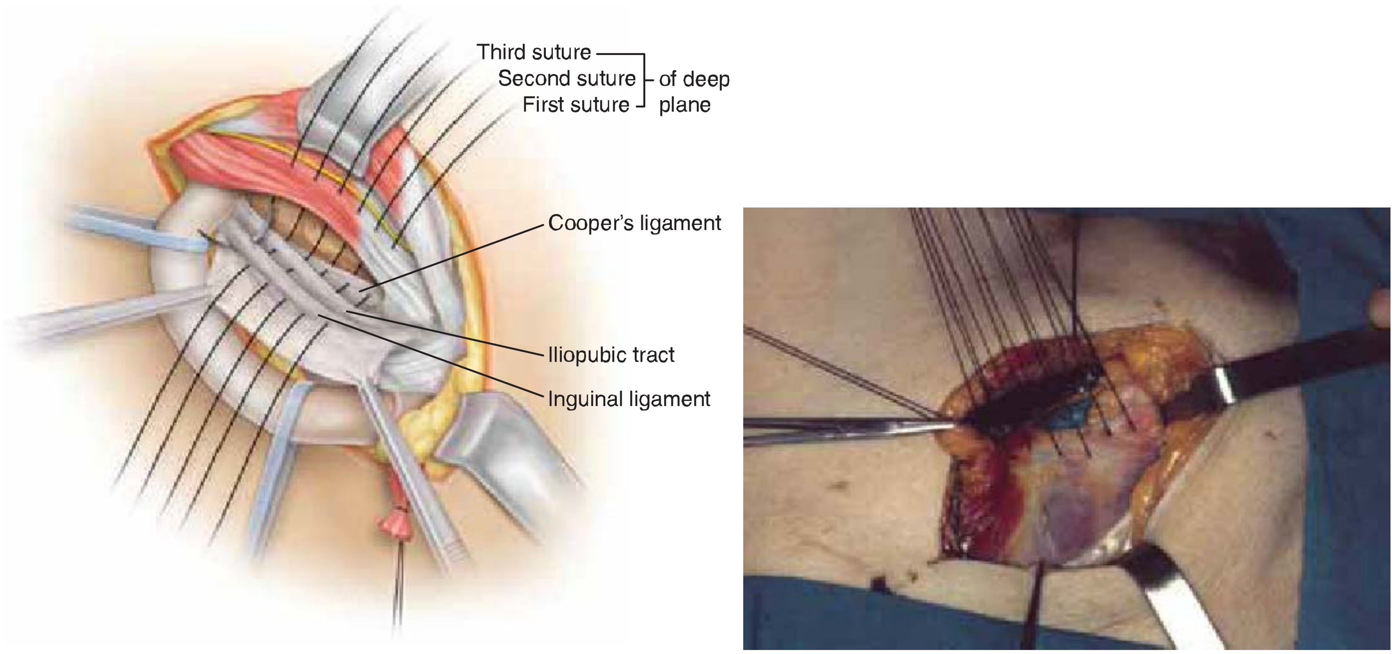



**Figure 5.14** Suture of the deep plane. Inferiorly the sutures pass through the iliopubic tract and the inguinal ligament. The second and third sutures usually include Cooper's ligament to ensure reinforcement of the femoral region.

The superficial fascia and subcutaneous fat are apposed with interrupted stitches so as to leave no dead space (Fig. 5.15A, B).

The wound is closed with a loop suture.

## CONCLUSIONS

The operation described above is the original technique; the estimated risk of recurrence is 8%. Therefore, among the changes later advanced was the more successful Shouldice technique proposed some 50 years ago. The principle is the same as that of the Bassini operation; the Shouldice technique differs in that the triple layer is sewn to the inguinal ligament and the iliopubic tract with multiple continuous sutures instead of loop sutures. In this way, the tension on the repaired tissue is reduced, with less space between the tissues and the elimination of areas of weakness between stitches that may occur with the Bassini technique.

The recurrence rate after a Shouldice intervention is between 0.8% and 1%.

The authors suggested using deep suture loops for parietal reconstruction, as Bassini had originally conceived of in his technique, wherein a suture is placed in the double layer of the transversalis fascia, corresponding precisely to the first and second suture lines of the Shouldice technique. This reconstruction of separate transversalis fascia is performed after passing all the sutures between the inguinal ligament and the triple layer before finally tying it.

In this way, the tension at the suture is reduced, starting at the deepest plane. This allows a stronger scar to form, ultimately producing a more physiologic and stronger reconstruction, with recurrence rates similar to the method devised by Shouldice. Today, tension-free hernia repair techniques have largely replaced these interventions: They are more easily learned, and more quickly performed, with a very satisfactory postoperative course.

For some authors, the drawbacks to the method are a recurrence rate less than 0.2%, the use of prosthetic material, and a rate of postoperative chronic pain of more than 10% in some cases.

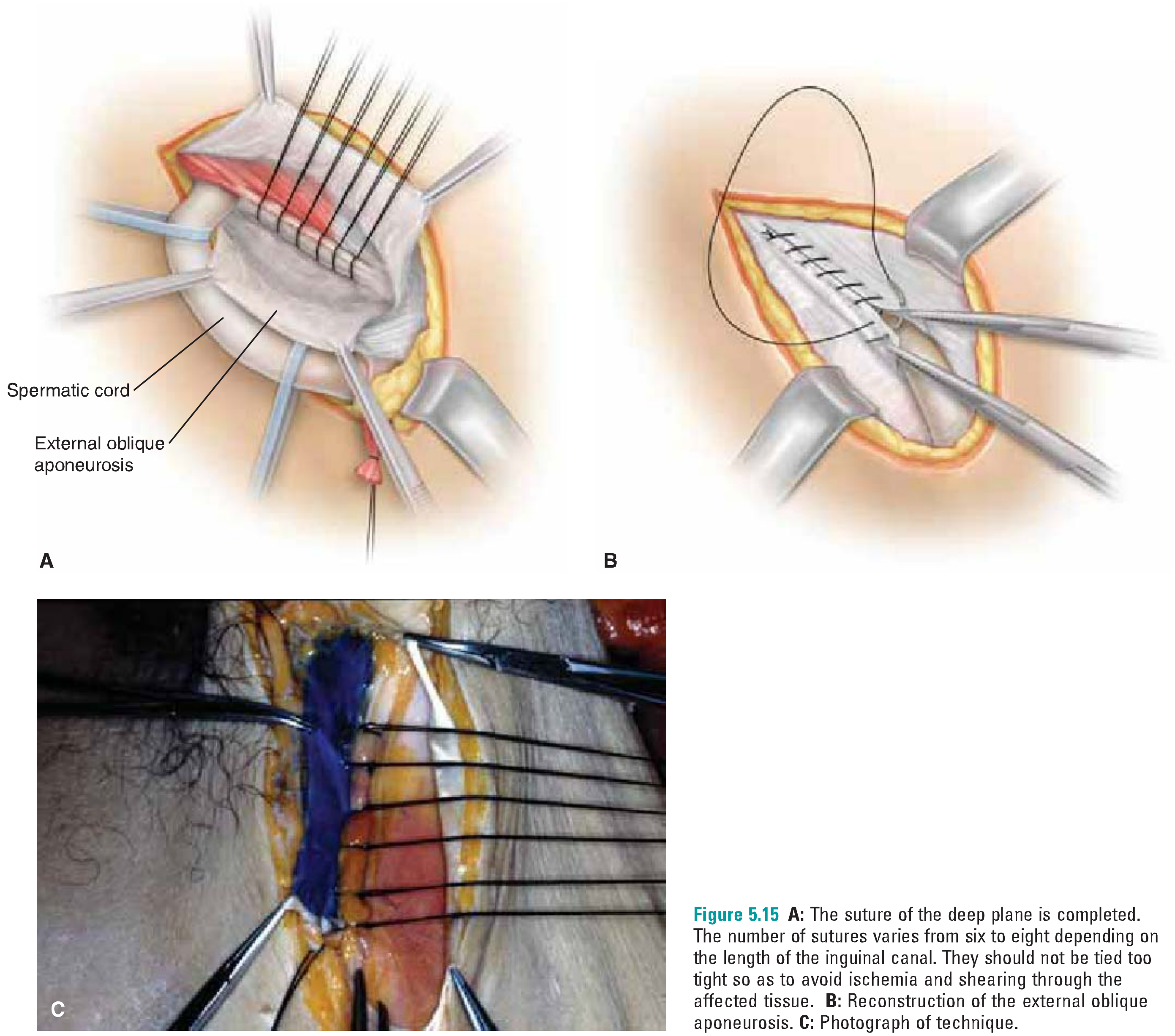



**Figure 5.15** **A:** The suture of the deep plane is completed. The number of sutures varies from six to eight depending on the length of the inguinal canal. They should not be tied too tight so as to avoid ischemia and shearing through the affected tissue. **B:** Reconstruction of the external oblique aponeurosis. **C:** Photograph of technique.

The final word has not yet been written on hernia repair. Today, the choice of technique is orientated to "customized" repair on the basis of place, size, type of defect, patient age, and clinical condition. What remains is the wealth of knowledge, experience, and treatment methods such as the Bassini technique, one of the great achievements in the history of medical science.

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# 6 Cooper Ligament Repair

**Alex Nagle and Kenric Murayama**

## INDICATIONS

The Cooper ligament repair is a primary tissue repair that involves suturing the conjoined tendon (superiorly) to Cooper's ligament (inferiorly) medial to the femoral vein and to the inguinal ligament at the level of and lateral to the femoral vein. It typically requires a relaxing incision and careful dissection near the femoral vessels. It provides closure of the femoral, indirect and direct spaces, and, as such, can be used to repair any hernia defect that may occur in the groin. However, it is almost always reserved for the repair of femoral hernias. Femoral hernias account for 2% to 4% of groin hernias, are more common in women, and are more apt to present with strangulation and require emergency surgery. The postoperative morbidity and mortality increase significantly in patients undergoing emergent repair. This highlights the importance of repairing femoral hernias in an elective setting and suggests that watchful waiting is not a prudent strategy in patients with femoral hernias, even those who are asymptomatic.

The Cooper ligament repair is rarely performed today, as it has been replaced by tension-free prosthetic mesh repairs. The well-known advantages of tension-free hernia repair have led to the development of various mesh techniques for femoral hernia repair. In addition, a laparoscopic approach provides an excellent repair of femoral hernias. However, there remain clinical situations in which a prosthetic mesh should be avoided and a Cooper ligament repair is indicated. The most common clinical scenario involves an emergent operation for a small bowel obstruction secondary to an incarcerated femoral hernia.

- Femoral hernia repair when a prosthetic mesh is contraindicated
- Femoral hernia repair in the presence of infected mesh
- Femoral hernia repair in the presence of gangrenous bowel
- Femoral hernia repair in the presence of a contaminated field

## PREOPERATIVE PLANNING

- Complete medical history is essential. Any existing co-morbidities should be identified and addressed. Cardiac and pulmonary consultations are occasionally indicated. Accurate documentation of any previous abdominal, pelvic, vascular, or groin surgery.

- Complete physical examination with focus on both groins including testicles. It is important to document the status of the testicles preoperatively.
- In a patient with a small bowel obstruction secondary to an incarcerated femoral hernia, proper resuscitation is essential prior to going to surgery.
- The risks and benefits of surgery versus expectant management, as well as potential surgical complications, should be reviewed with the patient. The risk of postoperative neuralgia should be discussed. All male patients are told of the possible occurrence of ischemic orchitis and subsequent testicular atrophy. In the setting of an incarcerated femoral hernia, the risk of bowel resection and possible laparotomy are discussed.
- Peri-operative antibiotics: The role of routine antibiotic prophylaxis for elective inguinal hernia remains controversial. There is a body of literature indicating no statistically significant advantage to the use of antibiotic prophylaxis in the performance of routine inguinal hernia repair with or without the use of a prosthetic mesh. Nevertheless, many surgeons argue that antibiotic prophylaxis is both inexpensive and safe, and that such practice should not be considered inappropriate. In the acute setting of a small bowel obstruction secondary to an incarcerated femoral hernia, peri-operative antibiotic should be given within 30 minutes of the initial skin incision.
- Decompression of the bladder immediately preoperatively. In most elective cases a foley catheter is not necessary.
- DVT prophylaxis with calf-length pneumatic compression devices.
- Anesthesia options for femoral hernia repair include general, spinal, or local with intravenous sedation. Emergent cases of small obstruction secondary to an incarcerated femoral hernia will require general anesthesia.

# SURGERY

## Anatomy

As with any hernia repair a thorough working knowledge and understanding of the anatomy of the inguinal region is mandatory. All groin hernias begin as a weak area within the myopectineal orifice. The myopectineal orifice is divided into the medial, lateral, and femoral triangles (Fig. 6.1). With a decreased strength of the aponeurotic

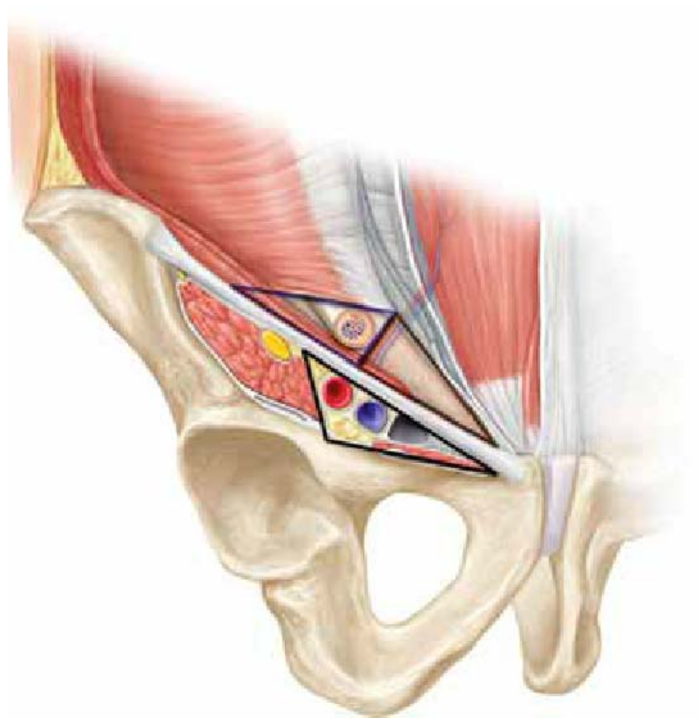

**Figure 6.1** Myopectineal Orifice with medial, lateral, and femoral triangles.

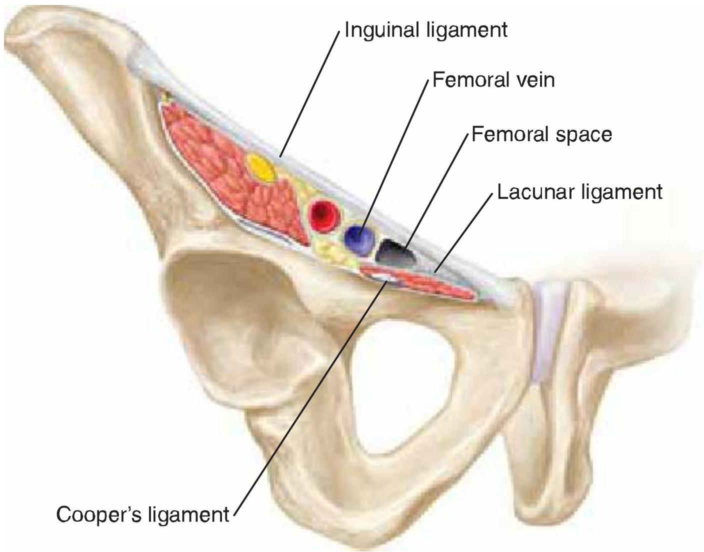


**Figure 6.2** Borders of a femoral hernia. Anterior—inguinal ligament, posterior—Cooper's ligament, medial—lacunar ligament, lateral—femoral vein.



fibers in this area from defective collagen metabolism (e.g., from smoking) and a gradual attenuation from increased intraabdominal pressure (e.g., from prostatism, obesity, constipation, or chronic lung disease), a hernia can result. The transversalis fascia deteriorates and allows a peritoneal protrusion through it. Depending on the length of the insertion of the transversus abdominis on Cooper's ligament, the presence of a patent processus vaginalis, and the width of the femoral ring, the hernia might be direct, indirect, femoral, or any combination of the three.

Borders of a femoral hernia (Fig. 6.2):

- Anterior: Inguinal ligament
- Posterior: Cooper's ligament (pubic ramus)
- Medial: Lacunar ligament
- Lateral: Femoral vein

## Technique

- Skin preparation with clipping rather than shaving is preferred.
- The surgical area is prepped and draped in a sterile fashion.
- An oblique inguinal skin incision is utilized. Using electrocautery the soft tissue is dissected down to the level of the aponeurosis of the external oblique. Appropriate retractors are utilized.
- The aponeurosis of the external oblique is dissected and the external ring is identified.
- The aponeurosis of the external oblique is opened in the direction of its fibers extending through and obliterating the external ring.
- The ilioinguinal nerve is identified and is usually preserved, but it may also be excised according to the surgeons' preference.
- The spermatic cord is mobilized in the canal but is not disturbed medial to the pubic tubercle to preserve testicular collateral circulation. At the level of the pubic tubercle, a penrose drain is placed around the cord structures and can be used to provide retraction allowing inspection of the inguinal floor (Fig. 6.3).
- The spermatic cord is explored for evidence of an indirect hernia. In addition, any cord lipoma or preperitoneal fat should be excised.
- The floor of the inguinal canal (transversalis fascia) is incised and completely opened destroying the internal ring (Fig. 6.4).
- This provides exposure of the preperitoneal space, femoral vein, and femoral canal (Fig. 6.5).
- The femoral hernia sac is reduced, thereby converting a femoral hernia to a direct hernia (Fig. 6.6).

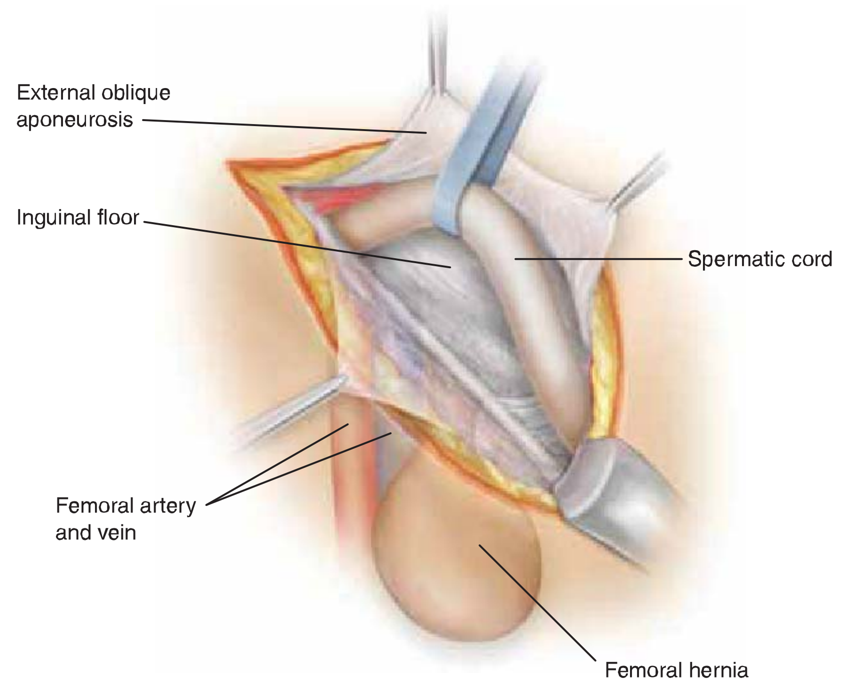


**Figure 6.3** Retraction of the spermatic cord to allow visualization of the inguinal floor (transversalis fascia).

- Occasionally, an incarcerated or strangulated femoral hernia cannot be reduced in spite of traction from above in the preperitoneal space and pressure from below the femoral ring on the anterior thigh. In such cases, the lacunar ligament (medially) can be incised to enlarge the femoral ring. If this is not successful, the inguinal ligament can be transected just above the femoral ring (Fig. 6.7).
- It is mandatory to open the hernia sac and evaluate the bowel for viability (Fig. 6.8). If the bowel is questionable or non-viable, a bowel resection and anastomosis is indicated. This can frequently be performed through the groin incision. However, if the exposure is inadequate a laparotomy will be required. Mesh may safely be

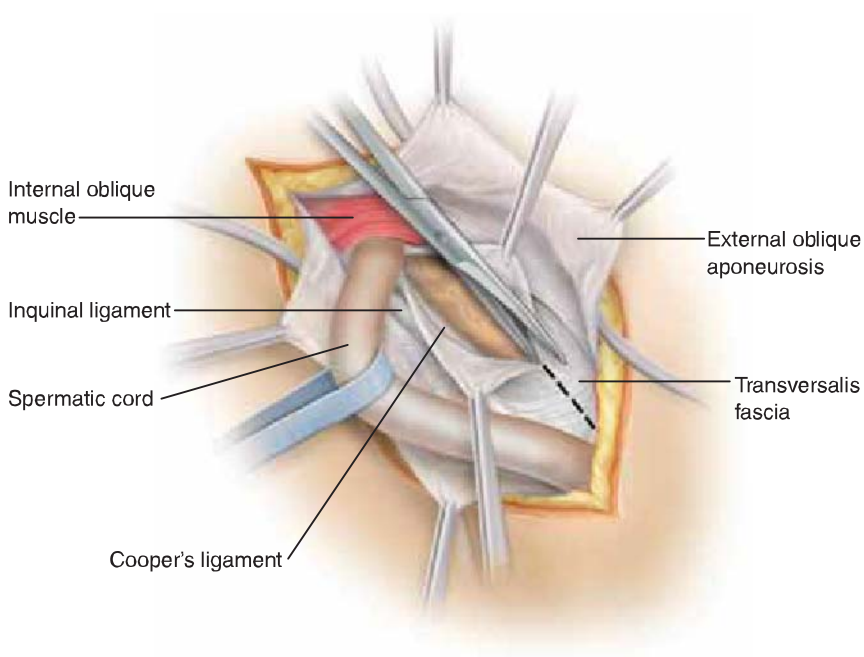


**Figure 6.4** Opening of the inguinal floor (transversalis fascia): Extends from the internal ring to the pubic tubercle.

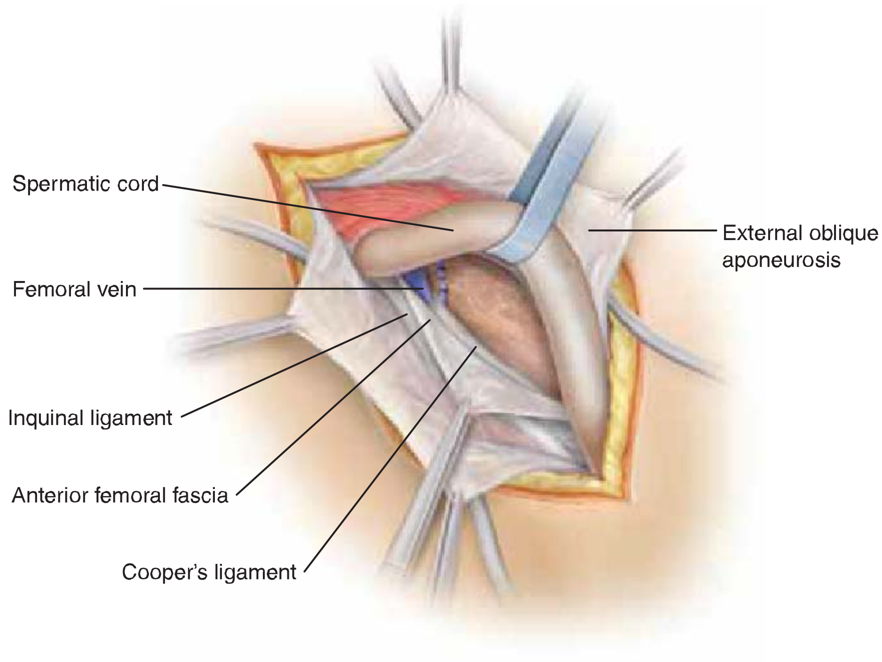


**Figure 6.5** Exposure of the preperitoneal space, Cooper's ligament, femoral vein, and the femoral canal.



used for the repair of incarcerated hernias if the herniated tissue looks normal or is only mildly edematous. Profound edema and/or dusky bowel that gains its normal color during observation mitigate against the use of mesh. Mesh should never be used in the presence of gangrenous tissue. If spontaneous reduction of the hernia occurs, the bowel should be explored by retrieving it through the opened hernia sac. Alternatively, laparoscopy can be utilized to assure that the bowel is viable and that the hernia has not reduced "en mass" with potentially obstructive adhesions. Clear yellow peritoneal fluid is reassuring, but does not necessarily rule out gangrene.

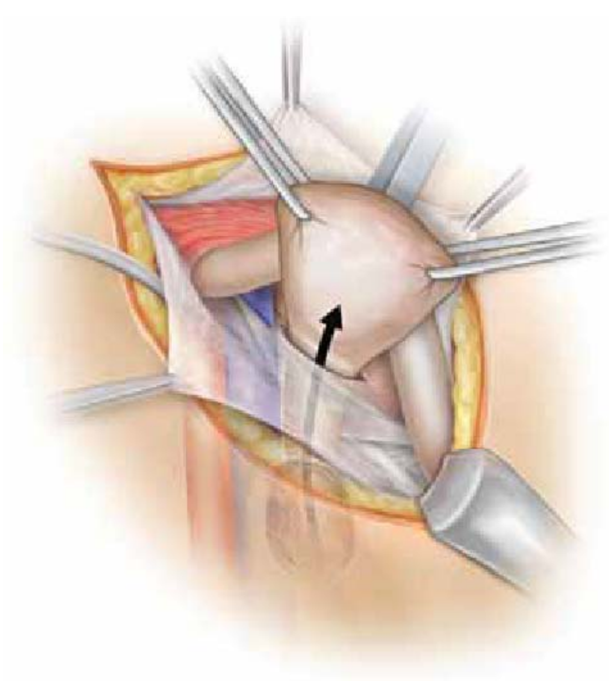

**Figure 6.6** Reduction of femoral hernia. Thereby converting a femoral hernia to a direct hernia.

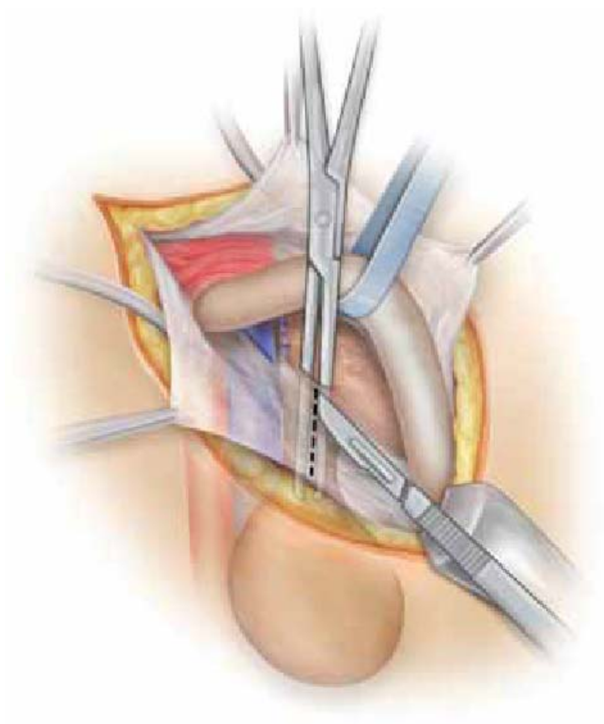

**Figure 6.7** Sharp transection of the inguinal ligament at the level of the femoral canal to facilitate reduction of a femoral hernia.

## Repair of Femoral Canal and Inguinal Floor

- The conjoined tendon is sutured to Cooper's ligament from the pubic tubercle medially to the femoral vein as it crosses Cooper's ligament laterally (Fig. 6.9). This is performed with multiple interrupted permanent sutures on a short thick needle. An Allis clamp is used to grasp the conjoined tendon to be certain that good bites are placed in it, not merely in the overlying internal oblique.
- A transition stitch is placed incorporating the conjoined tendon, Cooper's ligament, the femoral sheath at the medial aspect of the femoral vein, and the inguinal ligament

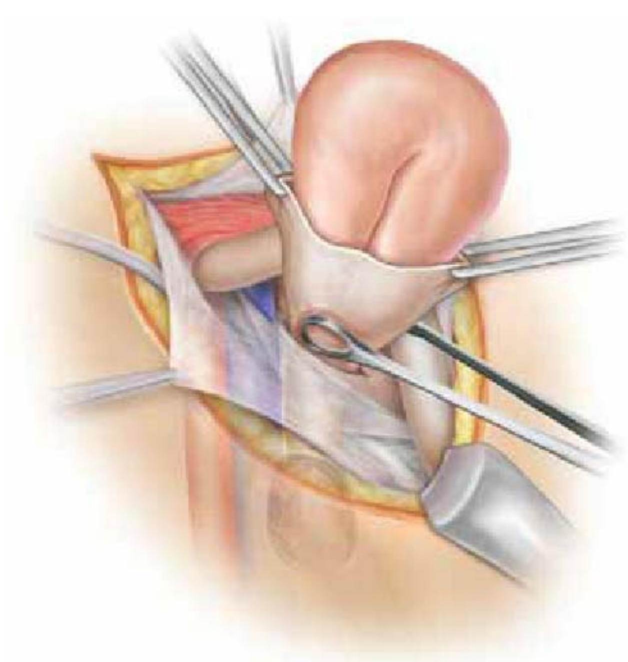

**Figure 6.8** Opening of the femoral hernia sac to allow visualization and evaluation of the bowel for viability.

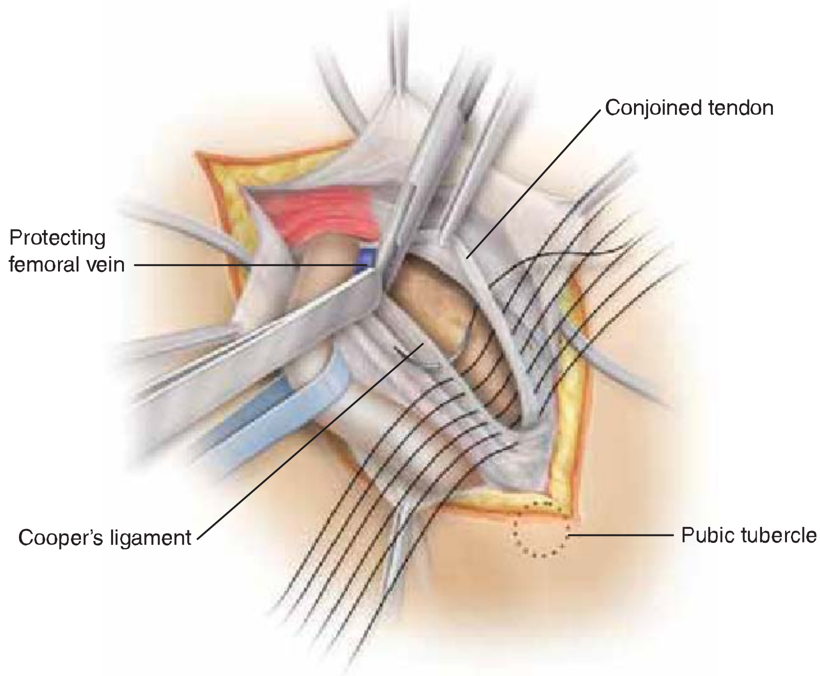


**Figure 6.9** Closure of the femoral canal. Conjoined tendon is sutured to Cooper's ligament from the pubic tubercle (medially) to the femoral vein (laterally).

(occasionally, the femoral sheath cannot be identified and can be excluded) (Fig. 6.10). *If there is bleeding from the suture site in the femoral sheath and gentle pressure does not abate the bleeding, the suture should be removed as it may have injured the femoral vein. Pressure should be held until bleeding stops and rarely is suture repair necessary.*

- The remainder of the inguinal floor is repaired by approximating the conjoined tendon to the inguinal ligament and extending laterally to the level of the internal (deep inguinal) ring (Fig. 6.11).
- The spermatic cord comes out obliquely laterally at the new internal ring. No sutures are placed lateral to the cord. The cord is moved laterally approximately 1.5 cm from its original position.

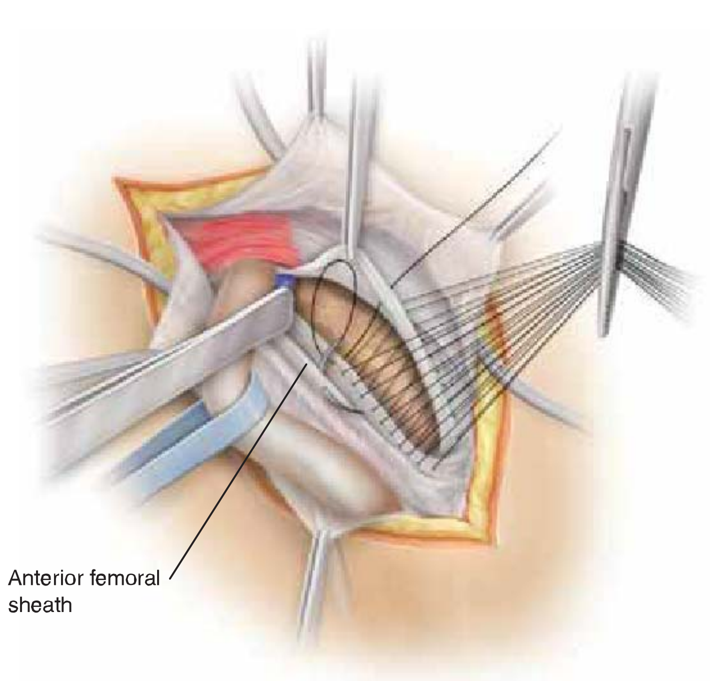


**Figure 6.10** Transition stitch. Conjoined tendon is sutured to Cooper's ligament, the femoral sheath, and the shelving edge of the inguinal ligament.

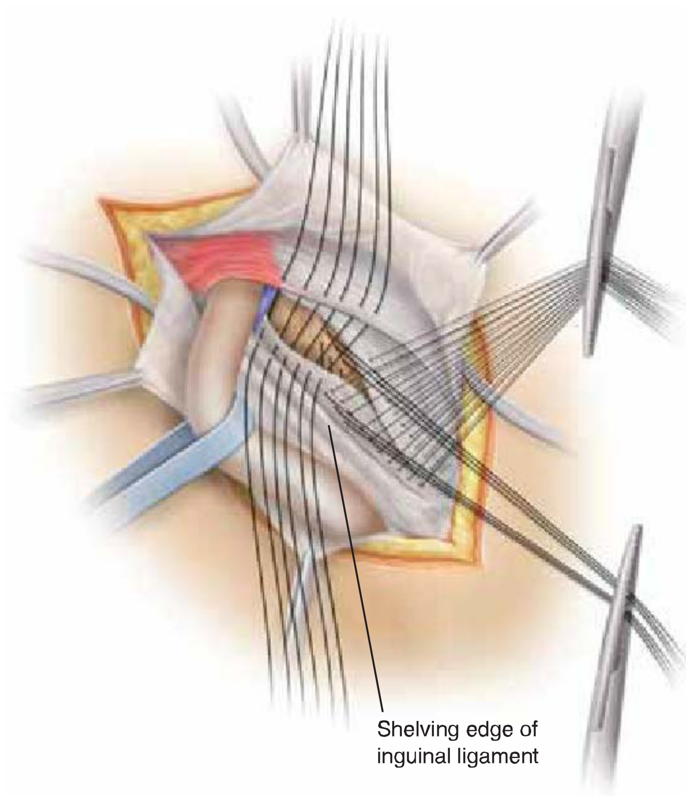


**Figure 6.11** Closure of the remaining floor. The conjoined tendon is sutured to the shelving edge of the inguinal ligament.

- The new internal ring is snug and admits only the tip of a clamp (Fig. 6.12).
- This repair creates considerable tension. To release this tightness, a relaxing incision is required (Fig. 6.13). This involves first exposing the rectus sheath behind the external oblique aponeurosis. Sparing the external oblique component, the rectus sheath is then incised vertically from the tubercle extending cephalad for approximately 6 cm along its lateral edge. *The relaxing incision should be performed BEFORE tying the sutures approximating the conjoined tendon to Cooper's ligament.*

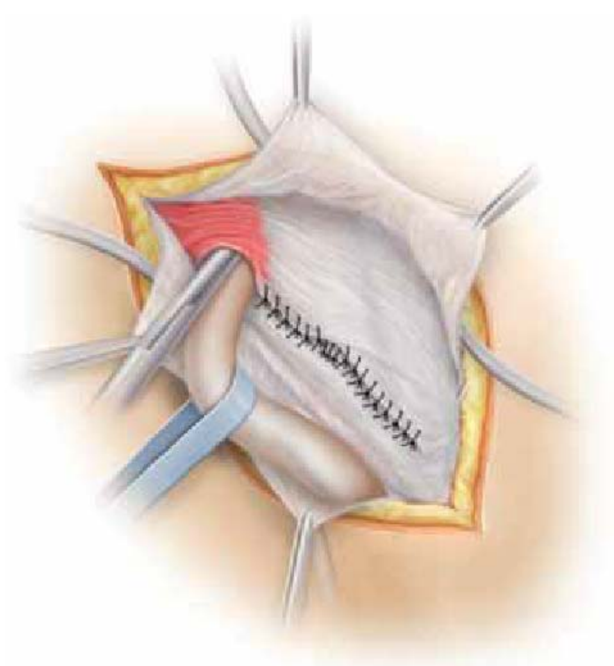

**Figure 6.12** Recreation of the internal ring. The new internal ring is snug and admits only the tip of a clamp.

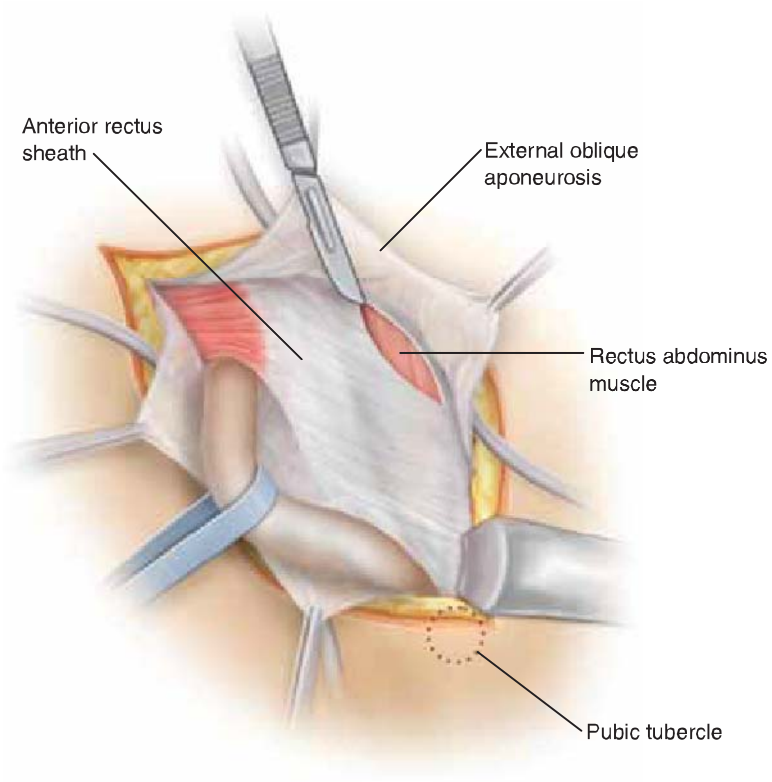


**Figure 6.13** Relaxing incision. Retraction of the aponeurosis of the external oblique to allow exposure of the anterior rectus sheath. The anterior rectus sheath is incised from near the pubic tubercle vertically (cephalad) for approximately 6 cm.

- The cord is returned to its anatomical position on top of the inguinal floor. The aponeurosis of the external oblique is closed over the cord with a continuous suture, thereby recreating the external ring.
- Scarpa's fascia and skin are closed. Sterile dressing is applied.

## POSTOPERATIVE MANAGEMENT

- Patients tend to have more pain and a longer recovery compared to a tension-free mesh repair.
- Patients are instructed to avoid heavy lifting or exercise for 6 weeks postoperatively.
- Considering that a Cooper ligament repair is typically performed in the setting of a contaminated field, i.e., strangulated bowel, hospitalization and recovery is dependent on bowel function and infectious complications.
- Follow-up is typically 2 weeks after discharge from the hospital.

## COMPLICATIONS

- Thromboembolic complications: Thromboembolism has been reported as a complication of a Cooper ligament repair. This is due to compression of the femoral vein by transition sutures placed too far laterally in Cooper's ligament. If the most lateral suture in Cooper's ligament is placed just medial to the femoral vein, there should be no venous constriction or increased thromboembolic risk.
- Surgical site infection (SSI): SSI is an uncommon postoperative complication following an elective Cooper ligament repair. However, in the present day, a Cooper ligament repair is almost always performed in the setting of bacterial contamination and therefore SSI is more frequent.
- Postoperative pain: The Cooper ligament repair is associated with more postoperative pain compared to a tension-free mesh repair. This has been minimized with the

addition of a relaxing incision. The relaxing incision does not make the repair "tension free", but it does reduce the tension to allow for better healing. However since mesh is not used, the risk of nerve entrapment within a mesh is eliminated.

## RESULTS

- Recurrence following a Cooper ligament repair is expected to be higher compared to a tension-free mesh repair. It is well documented that the use of prosthetic material minimizes the risk of recurrence. The published recurrence rates using a Cooper ligament repair is between 2% and 15%.
- A Cooper ligament repair is also associated with a longer convalescence and return to work.
- Femoral hernias are often associated with emergent operations and bowel resection. Compared to elective operations, the postoperative morbidity and mortality increase significantly in patients undergoing emergent repairs. The Swedish Hernia Register reported on 3,980 femoral hernia repairs between 1992 and 2006. 1,490 were men and 2,490 were woman. 1,430 (35.9%) patients underwent emergent operations. Bowel resection was performed in 325 (22.7%) of emergent femoral hernia repairs. An emergent femoral hernia repair was associated with a 10-fold increased mortality risk.

## CONCLUSIONS

- A Cooper ligament repair is primary tissue repair that provides a strong posterior wall reconstruction and closes the femoral canal. A relaxing incision is needed.
- The Cooper ligament repair is rarely performed today, as it has been replaced by tension-free prosthetic mesh repairs.
- A Cooper ligament repair is typically performed for repair of a femoral hernia in the setting when a prosthetic mesh is contraindicated, e.g., strangulated bowel. In this setting, a Cooper ligament repair provides acceptable results.

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# 7 The Shouldice Hospital Repair

**Robert Bendavid**

## Introduction

There is evidence that, despite advances in hernia surgery, the rate of hernia recurrence has remained the same, hovering at about 14% worldwide, with a range of 10% to 22% (Tables 7.1, 7.2 and Figure 7.1). By advances we mean the several varieties of prosthetic meshes, the numerous kinds of implantable, one size fits all gadgets which flood every surgical meeting, and the still controversial laparoscopic techniques. It may be that in the hands of surgeons sub-specializing in hernia surgery, the results are better but the overwhelming majority of hernias are repaired by general surgeons who, on average, do 50 cases a year only!. Statistics from the Shouldice Hospital point to the fact that 65% of the failed herniorrhaphies are due to an inadequate search for a hernia or simply due to a grossly inadequate knowledge of anatomy. Much to the regret of the surgical community, the Shouldice Hospital has not come forward, in the last 20 years, with meaningful peer reviewed publications or statistical data to support the claims which they put forth at conferences; nor have their statistics ever been presented with a seal of approval by a bona fide statistician. For those reasons, the comparative results must come from older series as well as from older reports, albeit from competent surgeons. It must also be kept in mind, in all fairness, that pure tissue repairs do not get the approval and support of an industry which is geared to produce and sell what it manufactures. We shall revisit these ethical issues.

## History

The Shouldice Hospital was established in 1945 by Earle Shouldice. Its accomplishment is not in having designed a new operation. It did not. It simply carried out the steps of the Bassini operation faithfully. These steps were introduced by one of the staff surgeons, Ernie Ryan. Three differences stand out between the classic Bassini operation and what is done at the Shouldice Hospital today: The use of stainless steel wire as a suture material, as opposed to the cotton and silk which were available in Bassini's days; a continuous suture rather than the interrupted sutures which Bassini inserted;

**TABLE 7.1** Review of Recurrences by Countries. Courtesy Pr. V. Schumpelick

| Country | Year | Operations for Rec. Ing. Hernias |
|---|---|---|
| Sweden | 1992 | 16% |
| Canada | 1995 | 11% |
| NL | 1996 | 20% |
| USA | 1996 | 12% |
| Belgium | 1997 | 13% |
| Japan | 1998 | 11% |
| Sweden | 1998 | 15% |
| Germany | 1999 | 15% |
| Italy | 2000 | 19% |
| Denmark | 2000 | 17% |
| Swiss | 2001 | 14% |
| USA | 2002 | 10% |
| Spain | 2003 | 22% |
| Sweden | 2003 | 17% |
| Germany | 2004 | 13% |

Note: Constant rate of operations for recurrences worldwide (14%).

**TABLE 7.2** Statistical Review (1999–2004) within Bavaria. Courtesy Pf V. Schumpelick

| Percentage of Recurrent Hernia Operations in Bavaria (Germany) | |
|---|---|
| 1999 | 13.3% |
| 2000 | 12.8% |
| 2001 | 12.4% |
| 2002 | 12.2% |
| 2003 | 12.1% |
| 2004 | 13.0% in Bavaria |

Data Base: BAQ Bayerische Qualitätssicherung 2004 Modul 12/3.
Note: No improvement despite technical optimation.

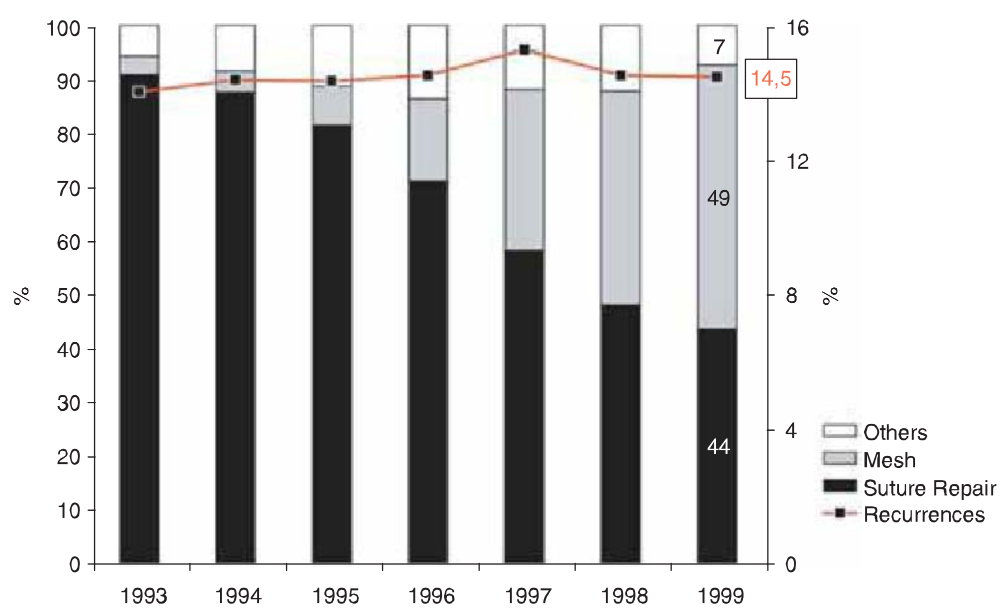


**Figure 7.1** Constancy of recurrence rate while mesh repair reaches its peak use.

the exclusion of the periosteum from the first suture as was suggested by Bassini. The Shouldice Hospital, can be said to have been the heir of Bassini in having honored and respected each and every step of his legacy. The Hospital, still in existence today, performs upwards of 7,000 operations a year, which are carried out by a staff varying from 10 to 12 dedicated surgeons.

Local anesthesia became, very early, a standard practice. That possibility was convincingly established by Halsted and Cushing 50 years earlier. Early mobility became the norm as soon as surgery is terminated when the patient walks to the recovery room and ambulation is encouraged when the effects of the preoperative sedation have dissipated. This trend was begun when Earle Shouldice observed that children could not be kept in bed following herniorrhaphies and that their early activity never resulted in any ill after-effect.

# Anatomy

The groin is unquestionably an area of the human anatomy which has long been recognized as a difficult area of study. This is probably due to the four dimensions of an anatomy which changes as one proceeds askew from front to back and from the midline to the side. A crab might have an easier time of it! Still, some important concepts must be retained which will ease the understanding of the complexities.

Without a doubt, the most complete study of the anatomy of the groin is provided by H. Fruchaud. His book, published in 1956 by Doin Publishers in France was difficult to find and the work had not been translated into English until 2006. As a result, very few authors had previously quoted from him in a limited manner. With Astley Cooper and Jules Cloquet, the Fruchaud has been one of the cornerstones in understanding the anatomy of the groin. A review of Fruchaud's text reminds us that the groin anatomy must always be referred to in the vertical, time honored position and tradition! Not with the patient in the supine position as in the dissection room cadaver so that the floor of the inguinal canal is the pubic ramus (with the patient in the erect position) and NOT the so-called "transversalis fascia." The transversalis fascia is the posterior wall of the inguinal canal with the patient in the standing position as well as in the supine position in this case. Another unfortunate deformation and confusion in the teaching of the anatomy of the groin is the definition of the transversalis fascia. The problem arose with Astley Cooper when he called the transversus muscle the transversalis muscle so that its continuation inferiorly became the transversalis aponeurosis or transversalis fascia. It should instead have been called transversus aponeurosis or transversus fascia which goes on to contribute to the posterior wall of the inguinal canal.

The true transversalis fascia is in fact the endoabdominal fascia which is continuous with the endopelvic fascia and the rest of the abdominal cavity. It is a very thin layer, marked by a profuse cellularity which differentiates it from the aponeurotic, sparse cellularity of the extensions infero-laterally of the transversus abdominis and internal oblique muscles. These last two fascial layers form the true posterior wall of the inguinal canal.

Another feature of Fruchaud's inguinal description is the elimination of the inguinal ligament. There is no such ligament! It is simply a continuation, a reflection of the external oblique aponeurosis. What Fruchaud refers to as the inguinal ligament is in fact, the iliopubic tract (the ligament of Thomson), a structure seen at the lower edge on the deep surface of the divided posterior wall of the inguinal canal. It is not always a solid structure, especially at its lateral end. That is why the reflection of the external oblique aponeurosis must be included in the Bassini and the Shouldice inguinal hernia repair. Since usage has forced us to call "Transversalis Fascia" the posterior aspect of the inguinal canal, we will continue to do so to avoid confusion. It follows therefore that the lower extension of the transversalis fascia joins the inner aspect of the recurved and lower portion of the external oblique aponeurosis to continue inferiorly over the pubic ramus.

# PREOPERATIVE PLANNING

## Obesity

Obesity is always a drawback in all surgery. Whereas the evidence is overwhelming on obesity being a factor in incisional hernia recurrences, the same cannot be said for inguinal hernias. Overweight makes surgery longer, will require more local anesthesia, and may limit ambulation after surgery. It will be a factor in postoperative infections. Otherwise, a moderate adiposity should not be an objection to inguinal hernia repair. It has been a custom at the Shouldice Hospital to promote weight loss and while the intent is noble, it is not always successful. Certainly not in the class that would be labeled obese. In larger centers, bariatric surgeons become part of the team.

## Sedation

Preoperative sedation consists of Diazepam (10 to 25 mg, orally) 90 minutes prior to surgery and Meperidine (25 to 100 mg) 45 minutes before making the incision. These drugs can be varied to suit the needs and condition of the patient and the experience of the surgical and anesthetic teams. Intravenous sedation is not uncommon and can be an additional option.

## Local Anesthesia

The Shouldice Hospital has had extensive experience with procaine hydrochloride (novocain) and continues to use it to this day. It is a safe, effective, and a cost-effective drug. The concentration is 1% to a maximum volume of 200 cc. Here again, the choice of anesthetic agent may vary with local customs and uses. Novocain has never been associated with malignant hyperthermia. It may induce tremulousness but this is properly controlled by the preoperative sedatives be they benzodiazepines or barbiturates. Properly carried out, in terms of quantity and timing of the medications, there is no doubt that adequate sedation and anesthesia can be effective and satisfying. The advantage of the method is that it makes surgery possible and safe for the majority if not all patients regardless of age and health status. Local anesthesia also imparts the benign nature that herniorrhaphies are in terms of surgery and safety, as many patients have a morbid and unreal fear of general anesthesia. Apprehension of cardiac complications are a justified risk particularly in the above 50 age group. These apprehensions were mapped out and at the risk of sounding trite through repetition, one must insist on that repetition. It has been established from the records of the Shouldice Hospital that the cardiac status of a patient population is as seen in Table 7.3.

**TABLE 7.3 Associated Cardiac Conditions in Patients Older Than 50 : 52.1% of all Patients**

| | |
|---|---|
| Cardiac arrhythmia | 50% |
| Hypertension | 20% |
| Congestive Heart Failure therapy | 17% |
| History of myocardial infarction | 15% |
| History of angina | 15% |
| Anticoagulation (aspirin, warfarin, sulfinpyrazone) | 12% |

# SURGERY

## The Incision

Most textbooks describe the inguinal incision 2 to 3 cm "above" a line joining the pubic crest to the anterior superior iliac spine. Experience has shown that the incision should be instead, along that line, not above. Also, it should be from the pubic crest laterally to a distance of 10 cm. This incision brings the inguinal area into full view without undue discomfort from the traction of retractors. This retraction is a source of marked discomfort under local anesthesia since it affects areas not covered by your local anesthesia.

## Local Anesthesia

The infiltration of the skin is carried out by raising a wheal 3 to 4 cm wide at the site of the proposed incision. A volume of 60 to 90 cc of 1% procaine hydrochloride will be generous and sufficient (Fig. 7.2). After the initial incision is made, when the external oblique aponeurosis is identified, another 20 cc of anesthetic agent is injected deep to this aponeurosis allowing it to bathe the sub-aponeurotic space. Later, when this aponeurosis has been incised, all the nerves in the groin will be easily identified and infiltrated individually with 1 to 2 cc of the anesthetic agent. One must remember their tremendous variation and distribution. The genital branch of the genitofemoral nerve which issues from the deep inguinal ring appears on the lateral aspect of the cremasteric muscle and often within the substance of that muscle.

## The Dissection

The external oblique aponeurosis is incised from the superficial inguinal ring laterally, along the direction of its fibers, to a level of 2 to 3 cm lateral to the deep inguinal ring (Fig. 7.3). After infiltrating the individual nerves, another 5 cc of anesthetic agent is injected within the loose aerolar tissue of the spermatic cord at the level of the internal ring to block conduction of the sympathetic nerve pain fibers within the cord. The two flaps of the external oblique aponeurosis are undermined as laterally and as medially as feasible (Fig. 7.4). Any nerves that can be spared gently are left intact; however, if the nerves should be in the way of a proper dissection and eventual reconstruction, I do not hesitate to resect them. The division of all the nerves (ilioinguinal, iliohypogastric, and genital branches of the genitofemoral) can be divided with impunity, Fruchaud had already made a mention of this fact in 1956! The loss of sensation on the skin is a discoid area of 2 to 5 cm at most near the pubic crest area. With time and the in-growth of nerve fibers, this area re-acquires its innervation. The only exception to the division of the nerves is seen in female patients in whom the genital branch of the genitofemoral nerve should be spared. If not, there may ensue a loss of sensation over the labiae.

The cremasteric muscle which has now become evident is incised longitudinally along the direction of its fibers, from the level of the pubic crest to the deep inguinal ring (Fig. 7.4). After developing medial and lateral flaps they are resected as follows. The medial flap is usually quite thin and negligible; however, near the deep inguinal ring, its musculature will often exhibit a substantial arterial vessel (not named) which must be carefully ligated.

The lateral flap of the cremaster is doubly clamped halfway between the pubic spine and the deep inguinal ring, divided and each stump doubly ligated. These stumps will include the genital branch of the genitofemoral nerves and the cremasteric vessels.

When the cremaster has been resected and the spermatic cord retracted laterally, the posterior wall of the inguinal canal becomes clearly evident, and in full view. At this stage, one should look for the presence of an indirect sac on the medial aspect of the spermatic cord at the internal ring. If a sac is found, it is dissected out and resected at

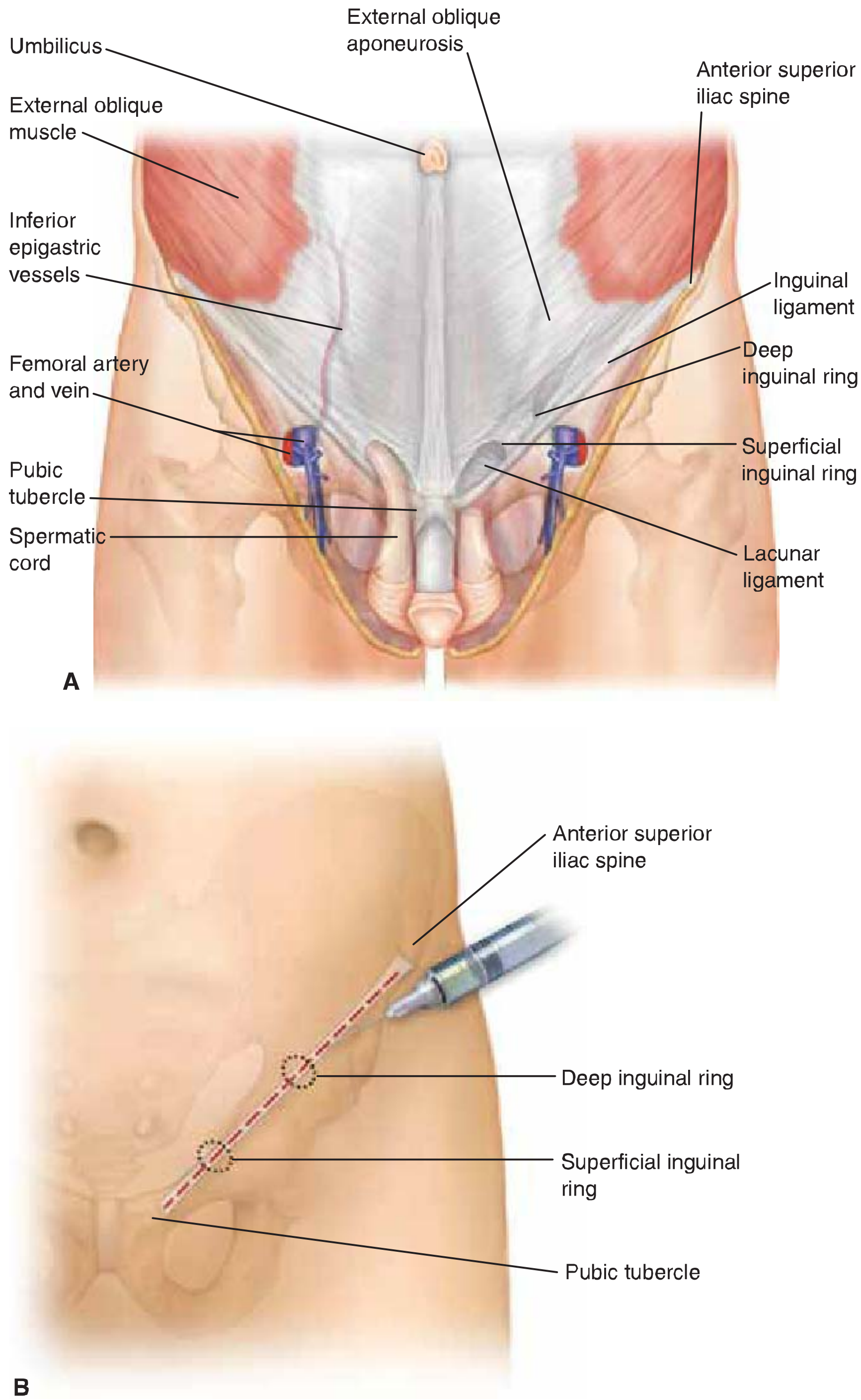


**Figure 7.2** **A:** Superficial anatomy and **B:** Proposed line of infiltration and incision, along the line joining the anterior superior iliac spine and the pubic crest.

the internal ring. Many surgeons may simply drop the sac into the preperitoneal space without resecting it. There is no harm to that practice, provided that the sac is not a tubular structure with areas of narrowing which may promote incarceration of a viscus. If no indirect sac is found, one must endeavor to identify a peritoneal protrusion which would literally guarantee the absence of an indirect hernia. Very rarely, I have seen a bi-lobed hernia sac when one side has been identified and the second could have been missed! At this stage, any direct inguinal hernia or defect will be easily observed. Next to be considered is the division of the posterior inguinal wall (Fig. 7.5). Beginning at the medial aspect of the deep inguinal ring, the posterior wall is incised carefully, taking care not to injure the inferior epigastric vessels. Under constant direct view, the incision is extended to the pubic crest. You are now in the preperitoneal space and more

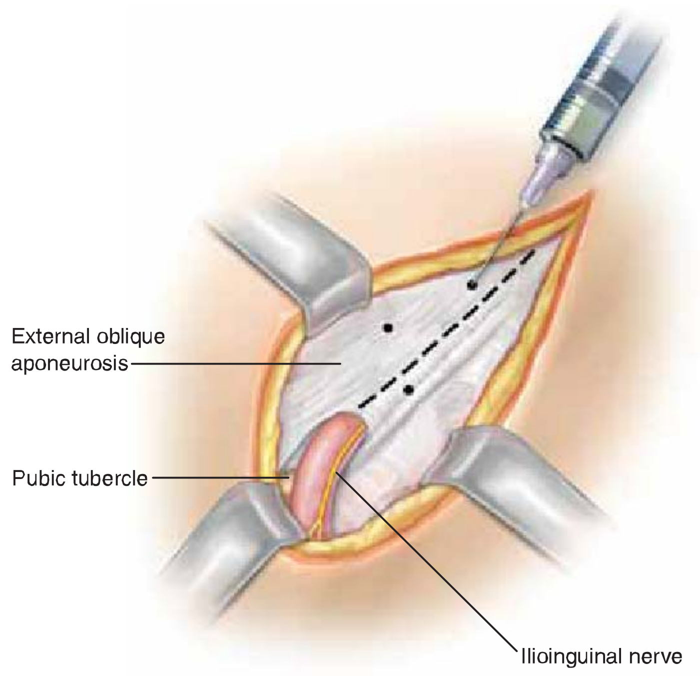


**Figure 7.3** Infiltration of local anesthetic deep to the external oblique aponeurosis.

particularly, the space of Bogros. The two resulting flaps are medially the triple layer described by Bassini and which consists of the true transversalis fascia, the aponeuroses of the transversus and internal oblique muscles, however thin they may have become. More medially as well as laterally, the muscle fibers of the internal oblique and transversus abdominis become evident and will be included in the repair. Laterally, the flap is made up of the same layers but its deepest edge is made up of the iliopubic tract of Thomson which is often extremely thin, especially at its lateral third. The iliopubic tract is thickest near the pubis where it is easily identified and must be included in the repair. Care must be taken not to injure a vein which is always found on the deep aspect of the iliopubic ligament which has now been named iliopubic vein (Fig. 7.6).

At this stage, the cribriformis fascia below the inguinal ligament, on the upper and anterior aspect of the groin is incised from the level of the femoral vessels to the pubis

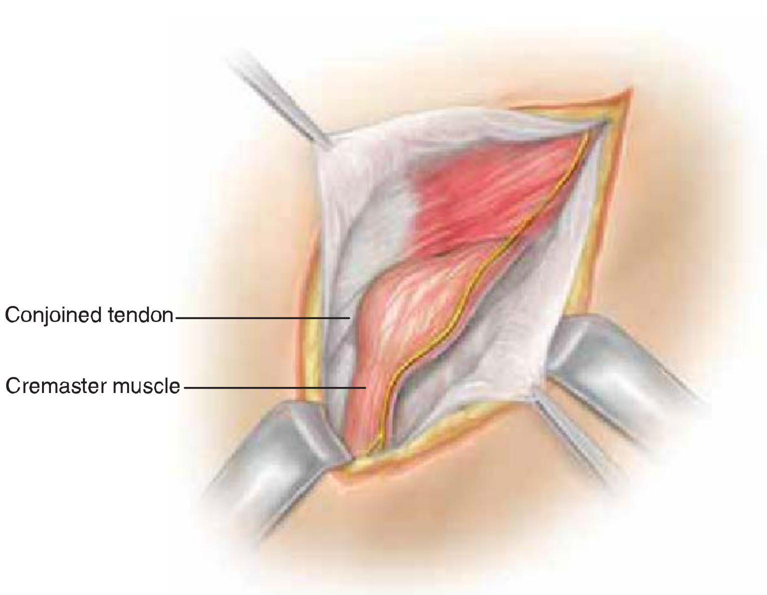


**Figure 7.4** Incision of the external oblique aponeurosis along the direction of its fibers.

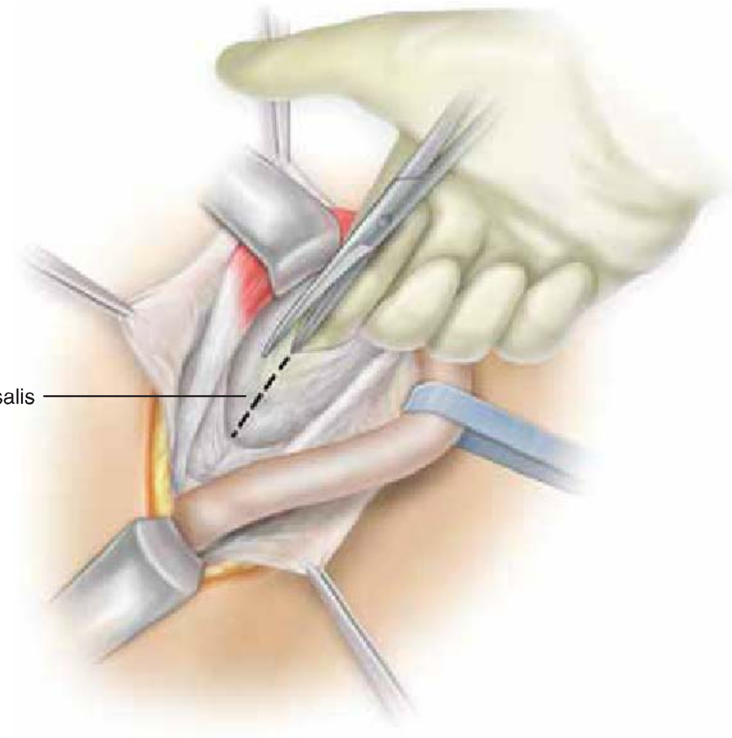


**Figure 7.5** Division of the posterior wall of the inguinal canal (the transversalis fascia).

(Fig. 7.7). This move will allow examination of the undersurface of the femoral canal and eliminate the possibility of a simultaneous femoral hernia. This exploration is carried out in conjunction with a look at the femoral ring from the space of Bogros.

## Reconstruction

Surgical repairs must be learned from the experts whenever feasible or possible. That possibility is afforded anyone by contacting the Shouldice Hospital and requesting that privilege. I have never known them to refuse that demand from anyone!

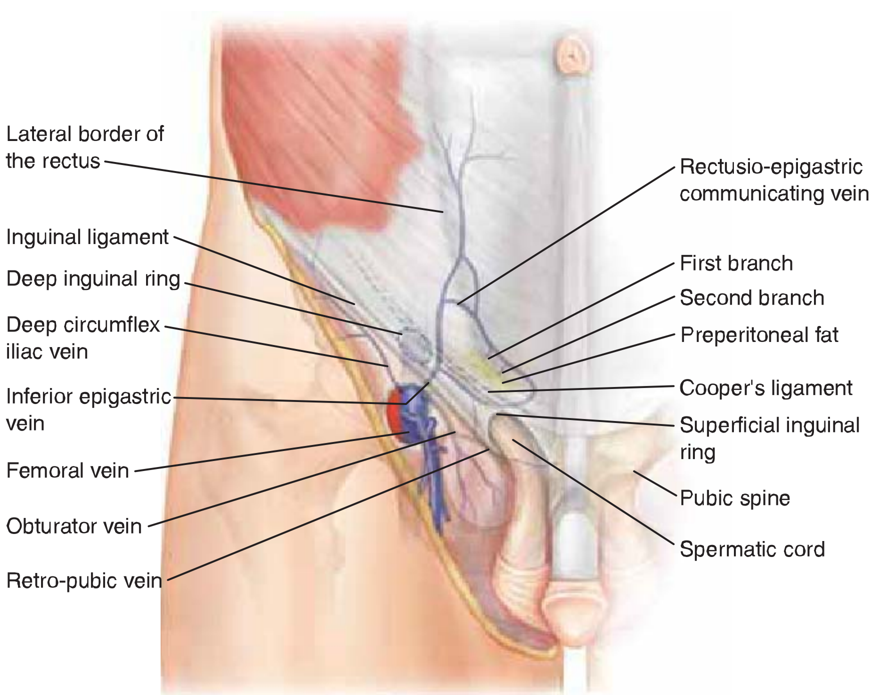


**Figure 7.6** Illustration of the venous vasculature in the preperitoneal space of Bogros.

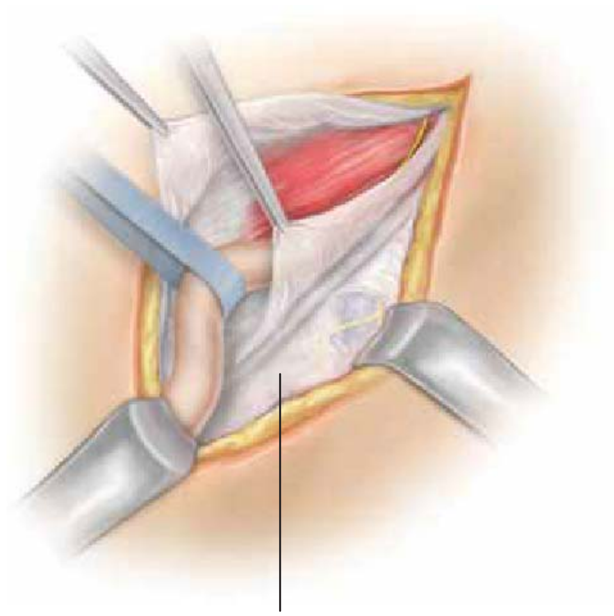


**Figure 7.7** Freeing the thigh fascia to reveal the lower end of the femoral canal and examine for the presence of a femoral hernia.

If an indirect inguinal hernia is identified at the medial side of the spermatic cord, at the deep inguinal ring, it should be dissected free from all surrounding elements of the cord from distal to proximal ends. The sac, if long and narrow, may be resected; if wide and short, it may simply be freed and reduced from the preperitoneal space of Bogros. An indirect sac need never be resected unless it is narrow and scarred or poses the possibility of adhesions to viscera or incarceration within the narrow sac. The posterior inguinal wall having been divided throughout its length, especially when a direct inguinal hernia is identified, is now to be reconstructed.

The reconstruction aims at the repair of a solid posterior wall of the inguinal canal in all cases. The repair begins near the pubic crest by approximating the iliopubic tract laterally to the medial triple layer: The true transversalis fascia, the transversus abdominis muscle or aponeurosis, the internal oblique muscle or aponeurosis but also the lateral edge of the rectus muscle which is not part of the triple layer (Fig. 7.8). Of course at that level and especially in the case of a direct inguinal hernia, the musculature may be markedly absent and one finds a thin bulged out wall made up of the thin, degenerating layers of the aponeuroses of the transversus and internal oblique muscles. In the case of direct inguinal hernias, if the tissues involved in the repair cannot be trusted, this would be the ideal situation for the use of a sheet of mesh. The repair might otherwise be under a great deal of tension and with poor tissues. To get substantial tissue would mean relying on a triple layer too close to the midline and therefore far too "unphysiologic" due to the extreme tension. The suture proceeds towards the internal ring and at about the halfway mark, the lateral edge of the rectus (Fig. 7.9), which becomes almost vertical, and therefore not parallel to the "inguinal ligament" becomes too distant for inclusion in the line of repair. At the internal ring, the suture picks up the lateral stump of the cremasteric bundle then crosses over to the opposite side (Fig. 7.10), piercing from inside out, the true transversalis fascia, the transversus abdominis muscle, and the internal oblique muscle. A new internal ring is thus created. The suture reverses its course and becomes the second line of suture towards the pubic crest. This second line approximates the borders of the transversus and internal oblique muscles to the shelving edge of the "inguinal ligament" or more accurately, the external oblique aponeurosis, along a line parallel to the first line of sutures, thus creating a second, artificial "inguinal ligament" (Fig. 7.11). The suture ends are tied near the pubic crest. The first suture has now contributed two lines of repair. At this stage, a relaxing incision can be made if the surgeon feels that the repair is under some tension. This

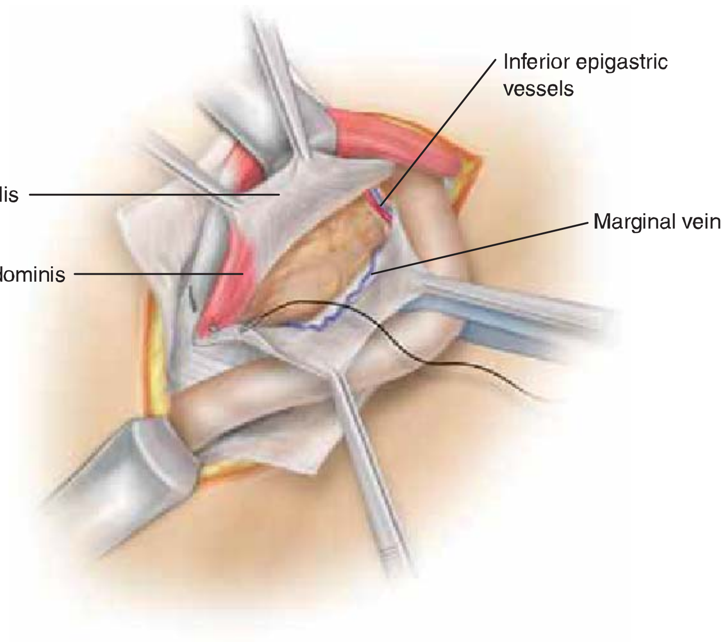


**Figure 7.8** Appearance of the preperitoneal space when the dissection has been done. Note the inclusion of the lateral edge of the rectus muscle and be careful to avoid the marginal (pubic) vein.

relaxing incision should be generous and can extend from the pubis to the level of the internal inguinal ring. The defect resulting from the relaxing incision is recovered within a week by a new sheath, a fact that was confirmed by Amos Koontz, professor of surgery at Johns Hopkins, in his textbook "HERNIA" (Appleton, Century, Crofts, 1963).

Another two lines of repair will now be created by a second suture. The latter is begun near the internal ring (Fig. 7.12) where medial to the ring the needle is driven through the internal oblique, the transversus abdominis muscles then across to the inner aspect of the external oblique aponeurosis along a line parallel to the previous artificial inguinal ligament, namely the second line. This third line proceeds to the

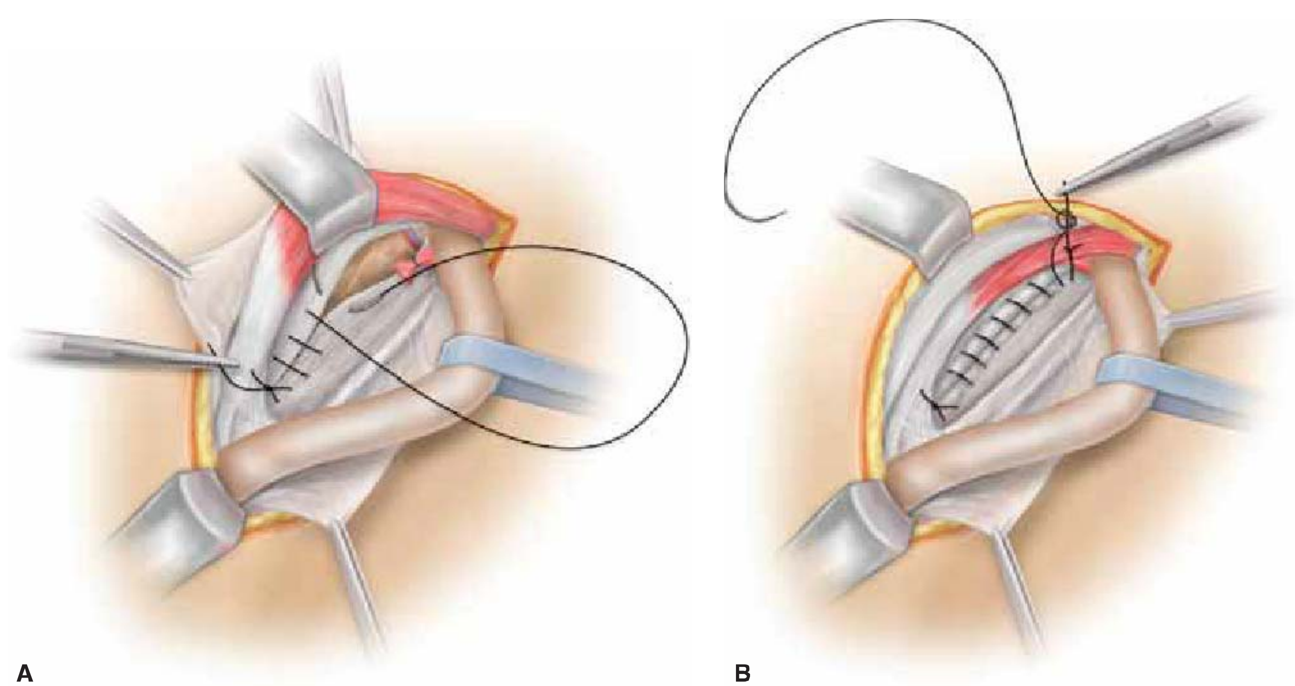


**Figure 7.9** **A:** First line of the first suture proceeding toward the internal ring. **B:** End of first line of first suture just before reversing its course as second line of first suture towards the pubic crest, where it will be tied.

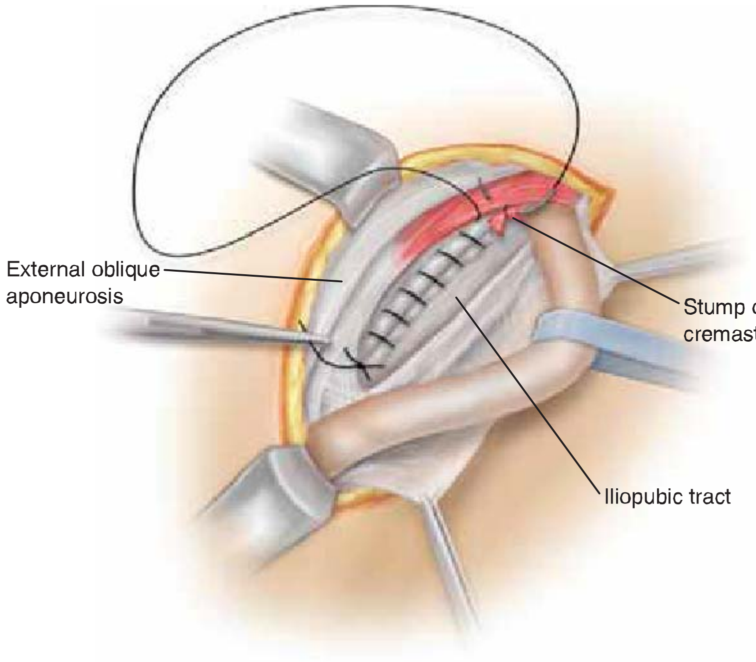


**Figure 7.10** The final bite of the first line of the first suture includes the lateral stump of the cremaster muscle. The suture now reverses its course to become the second line of the first suture.



pubic crest from which it reverses its course back towards the internal ring where it is tied to the strand of the suture left awaiting. This completes the fourth line (Fig. 7.13). You will observe from the diagrams that medially, the external oblique aponeurosis is used to cover and protect the medial aspect of the posterior wall of the inguinal canal. This maneuver displaces the superficial inguinal ring by 2 to 3 cm laterally. This medial portion of the posterior wall of the inguinal canal is the commonest area for direct recurrences in the hands of even experts! The medial or distal cremasteric muscular bundle is anchored near the pubis or the superficial pubic crest and this step will prevent the eventual drooping of the testicle and scrotum. This drooping is a minor complication but nevertheless one that causes distress to many patients. At this stage, the cord is placed back in its normal anatomical position and the external oblique aponeurosis is closed over it with a running absorbable suture (Fig. 7.14). Subcutaneous tissues

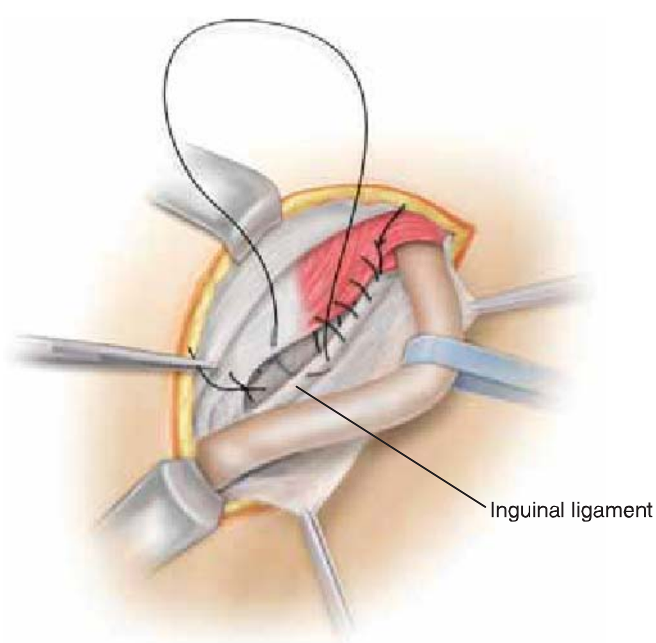


**Figure 7.11** The second line incorporates the external oblique aponeurosis along a line parallel and superficial to the inguinal ligament.

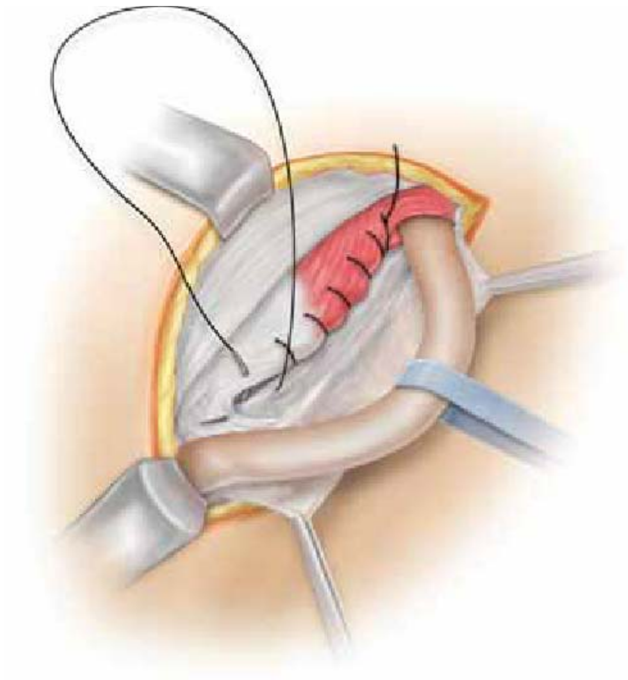

**Figure 7.12** The third line (or first line of the second suture), begun at the internal ring and proceeding toward the superficial ring, incorporates the external oblique aponeurosis along a line parallel and more superficial yet to the inguinal ligament.

are also approximated in the same fashion. The skin is closed with Michel clips half of which are removed in 24 hours and the remainder in 48 hours.

## POSTOPERATIVE MANAGEMENT

At the end of surgery, the patient is made to stand away from the table, to walk to a waiting wheelchair, and to be taken to his room. There he will sleep off the preoperative medications for 4 to 6 hours after which he is encouraged to be up and about. His

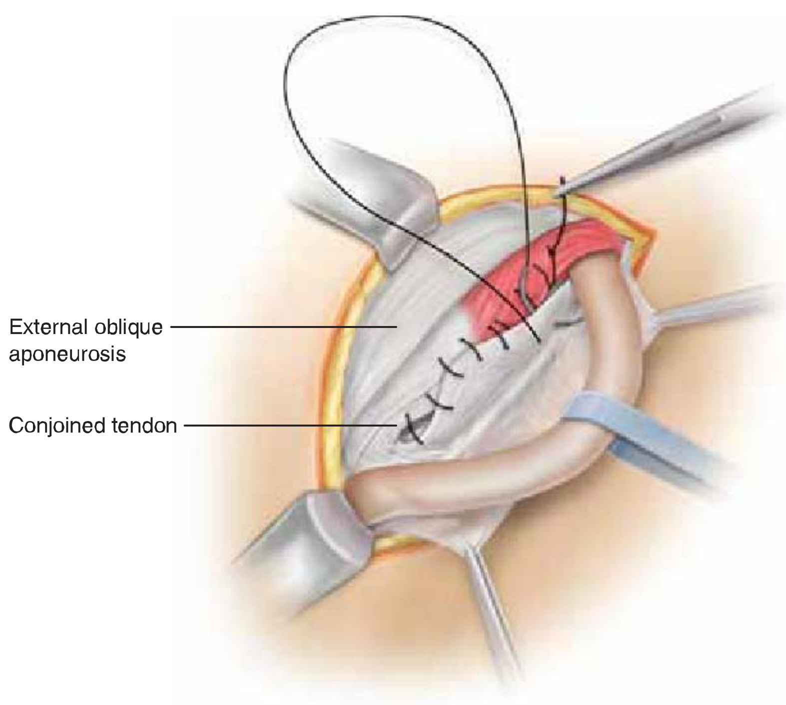


**Figure 7.13** The fourth line of suture (or the second line of the second suture) reversing its course near the superficial ring toward the deep inguinal ring.

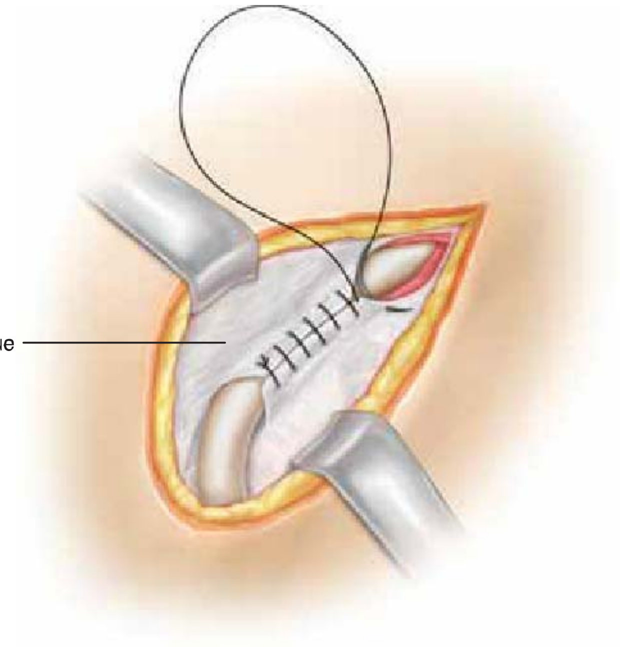


**Figure 7.14** Closure of the external oblique aponeurosis over the spermatic cord which is placed in its normal anatomical space.



first meal will be in his room, after that the patient is expected to go to the common dining room for his meals. Beginning the next morning, light exercises are performed by all patients as a group. These will be repeated every day for 2 to 3 days until the patient goes home after 48 to 72 hours following surgery.

## RESULTS AND FOLLOW-UP DATA

There have been very few series reported recently on the Shouldice repair, compared to even 10 years ago. The reasons for this aberration have been the relentless push and promotion by the manufacturing companies to use prostheses and gadgets. For obvious reasons, no one stands to profit financially from pure tissue repairs. The only profit would be seen by hospitals and Health Care Systems whose budgets would be improved by the abandonment of laparoscopic and mesh techniques. Such a radical abandonment is not implied here for there is a definite use for meshes but the use should be indicated, judicious and not in a blanket manner for everyone regardless of types of hernias. The last review of the Shouldice repair as presented by Dr. Byrnes Shouldice himself (International Hernia Congress, Boston, USA, June 7 to 11, 2007) stated that the overall recurrence of a Shouldice repair is less than 1% for all repairs; 0.5% following primary inguinal repairs. Still, others have reported comparable success as seen in Table 7.4, from series in the last 20 years. Despite their success, it is puzzling to see that many of those authors have gone on to include meshes in most of their repairs.

Interesting to note that Berliner used two lines of repair instead of the usual four!

## COMPLICATIONS

### Infections

Infection is a negligible complication at the Shouldice Hospital simply because the hospital limits itself to a single operation. That is, no other surgery is carried out in their hospital. If any patient should present with any sepsis, as minimal as it may be (ear infection, a boil, urinary tract infection, etc.), surgery is delayed. There is no such thing as a nosocomial infection. Also, the majority of surgeries take less than an hour

TABLE 7.4 Incidence of Recurrence Following the Shouldice Hospital Repair

| Author | # Cases | Follow-up (%) | Follow-up (y) | Recurrence |
|---|---|---|---|---|
| Shearburn | 550 | 100 | 13 | 0.2 |
| Volpe | 415 | 50 | 3 | 0.2 |
| Bocchi | 1640 | 84 | 5 | 0.6 |
| Devlin | 350 | — | 6 | 0.8 |
| Flament | 134 | — | 6 | 0.9 |
| Wantz | 3454 | — | 1–20 | 1 |
| Moran | 121 | — | 6 | 2.0 |
| Berliner | 591 | — | 2–5 | 2.7 |

to perform. I have seen superficial, subcutaneous abscesses develop but never a deep infection deep to the repair requiring dismantling the repair for proper drainage! Still the recorded infection rates are less than 0.5% on a yearly basis.

## Hematomas

A most unusual complication which invariably originates from the cremasteric stumps. The incidence in a personal series of close to 6,000 cases is about 0.3%. It is wise to return a patient to the operating room within hours or the hematoma may reach enormous sizes and require several months for complete resorption.

## Hydrocoeles

An incidence of 0.7% was reported by N. Obney who suggested to minimize suture ties along the spermatic cord as well as to ensure loose reconstructions of the deep and superficial inguinal rings.

## Testicular Atrophy

No technique of hernia repair is free from this complication be it pure tissue, tension free, or laparoscopic. A series of 59 752 inguinal hernia repairs from 1986 to 1993 was reviewed at the Shouldice Hospital. Recurrences were recorded in 19 instances following 52 583 primary inguinal repairs (0.036%) and 33 instances following 7,169 repairs of recurrent inguinal hernias (0.46%). Such an incidence must be explained to the patient beforehand as such unfortunate results may lead to a suit alleging malpractice or negligence when in fact neither can be the cause.

## Dysejaculation

Dysejaculation is a rare complication and most distressing situation for patients. This syndrome should not be confused with groin pain reported to occur during the sexual act and which is associated with strain, pull, push, and twists of the groin muscles. The dysejaculation syndrome is characterized by a burning or searing sensation occurring just before, during, or just after ejaculation at the time of the sexual act. I have seen it happen when sexual stimulation has begun when the sex act has not taken place yet. That is even before the stimulus leading to ejaculation! The incidence has been estimated at 1 in 2,500 cases. Fortunately, this complication requires patience and no surgical intervention. The mechanism has been alluded to as being an obstruction of the vas as can be seen during fibrosis formation following hernia repair which leads to kinking and tortuous appearance of the vas. The pain, of necessity, has to be due to the distention of the hollow organ which the vas is and the stimulus is mediated through the autonomic nervous system via the three nerves of the groin. The worst and most trying case I have observed lasted 5 years! It is to be pointed out that this syndrome is being over-reported and I have rejected many an article purporting to describe the syndrome when in fact what were described were episodes of nerve affected by entrapment, sutures, clips, tacks, erosion by polypropylene meshes, etc.

### Chronic Postoperative Pain (Inguinodynia)

Much is being said and written nowadays with reference to postoperative inguinal pain. Some have gone as far as claiming that postoperative inguinodynia has surpassed recurrences as a complication following inguinal hernia repair. Incidence of inguinodynia has been reported as high as 50%! Another fact I have personally observed is that when statisticians of non-surgical background are involved, the figures are apocalyptic!

My personal experience and that of the Shouldice Hospital do not mirror this concern. In a personal series of 100 cases, our incidence was recorded as 1% in 1995. By chronic pain, we defined any pain following inguinal hernia surgery, lasting a year or more and distinctly different from any strain syndromes of the groin such as adductor, pectineal and rectus strains which can mar a post-op course perhaps because of the imbalance of muscular exertion which may follow on such surgeries for weeks if not months in some cases. In the 100 cases cited above, a careful review of the operative notes revealed that 90% of the patients had their nerves "carefully preserved!" The other 10% had operative notes stating that "all nerves were divided!" This has justified my practice since 1985 of dividing all nerves which would prevent an adequate dissection, at the time of surgery. Often, this amounted to a prophylactic triple neurectomy. It is of interest that this practice had already been recommended by Fruchaud in his outstanding "Surgical Anatomy of Hernias of the Groin" (Doin-Publishers, 1956).

### Major Complications

This class of complication is essentially non-existent, because surgery is carried out under local anesthesia and followed by early ambulation.

## CONCLUSION

Pure tissue repairs, such as the Shouldice (and the Bassini by extension) can yield excellent, life-long good results. The key is to remember to perform the procedures exactly as described by the originators of those techniques. These techniques demand only one strict imperative: The flawless knowledge of your inguinal anatomy. Whatever technique you perform routinely, you must remember that a pure tissue repair is a must in the armamentarium of the surgeon because the day will come when nothing but a pure tissue repair and its necessary accompaniment of detailed and clear anatomy will save the day in the presence of infection, recurrences, previous mesh repairs, and laparoscopic repairs.

# Epilog and Ethics

The advances of medicine are forever creating new dawns. In western countries, where health is an important issue, the right to health is no longer the purview of the rich but a state that must be added to that most perfect of declarations and changed to "Life, liberty, health, and the pursuit of happiness." Such "unalienable rights" are a noble cause, a feasible target but unfortunately at a tremendous financial cost. We, as surgeons, must do our part. Professor Volker Schumpelick, Editor-in-Chief of the World Journal of Hernia and Abdominal Wall Surgery, in his address to the American Hernia Society meeting in Boston, Mass, 2006, stated that despite the introduction of meshes, implantable gadgets, laparoscopic surgery with a net result that more than 90% of all hernia surgery is done with one mesh or another, the incidence of hernia recurrence has not improved in the last 30 years. The rate of recurrence hovers at 14% with a range of 11% to 22%! The irony of this paradox is that the cost of failure has become prohibitive! Whereas the Shouldice Hospital claimed in 1995 that the expenses of all disposables (including IV fluids, drugs, masks, gloves, etc.) amounted to $20 per patient, the cost of mesh and laparoscopic set-up and disposable equipment will amount to $200 to $2,000 and more. The cost of some prosthetic meshes, at least in Canada cost as much as ten times the surgeon's fee for that particular incisional hernia repair. While 90% of hernia surgery occurs in the groin, the claim that meshes and laparoscopy imply a saving because of decreased hospitalization, no longer stands. Many publications have confirmed this fact. Never has a Genesis made itself so necessary amid this chaos. Surgeons must re-assume their own intellectual independence and meet their challenges. I am not decrying the progresses and opportunities of new technologies. I am promoting the judicious and intelligent use of new technologies by applying it to necessary demands instead of blind, blanket use of one size of gadget fits all hernias. The unfortunate plug (!) is that "with the plug, you do not need to know your anatomy!" The real problem, in fact, is the lack of knowledge of the most accurate anatomy necessary for a problem which requires exquisite knowledge of anatomy!

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# 8 Groin Hernia Repair/ Kugel Technique

**John T. Moore**

## Introduction

Hernia repair constitutes a major part of the typical general surgical practice. Expansive literature has been produced demonstrating benefits associated with a large number of repairs. Most of these repairs have focused on tension-free techniques. Tension-free repairs, when performed properly, reduce the risk of recurrence to low levels. These repairs also reduce postoperative pain and accelerated return to normal activity. Surgeons have been exposed to many mesh-designed tension-free repairs. In order to achieve the published results of these repairs, proper performance of the technique selected is the key element. These techniques require a thorough understanding of the procedures used as well as a thorough understanding of groin anatomy.

### INDICATIONS

The Kugel technique for groin hernia repair is a tension-free minimally invasive, yet open, preperitoneal or posterior abdominal wall groin hernia repair. It is applicable to the treatment of indirect and direct inguinal hernias as well as femoral hernias. It is particularly useful for the treatment of recurrent groin hernias after previously failed anterior repair. It can be used selectively in patient's having undergone prior radical prostatectomy or pelvic radiation, but should be avoided in patients with recurrence after a failed laparoscopic groin hernia repair. This technique allows for rapid return to regular work and other activities without restriction. It further minimizes the risk of nerve injury and associated burdensome chronic pain syndromes because the inherent nature of this repair is to avoid direct nerve injury and avoid exposure of the groin nerves to the mesh.

## Patient Selection

The key elements in successful hernia surgery are proper patient selection and proper performance of the repair. However, not all patients with hernias need to be repaired.

Elderly, debilitated, and inactive patients with asymptomatic hernias where the hernia is easily reduced may be best left alone with rare exceptions. Symptomatic patients should all be repaired promptly. Even here, postponement of the repair may be considered if the symptoms are minimal and the hernia is easily reduced. Factors to consider are cost (immediate and delayed), age, patient's health, and type of work. There is no question delaying a repair may create a much more different repair later with more complications. Incarceration also is a rare threat.

Not every patient with groin pain needs surgery. The groin area is particularly susceptible to injury. Muscle and ligamentous tears and strains can cause groin pain and even result in chronic pain, which will not improve with the hernia operation. Very small and occult hernias do exist and can be particularly difficult to diagnose, especially femoral hernias. These can cause pain in patients, but in the absence of clear physical findings for a hernia observation seems to be the best initial course. Special caution in patients is also warranted with a very short history of symptoms or a very long history of symptoms, who do not demonstrate positive physical findings of a hernia. Ultrasound in these patients is sometimes helpful, but frequently overstates the presence of a hernia. The ultrasound also does not correlate well with the symptomatology. A wait and see approach is advised in these patients. If the surgeon is to avoid the not uncommon patient complaint after surgery that "the pain is worse now than before the surgery" or even "the mesh must be causing the pain."

While the bias of this presentation is that the Kugel technique is useful for the majority of groin hernias, there are incidences where it would be inappropriate (see "Indications") and even instances where it might not be the best technique. Although, the repair is great for bilateral hernias and in obese patients, it might be easier to treat the morbidly obese patient with a different technique.

# The Mesh Patch

The Bard Kugel patch (Davol, Cranston, Rhode Island) was developed to facilitate performance of the Kugel hernia repair. Although it is started out as a simple single-layer mesh, it became progressively more intricate in order to make the performance of the procedure easier and the repair more secure.

The patch is composed of two overlapping layers of knitted monofilament polypropylene mesh material that have been ultrasonically welded together (Fig. 8.1). A pocket of polypropylene is constructed on the outer edge of the patch which contains a single polyester fiber spring or stiffener that helps the patch to unfold after placement and maintain its configuration. One centimeter of mesh material extends beyond the outermost welds into which have been cut multiple radial slits. This outer fringe allows the patch to conform and fill more perfectly in the preperitoneal space, particularly when the patch folds back over the iliac vessels. A transverse slit is made in the center anterior patch, which is utilized for insertion of a finger which helps in positioning the patch in the preperitoneal space. Just beyond the anterior slit and inside of the mesh ring are multiple 3 mm holes through both layers of the patch. These serve to allow tissue to tissue contact through the patch to prevent movement of the patch after placement. This movement prevention is further augmented by several small V-shaped cuts associated with all of these holes in the anterior layer only. These cuts create a triangle of mesh which tends to pop up when the patch is placed and these act as sutureless anchors for the patch.

There are two mesh sizes used for groin hernias. The small patch is 8 × 12 cm and the medium patch is 11 × 14 cm. The small patch is adequate in most patients, although the larger patch does provide greater margin for error and is preferred in very large hernias. It is up to the surgeon to decide the appropriate size mesh patch used recognizing that the greater amount of underlay will probably result in fewer recurrences.

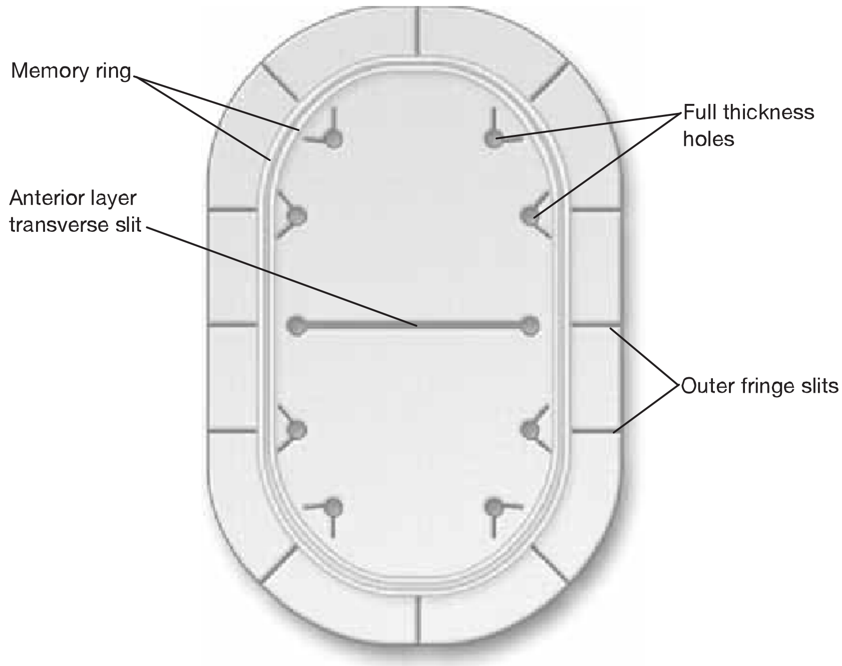



**Figure 8.1** Mesh patch.



# Operative Procedure

## Anesthesia

a. **General Anesthesia:** This is my anesthetic of choice for this operation. The primary disadvantage of a general anesthesia is the limitation of the ability to test the repair at the completion of the operation.
b. **Regional Anesthesia:** This is the preferred choice for some patients with epidural anesthesia being preferred over spinal anesthesia. The epidural anesthetic has the advantage for re-dosing when the catheter is left in place during the procedure. This not only allows for minimal initial dose, but also for the administration of additional doses as needed, if the operation takes longer which may happen with bilateral hernias. Furthermore, epidural anesthesia results in less muscle paralysis enabling the patient to respond more forcefully when testing the repair following the operation.
c. **Local Anesthesia:** I have preformed this procedure using local anesthesia and monitored anesthesia care provided by an anesthesiologist, but maintenance of a relaxed patient is imperative to be able to enter and maintain appropriate visualization of the preperitoneal space through the incision. If the patient experiences pain and begins to bear down in response, it can make the procedure very difficult. Very obese patients with recurrent hernias or patients who do not tolerate monitored anesthesia care should not be done under local anesthesia because of the loss off visualization associated with muscle contraction and discomfort.

# Patient Preparation

Appropriate laboratory and radiographic evaluation of patients preoperatively depends on the surgeon and the policies and procedures of the facilities in which they practice. Because of the risk of bleeding into the preperitoneal space, it is recommended that Coumadin be stopped 3 to 5 days prior to the surgery. Use of prophylactic antibiotics is recommended due to the implantation of the foreign body into the wound. Although infection reduction is not clearly substantiated in controlled studies, antibiotics add little risk and may reduce graft infections.

Clipping of hair in the operative area is recommended over shaving at the time of the procedure, followed by an appropriate skin preparation.

The patient is positioned in a supine manner. During the performance of the operation exposure is improved by placing the patient in a Trendelenburg position with slight rotation away from the site of the procedure.

## SURGICAL TECHNIQUE

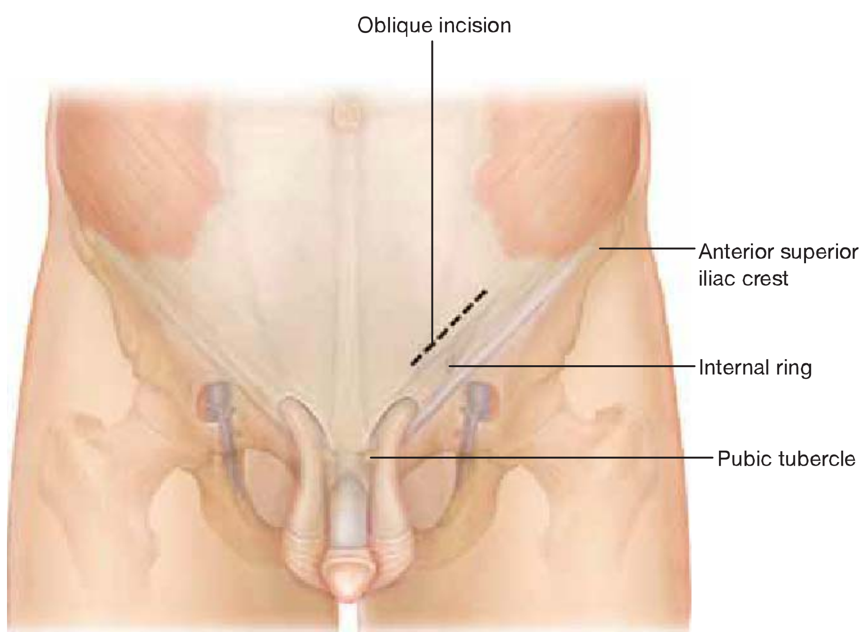
Regardless of the type of the hernia to be repaired, the mesh patch is placed in the same fashion into the preperitoneal space in every patient. The repair can be more difficult to learn because of a lack of familiarity with the anatomy in the posterior space and the angle in which the repair is approached. Understanding the unique approach is key to the successful performance of this procedure. Ideal first patients are of average size or thin where the anatomy should be clearly visible. Avoid recurrent hernias or large scrotal hernias initially. One of the advantages of this repair is the ease with which it can be converted to an anterior repair. The surgeon needs to back out of the preperitoneal space, allow the internal oblique muscle to re-approximate, and extend the skin and external oblique incision through the external ring and perform an anterior repair.

### Incision

I think it is critical to utilize a headlight during the performance of this operation. Because of the angle in which the repair is approached, a headlight helps to illuminate extremely well the area of the preperitoneal space and allows for accurate placement and deployment of the mesh patch. In addition, use of a dedicated assistant is also extremely helpful. The operation can be performed with the surgical scrub functioning as the assistant. A dedicated assistant, particularly in larger patients, allows for continued visualization of the preperitoneal space through continuous retraction.

Incision placement is important and can have a bearing on how easy it is to perform the operation (see Fig. 8.2). The most important thing is to avoid making the incision too low. The idea is to pass directly through the skin, muscle, and fascia into the

**Figure 8.2** Incision.



preperitoneal space. This approach is superior to the internal ring and lateral to the inferior epigastric vessels. It avoids the inguinal canal. Marking the anatomic landmarks on the surface of the patient will ensure the correct placement of the incision. Identify the anterior superior iliac crest and the pubic tubercle. Measure the distance between these two points and mark the halfway point. This identifies the location of the internal ring. Measure directly superior to this point identified as the internal ring 2 cm and mark the site of the incision. This appropriately positions the incision in the high position to avoid entering into the inguinal canal. A 4 cm oblique incision is made with two-thirds of the incision being made medial to the point marked on the skin and one-third of the incision lateral. Four centimeters is an arbitrary measurement. In the initial performance of this operation, the surgeon may want to make a slightly larger incision as it does not affect the overall outcomes of this operation and may give better visualization.

The skin incisions can be made either transversely or obliquely, but oblique incisions enable the surgeon to move into a more conventional anterior repair if needed with less difficulty. I prefer to make an oblique incision. The incision is made straight down through the skin and subcutaneous tissue on to the external oblique fascia. The external oblique fascia is then opened a short distance in the direction of its fibers, but not through the external ring. This exposes the underlying internal oblique muscle. Frequently, the ilioinguinal and iliohypogastric nerves can be visualized on the surface of the internal oblique muscle when the external oblique fascia is split. Great care should be taken to avoid traumatizing a sensory nerve when splitting the internal oblique muscle, but otherwise there is no need to directly visualize the ilioinguinal or the iliohypogastric nerves at this point. The internal oblique muscle is bluntly split in the direction of its fibers to expose the transversalis fascia The muscle splitting of the internal oblique musculature when placed in the proper position frequently lies inferior to the iliohypogastric nerve and medial to the ilioinguinal nerve. Transversus abdominis muscle fibers are occasionally encountered superficial to the transversalis fascia may need to be split as well. The transversalis fascia at this level is frequently a very thin and fragile structure. It can usually be penetrated by gentle blunt dissection. On occasion when it is more tenacious, cutting of the fascia may be necessary. It is recommended that this is done in a vertical manner to avoid injury to the inferior epigastric vessels, which lie in the medial aspect of the incision. Identification of the preperitoneal space is made by the characteristic appearance of the fat of the preperitoneal space and the identification of the inferior epigastric vessels in the medial aspect of the incision. A crucial aspect of the operation is to ensure that the surgeon dissects within the preperitoneal space. Identification of the inferior epigastric vessels, which lie in the medial portion of the incision within the preperitoneal fat and keeping the dissection posterior to these vessels, will assure that the surgeon will complete the operation in the correct compartment.

## Preperitoneal Dissection

Once the preperitoneal space is entered, it is important to become oriented to the anatomy. The internal ring will lie immediately inferior to your incision with the cord structures lying anterior and lateral as they prepare to exit the preperitoneal space through the internal ring. Hesselbach's triangle will lie just inferior and medial to the inferior epigastric vessels. It is best to approach the dissection as consisting of two compartments: Medial and lateral. Direct and femoral hernias will be in the medial compartment. Indirect hernias will lie in the lateral compartment. The order of approaching the compartments depends on the surgeon's preference. My preference is to perform the medial dissection first unless there is such a large indirect hernia present that would prohibit entering into the medial compartment. This would require doing the lateral compartment dissection first. The principal in the medial compartment dissection that needs to be maintained is complete reduction of the preperitoneal contents from the attachments to the transversalis fascia. Clear visualization of cooper's ligament from the pubic tubercle to the external iliac vessel is essential. In doing so,

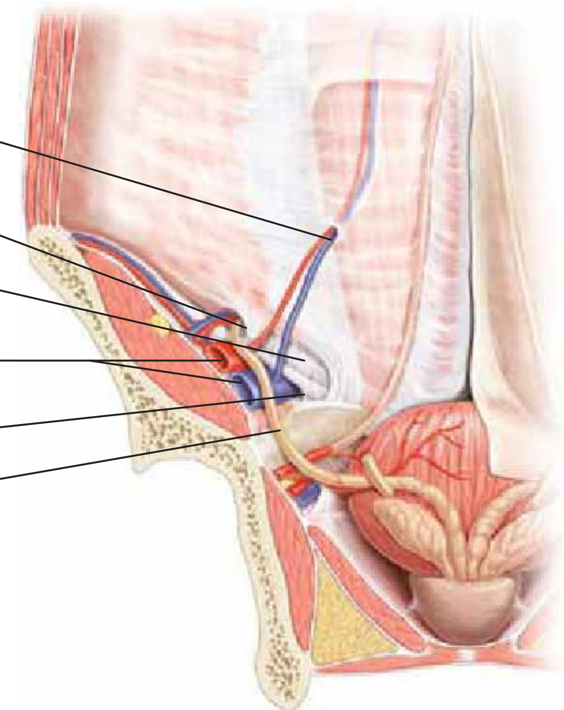



**Figure 8.3** View into the preperitoneal space prepared for receiving the patch.

the direct hernias will be reduced and femoral hernias if present will be identified. This dissection is carried out using blunt dissection with the finger of the surgeon sweeping the preperitoneal contents posteriorly and superiorly. This medial compartment dissection should be carried out to a point just medial to the pubic tubercle and superior to the incision in the transversalis fascia, which will create the space for the mesh. The headlight and the retraction provided by the dedicated assistant greatly help the visualization.

Attention is then turned to the lateral compartment. The first step in the lateral compartment dissection is identification of the cord structures. The goal to be achieved is skeletonization of the cord thereby identifying a potential indirect hernia. The peritoneal reflection should be reduced approximately 3 cm above the internal ring or to a point above the diversion of the vas deferens from the cord vessels. Once reduced, the indirect hernia sac can be left alone or ligated and amputated. Inspection should also be carried out to the area lateral and superior to the cord structures creating space by freeing the preperitoneal contents, which will allow for free deployment of the mesh (see Fig. 8.3). Again the headlight and the dedicated assistant.

The space is now ready for mesh insertion (Fig. 8.4). A useful technique is to use a narrow malleable retractor placed on the peritoneum retracting it superiorly as the mesh is slid into position over the surface of the retractor. The Kugel inguinal mesh is specifically designed for this application. The transverse slit is designed into the mesh to allow for the surgeon to place the mesh over the index finger of the hand of the surgeon opposite to the patient's side upon which they are operating, i.e., left-sided hernia right-handed insertion. The mesh is gently folded over the finger of the surgeon into their palm in the form of a taco to allow for this placement. The mesh is slid into position with the extensor surface of the surgeon's hand sliding along the malleable retractor until the surgeon can easily palpate the pubic tubercle with the tip of the index finger that has been inserted into the mesh slit. The surgeon's hand is then withdrawn and replaced by the malleable retractor into the slit to stabilize and hold the mesh in position as the mesh is unfolded into its proper deployment. The mesh is then deployed back over on to the peritoneum in a curved but unbuckled profile covering all potential defects in the groin. The mesh chosen ought to be large enough to cover the opening in the transversalis fascia extending 2 to 3 cm above the opening that was made for the

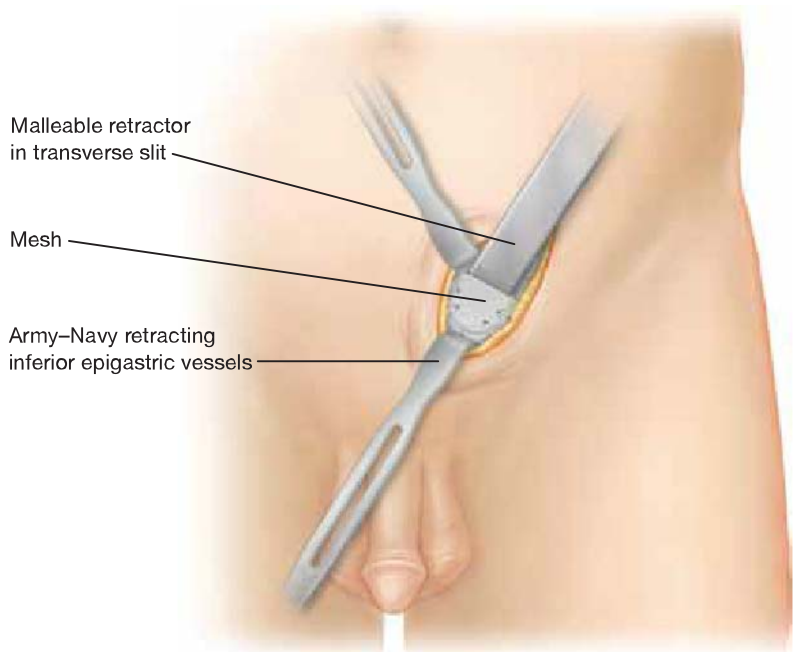



**Figure 8.4** Mesh Insertion.



incision. Two sizes of the mesh are available for insertion as previously described. In our experience, approximately 75% of hernias have been repaired with the smaller patch. The mesh is secured to the transversalis fascia in the medial portion of the transversalis incision with one absorbable suture. The transversalis fascia is then closed over the surface of the mesh with a running suture. The internal oblique musculature is allowed to recompose itself without suture thereby avoiding possible nerve entrapment. The external oblique and skin can be closed per the surgeon preference, again taking care not to entrap any underlying nerves.

### Recurrent Hernia

Repair of recurrent hernias following this repair or previous laparoscopic repair are best avoided using a Kugel approach. Recurrent hernias following prior anterior repair, however, are ideal candidates for this approach. The majority of scar tissue from the original repair is avoided and the repair is generally not much more difficult than a primary repair. This approach allows for a more thorough evaluation of the posterior space and should reduce the risk of a missed second defect. The most common difficulty encountered with these repairs is scar tissue at the internal ring associated with a prior high ligation of the sac.

### Femoral Hernias

Experience with this technique and with laparoscopic hernia repair suggests greater prevalence of femoral hernias than previously believed. These will sometimes be encountered unexpectedly during the surgery for an indirect or direct inguinal hernia. The hallmark of the femoral hernia from within the preperitoneal space is an obstructing mass just medial to the external iliac vein which extends into the femoral canal. This will prevent proper deployment of the preperitoneal pocket for the mesh patch until the mass is reduced.

## POSTOPERATIVE MANAGEMENT

The majority of patients are discharged from the recovery area when appropriate. No specific restrictions are placed on them regarding all activities including lifting. The patient is cautioned that their greatest discomfort can be expected during the first 2 to 3 days and this should taper off rapidly thereafter. Patients are asked to increase their activities a little every day until returning to normal. Most patients are usually able to resume most regular activities within a few days to a week. Most patients will require approximately three to ten mild narcotic pain relievers over the first few days following the operation, but generally these can be replaced with either non-steroidal anti-inflammatory medications or other over-the-counter pain relievers. Most patients are seen in 1 to 2 weeks following surgery and then discharged.

## RESULTS

In an earlier addition of this text book, Dr. Robert Kugel reported 1,662 groin hernia repairs. Of these, there were 803 primary right inguinal hernia repairs and 725 primary left inguinal repairs. There were 85 repairs performed for recurrent right inguinal hernias and 49 repairs performed for recurrent left inguinal hernias. In the 10 years following that initial report, there had been a total of seven recurrences. All of those recurrences were in the primary repairs with an overall recurrence rate of 0.42%.

My group reported our results in 2005. We did 1,072 repairs with an overall recurrence rate of 0.47% with a mean follow-up of 23 months. We demonstrated rapid operating times, minimal postoperative pain, expeditious return to work, and no reports of chronic pain. Multiple other studies have been published since that time and with similar results.

## COMPLICATIONS

Complications are infection, bleeding, recurrence, or chronic pain. These issues will be addressed individually.

1. **Infections:** Infections are early or late. Early infections occur within the first couple of weeks following the hernia procedure and should be treated as skin and subcutaneous infections. Aggressive local wound care and antibiotics are advised. I think the initial approach should be one with the idea of salvaging the mesh. CT scan imaging can be helpful to determine the depth of the infection. If the infection does not penetrate into the preperitoneal space, the wound can be opened for good drainage. With antibiotics, salvaging the mesh is usually successful. If however, there is clear evidence of infection extending into the preperitoneal space, I believe that the most prudent course is to remove the mesh and handle the infection appropriately. It would be ill-advised to immediately place another synthetic mesh material into the wound. The use of biologic meshes or tissue repair in this setting would be up to the discretion of the operating surgeon.

   Late infections usually occur well past the initial operation. It generally means that a mesh infection is present. Prolonged antibiotics can be attempted, but they generally are not effective and in most cases the mesh will need to be removed. Early removal of the mesh results in a more rapid resolution of the problem rather than prolonging the problem with unsuccessful therapy.
2. **Recurrences:** There are few recurrences in the published reports. Causes and mechanisms of recurrences have not been clearly defined. One of the primary concerns involves the extent of mesh shrinkage secondary to the ongoing inflammatory reaction through the polypropylene in the mesh. This shrinkage has been estimated in multiple published reports to range between 5% and 30%. As long as an adequate-sized mesh is utilized and the mesh is deployed in the proper position, this should allow for the estimated shrinkage and prohibit recurrence from that point of view.

   In our experience of operating on our own recurrences as well as other recurrences, the most common cause was a missed indirect hernia. This probably resulted from the failure to completely skeletonize the cord structures at the time of the initial operation and recognize the presence of an indirect hernia. This resulted in a persistent indirect hernia rather than a recurrence.

3. **Bleeding:** Bleeding is not a common problem as the dissection is generally performed in a bloodless plane. A preperitoneal repair should be avoided or approached with caution in patients who require aggressive preoperative anticoagulation secondary to other underlying hypercoagulable or thromboembolic conditions (i.e., mechanical cardiac valves), the preperitoneal space is very susceptible to ongoing hemorrhage secondary to the induced hypocoagulable situation. This ongoing hemorrhage can be extremely difficult to recognize in the preperitoneal space and significant hemorrhage can occur before it is picked up. It is therefore advisable that an anterior repair be carried out in these patients so that if bleeding does occur it is obvious and can be addressed immediately.
4. **Seromas:** Seromas commonly occur, particularly in direct hernia repairs. The patient will usually present at the initial postoperative visit complaining of persistence of the hernia.

   On examination, a smooth slightly tender mass, which is nonreducible and does not change with Valsalva will be identified in the inguinal canal. If obtained, an ultrasound will demonstrate the presence of the seroma and we will reassure the surgeon as well as the patient. Unless there are clear signs of infection, no other intervention needs to be or should be taken in regards to the presence of the seroma. They will resolve spontaneously if left alone.
5. **Chronic groin pain:** Chronic groin pain or inguinodynia is defined as pain within the groin. General surgeons see this condition most often following inguinal hernia repair. The most common etiology for this chronic pain is suspected to be related to either direct injury or entrapment of one of the four nerves within the inguinal region. These nerves are the iliohypogastric, ilioinguinal, genitofemoral, and lateral femoral cutaneous nerves.

Because of the performance of the Kugel hernia repair in regards to its muscle splitting technique and avoidance of sutures within the internal oblique, nerve injury and subsequent entrapment is rare. In addition, in the Kugel approach, there is no need for fixation within the preperitoneal space that could entrap the lateral femoral cutaneous nerve. The surgeon needs to be very aware of the anatomical course of these nerves and keep the dissection in the planes as described and avoid placement of sutures into the external oblique at the completion of the operation, which could entrap the ilioinguinal nerve.

## MISCELLANEOUS COMPLICATIONS

There have been concerns about the direct exposure of the mesh to the iliac vessels. The mesh is specifically flanged on its peripheral 1 cm to prevent direct pressure onto the vessels as it is deployed over the surface of the peritoneum in the preperitoneal space. In addition, it is not necessary or recommended to skeletonize the external iliac vein, the most medial structure within the vascular bundle. Dissection only needs to be carried out at the level of the lacunar ligament to assure that no femoral hernia exists. Avoidance of this excessive dissection will protect the vessels from direct exposure with a surface layer of undisturbed tissue.

There has been intense medical and legal discussion in regards to fractured rings within the Kugel patches resulting in bowel injury. This problem has only been reported in Extra Large Composix Kugel products utilized in ventral hernia repairs and never truly verified. No reports of such injuries have been reported in a Kugel inguinal repair with the Kugel hernia patch.

# Discussion

The preperitoneal mesh patch prosthesis utilizes those forces only available to a posterior repair. Intraabdominal pressure works in securing the patch in position. A fully expended and appropriately sized patch, with its semi-rigid ring, is difficult to displace through any hernia defect encountered in the groin. Since the patch is placed without fixation sutures, hydrostatic tissue forces also come into play in securing the patch into position. The patch is allowed to more perfectly conform to the patient's unique anatomy, and the two wet surfaces on either side of the patch sandwich it in place and resist patch movement. This method of repair provides protection for the entire groin including the femoral canal and the surgical incision itself. It is an ideal approach following prior anterior hernia repair as it avoids most of the associated scar tissue from the prior repair.

The disadvantages of this repair are related to obtaining the appropriate visualization of the preperitoneal space, assurance of dissection within the correct preperitoneal space, and confidence on the part of the surgeon in regards to the proper deployment of the mesh into the appropriate space. Use of a headlight and a dedicated assistant reduce the disadvantages.

Working with an experienced surgeon on several cases before attempting the repair solo allows for the surgeon to gain the confidence in regards to being able to clearly identify the preperitoneal space and its anatomy as well as to recognize when proper deployment of the mesh is achieved.

# Summary

As incidence of recurrence, safety, ease of performance, and shortened disability periods are considered in selection of a hernia repair, the Kugel inguinal hernia repair demonstrates its attractive advantages. Accumulated experience has demonstrated it to be an effective repair.

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# 9 Incarcerated Femoral Hernia

**Shirin Towfigh**

## INDICATIONS/CONTRAINDICATIONS

Femoral hernias are rare, comprising 4% of all groin hernias. Patients with femoral hernias are on average older than those with inguinal hernias (63 year vs. 59 years), and twice as many are over age 80 (19% vs. 8.5%). This is important because 35% of femoral hernias require emergent surgery due to incarceration or strangulation, compared to 5% of inguinal hernias. Also, 18% of emergent femoral hernia repairs require a bowel resection, as compared to 5% of inguinal hernias.

Historically, mortality rates as high as 25% had been reported, and modern day mortality rate for femoral hernia surgery is 3%, which is ten-fold higher than other hernia repairs. Thus, watchful waiting is not advocated for femoral hernias and early elective repair is recommended whenever possible.

## PREOPERATIVE PLANNING

Patients with incarcerated or strangulated femoral hernias are often misdiagnosed, diagnosed late, or die without diagnosis. In thin patients, an irreducible, often painful bulge is seen in the groin. The hernia has a tendency to migrate anteriorly; thus on examination this bulge may present as a mass above the inguinal ligament and misdiagnosed preoperatively as an incarcerated inguinal hernia. In obese patients, it is common to miss a small incarcerated or strangulated hernia.

With the liberal use of CT scanning for patients with abdominal pain, the diagnosis of an incarcerated to strangulated femoral hernia may be formed preoperatively. This will help in planning for surgery, as the surgical approach differs based on the clinical scenario.

- **Strangulated hernia.** If a strangulated hernia is diagnosed clinically or radiologically preoperative, the preferred choices of repair include: (1) Open preperitoneal approach, or (2) laparoscopic transabdominal approach. With both of these techniques, the hernia contents may be examined for signs of strangulation and addressed through the same approach while performing the femoral hernia repair. Also, a concomitant inguinal hernia (usually direct) may be diagnosed and repaired.

- **Incarcerated hernia.** If there is clearly no clinical sign of strangulation, such as sepsis, skin erythema, and no radiologic suggestion on CT scan, the choices of repair are much greater. These include: (1) Infrainguinal approach, (2) transinguinal approach, (3) open preperitoneal approach, (4) laparoscopic preperitoneal or transabdominal approach.
- **Recurrent hernia.** Femoral hernias may be missed after repair of an inguinal hernia, may occur after repair of a direct hernia, or may be recurrent. In these situations, a mesh repair is highly encouraged. These may be performed via the approaches listed below.

## SURGERY

The history of femoral hernia repair dates back to 1876 when Thomas Annandale plugged a femoral hernia defect with the hernia sac excised from a concomitant inguinal hernia repair. In 1883, Lawson Tait primarily repaired a femoral hernia using a silk suture; William Cheyne placed a pectineus muscle plug in 1892, and Howard Kelly inserted an agate marble in a femoral defect in 1898. Below are the most commonly performed procedures in modern day femoral hernia repair.

### Infrainguinal Approach

Commonly referred to as the "low" or "Lockwood" approach, this repair has been described by Marcy, Bassini, Lockwood, and Lichtenstein. This approach should be reserved for elective repairs or simple incarcerated hernias without evidence of strangulation. The low approach is more appropriately applied to women, as men are more likely to have a concomitant inguinal hernia that may need to be addressed at the same setting.

- A transverse skin incision is made at the level of the bulge, 4 cm wide (Fig. 9.1A and Fig. 9.2). The fat is meticulously dissected with electrocautery until the sac is encountered. Small vessels in communication with the long saphenous vein are ligated. The femoral vein is identified early and gently retracted to avoid injuring it throughout the rest of the procedure. The sac is dissected deep toward the femoral canal orifice. Pull on the sac toward you and laterally in order to inspect the medial wall of the femoral sac, which may contain the bladder wall. The neck of the sac is dissected circumferentially and it is allowed to retract back through the canal into the retroperitoneal space.
- Often, the sac is not reducible due to the tight femoral orifice. The orifice should initially be bluntly widened by passing a dissector through the orifice and spreading it open. If this is not successful, the lacunar ligament of Gimbernat, which is immediately medial to the canal, can be incised transversely (Fig. 9.3). This is not a

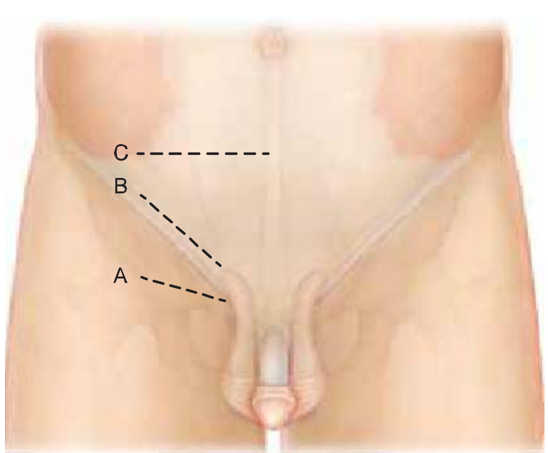


**Figure 9.1** Location of incisions based on approach. **A:** infrainguinal approach; **B:** transinguinal approach; **C:** nyhus transabdominal preperitoneal approach.

**Figure 9.2** Right femoral hernia defect with preperitoneal fat content. Infrainguinal incision.

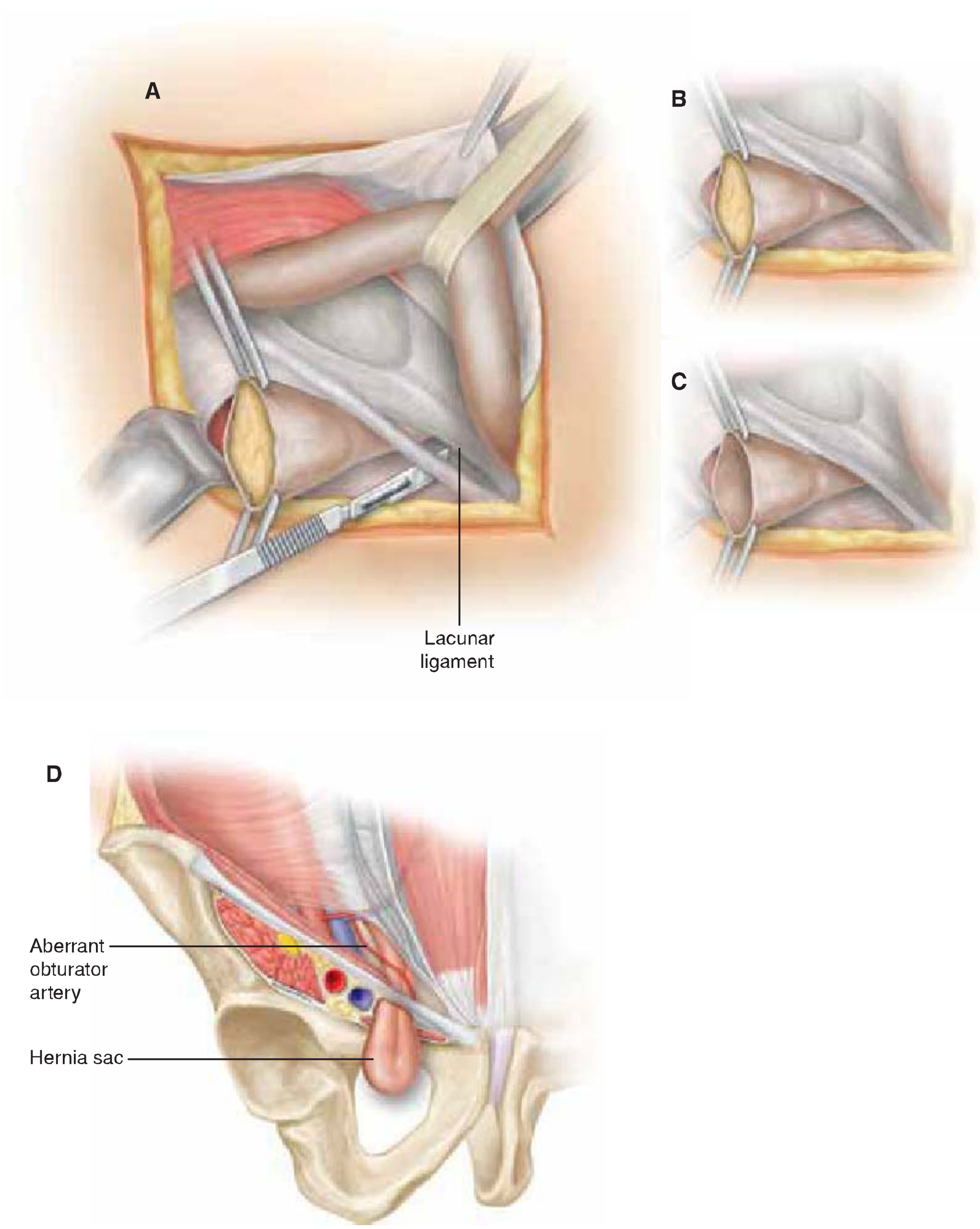


**Figure 9.3** Lateral incision of the lacunar ligament of Gimbernat (**A–C**). Note the variable anatomy of the obturator artery as it relates to lacunar ligament (**D**).

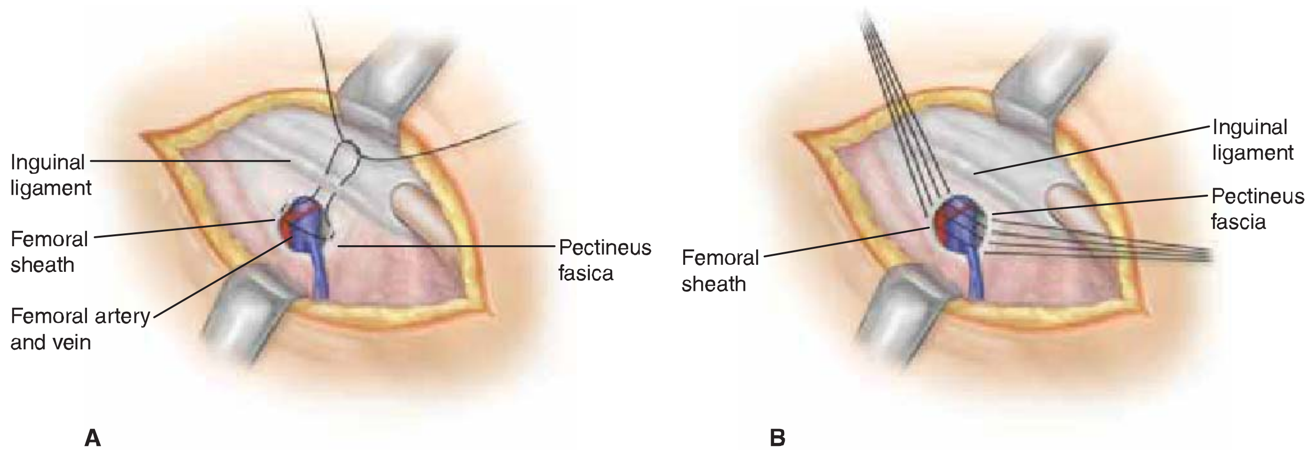


**Figure 9.4** Primary repair of femoral hernia using the low infrainguinal approach. **A:** Macy purse-string; **B:** Bassini

risk-free procedure, as there may be an aberrant obturator artery (less than 1/3) in this plane. An alternative procedure is anterior incision (without transection) of the inguinal ligament.

- Opening of the hernia sac is not necessary, unless there is a question of strangulated content. Similar to inguinal hernias, a high dissection and reduction of the sac is adequate. However, if the contents cannot be reduced or there is a need to inspect the hernia content, then carefully open the sac, as the bladder may be involved with the medial wall. Fluid will likely exude from the sac.
- **Primary repair.** Primary closure of the defect is performed with non-absorbable suture. It is known to have a high recurrence rate and can cause significant postoperative pain due to the tension in this region. It should be reserved for defects 1 cm or less.
  - **Macy purse-string.** The external oblique fascia is grasped and elevated, demonstrating the ilioinguinal ligament. A single suture is used, starting from the ilioinguinal ligament superiorly, the lacunar ligament of Gimbernat medially, the pectineal fascia inferiorly, and the femoral sheath laterally, and then back onto the ilioinguinal ligament (Fig. 9.4A).
  - **Bassini repair.** The external oblique fascia is grasped and elevated for exposure. Interrupted sutures approximate the ilioinguinal ligament (superiorly) with pectineal fascia (inferiorly) (Fig. 9.4B).
- **Mesh Repair.** Since primary repair has a three-fold higher recurrence rate than mesh repair, larger hernias and recurrent hernias should be repaired with mesh.
  - **Lichtenstein plug.** A 2 × 20 cm flat polypropylene mesh is rolled and snugly placed into the femoral orifice (Fig. 9.5). It is sutured full-thickness in three places: Ilioinguinal ligament (superiorly), lacunar ligament of Gimbernat (medially), and pectineus fascia (inferiorly).
  - **Mesh Plug.** A pre-made shuttle-cock type plug, originally designed by Robbins and Rutkow, is inserted into the femoral defect. The typical size used is a small or medium plug. The inner leaflets may be trimmed to reduce the bulk of the mesh as needed. The outer leaflet of the plug may be left within the canal, as originally described, or pushed deep through the femoral ring and allowed to spring open, covering the femoral vessels laterally, the lacunar ligament medially, and Cooper's ligament inferiorly (see Chapter 3, Plug and Patch Inguinal Hernia Repair). The inner leaflets are sewn similar to the Lichtenstein plug.

In my experience and others, primary repair of anything but the smallest of femoral hernias causes severe and at times disabling groin pain due to undue tension. At the same time, I do not advocate placing a large bulky mesh in the femoral canal, as this may cause pain due to mass effect, venous obstruction, or even deep vein thrombosis. My preference for elective or non-strangulated hernia repairs is a modification of the

**Figure 9.5** Right femoral hernia repaired using modified Lichtenstein plug procedure. Infrainguinal approach.

Lichtenstein plug technique, which was taught to me by Dr. Edward H. Phillips. A flat polypropylene mesh is cut and rolled. The length of the mesh should be no longer than the depth of the canal; i.e., 1 to 2.5 cm, in order to reduce the chance of invasion into other organs once it is sutured in place. The length of the mesh should be determined by the width of the orifice. Once the mesh is rolled, it should be placed in the orifice and allowed to gently roll open, as opposed to fitting snugly (Fig. 9.5). The mesh is then sutured similar to the Lichtenstein plug approach. A suction drain should be considered, as hematoma or seroma after this procedure is common.

## Transinguinal Approach

This approach has been described by Ruggi, Moschcowitz, and Lothiessen, and McVay. The transinguinal approach is the most commonly chosen approach when an incarcerated femoral hernia is preoperatively misdiagnosed as an inguinal hernia. At the same time, it is important to note that among men, femoral hernias are often associated with (direct) inguinal hernias, thus many advocate the transinguinal (or preperitoneal) approach for men, since a low infrainguinal approach may miss another hernia.

The transinguinal approach was first described by Annadale when repairing a combined femoral and inguinal hernia and the redundant hernia sac was used to plug the femoral defect. However, if preoperative testing, such as the ultrasound or CT scan, confirms there is no inguinal hernia, then a transinguinal approach is not advocated, as it may weaken an otherwise normal inguinal floor.

- The approach begins similar to an open inguinal hernia repair (Fig. 9.1B). If an inguinal hernia (direct or indirect) is encountered, it should be repaired at the same setting.
- The transversalis fascia is incised from the pubis to the internal ring, transversely. The lower edge is grasped and careful blunt dissection is carried down toward Cooper's ligament. Be wary of an aberrant obturator artery which lies medially over the lacunar ligament of Gimbernat and can be injured with dissection in this region (Fig. 9.3D). Reduction of the femoral hernia can be performed by gentle traction from this angle in addition to external pressure at the lower groin. If the sac still cannot be reduced, then anterior incision of the peritoneum and manual reduction of the abdominal contents is required.
- The hernia sac may be delivered into the inguinal floor opening. The choice of opening the sac is dependent on the need to examine its contents. The sac should be highly dissected off the pelvic wall.
- **Primary repair.** Primary closure of the defect is performed with non-absorbable suture. It is known to have a high recurrence rate and can cause significant postoperative pain due to the tension in this region. It should be reserved for defects 1 cm or less or situations where the mesh is contraindicated, such as a strangulated hernia.

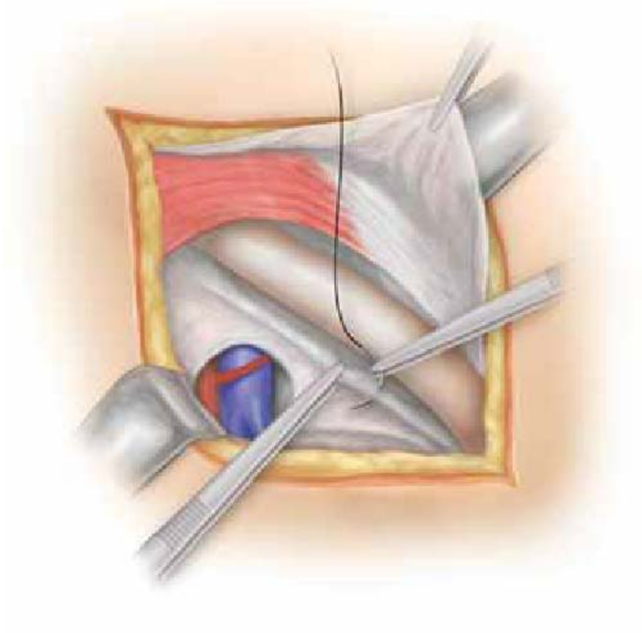

**Figure 9.6** The Ruggi primary repair of the femoral hernia.

Unlike the low infrainguinal approach, the transinguinal approach does allow for access to strangulated hernia contents, though limited, with the ability to perform a resection as necessary.

- **Lytle purse-string.** The goal of this closure is to close off the distal femoral orifice, which is the source of incarceration. This closure is performed inside the femoral ring as opposed to the Macy purse-string, which closes the orifice on the outside. The femoral orifice (canal end) is 2 cm caudal to the femoral ring (canal opening). Due to the intrinsic tension in this repair, it should be limited to defects less than 1 cm. A single suture is used, starting anteriorly at the lacunar ligament of Gimbernat, below the level of the iliopubic tract. Medially, the medial wall of the femoral canal; i.e., the lacunar ligament, is sutured. Posteriorly, the pectineal fascia is sutured, and laterally, the femoral sheath is sutured.
- **Ruggi repair.** The external oblique fascia is grasped and elevated for exposure. Interrupted sutures approximate the iliopubic tract (superiorly) with Cooper's ligament (inferiorly) (Fig. 9.6). This requires suturing between two fairly stiff structures, resulting in a tension repair which can cause pain and early recurrence. The Moschcowitz modification adds an inguinal hernia tissue repair, understanding that the iliopubic tract repair alone may result in a direct inguinal hernia.
- **Lothiessen repair.** The conjoint tendon (internal oblique, transversus abdominis, transversalis fascia) is sutured to Cooper's ligament, thus closing off the femoral canal. This is essentially the technique more commonly known as the McVay procedure (see Chapter 6, Cooper Ligament Repair). Care must be taken not to narrow the femoral vein with this technique. Also, a relaxing incision at the anterior rectus fascia will help reduce the inherent tension in this repair.

- **Mesh repair.** Use of prosthetic mesh transinguinally can provide for a tension-free repair of a femoral hernia and may also provide for inguinal hernia repair or strengthening of a weak inguinal floor.
  - **Modified Lichtenstein mesh onlay.** The typical flat mesh repair popularized by Lichtenstein can be tailored to repair an inguinofemoral hernia. This requires cutting the mesh to include a triangular lip on the underside (Fig. 9.7). The inguinal floor has already been opened and the femoral hernia reduced. The mesh is then sutured to the inguinal ligament in normal fashion (see Chapter 2, Lichtenstein-based Groin Hernia Repair); however, the lip is also sutured to Cooper's ligament, thereby covering the femoral canal.

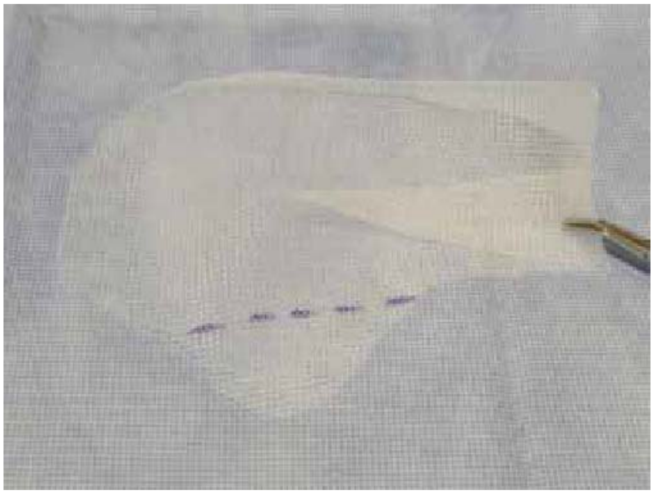

Figure 9.7 Modified Lichtenstein hernia repair onlay mesh.



- **Mesh plug.** See “Mesh plug” above, as the transinguinal technique is similar. Note that the femoral canal is a conical structure, widest at the femoral ring and narrowest at the femoral orifice caudally, thus a conical mesh plug may naturally fill in this space. Care must be taken not to injure or cause a mass effect on the femoral vein or the bladder.
- **Preperitoneal mesh underlay.** Premanufactured two-layer mesh can be used to repair a femoral hernia due to its broad underlay component. Such a product is placed without suturing of the underlay component, thus a large enough mesh is necessary to ensure wide overlap with the femoral canal (see Chapter 4, Prolene Hernia System).

## Open Retroperitoneal Approach

Often called “high,” “transabdominal,” or suprainguinal approach, this repair is the most sophisticated approach and should be considered as the preferred approach when suspecting strangulation. This was first described by gynecologists who noted femoral defects when operating in the pelvis. The techniques were later promoted as the primary mode of repair of both inguinal and femoral hernias by Cheatle, Henry, McEvedy, and Nyhus.

- A transverse incision (Nyhus) is made on the same side as the hernia, 2 finger-breadths above the inguinal ligament (Fig. 9.1C). Alternatively, an oblique lateral incision (McEvedy) can be made or a low midline incision (Cheatle, Henry) can be useful for bilateral repairs. The key is to place the incision close enough to the hernia defect to be able to repair it, but not so low that it invades the inguinal floor.
- The rectus muscle is either transected or retracted while the fascial layers are cut parallel to the incision. In effect, this is a very low transverse laparotomy.
- When incising the transversalis fascia, take care in maintaining an intact peritoneum. Next, develop a retromuscular, preperitoneal plane and dissect caudally toward the inguinal region, dissecting around the neck of the incarcerated hernia. If possible, the hernia should be reduced at this time. It may be necessary to apply external pressure at the lower groin to help in the reduction. If this is not possible, then incise the peritoneum to manually decompress the contents from the hernia. The lacunar ligament of Gimbernat may need to be incised medial to the defect, with care not to injure an aberrant obturatory artery (Fig. 9.3). Rarely, the inguinal ligament requires anterior incision.
- With the peritoneum opened, the abdominal contents are carefully examined for strangulation. If necessary, resection is performed via this approach in a much more facile manner than any other open approach.
- The peritoneum is fully dissected off the pelvic wall, similar to a Stoppa dissection, with care not to injure the bladder, external iliac vessels, and inguinal nerves. The

inguinal floor is examined for concomitant hernias. Once the area is prepared, tissue or mesh repair is performed.

- **Primary repair.** Suture repair of the femoral hernia defect follows the guidelines of Ruggi, described above; i.e., interrupted sutures between the iliopubic tract (superiorly) and Cooper's ligament (inferiorly) (Fig. 9.6). The postoperative recurrence rate and pain after suturing these two rigid structures is unacceptable and thus this technique should be limited to situations in which prosthetic is contraindicated, such as strangulated intestine.
- **Mesh repair.** Modern day hernia repair has demonstrated the superiority of mesh repair over tissue repair in terms of hernia recurrence rate. Using the transabdominal approach, the retroperitoneal space that is developed is much larger than that seen with the transinguinal approach, and thus a larger mesh may be placed. This advantage results in a lower hernia recurrence rate, which may be important if a concomitant inguinal hernia is found or if the defect is large.
  - **Kugel repair.** The retroperitoneal placement of mesh with wide overlap of the hernia defects was first promoted by Rives and Stoppa. Kugel promoted the unilateral open preperitoneal approach for both inguinal and femoral hernias using a small incision (see Chapter 8, Groin Hernia Repair/Kugel Technique).
  - **Laparoscopy.** Transabdominal laparoscopic exploration can provide for accurate diagnosis and treatment of an incarcerated or strangulated femoral hernia. It can also allow for exploration to rule out other inguinal floor hernias, which are more commonly seen among men. Reduction of an incarcerated omentum or intestine can be done safely with this method. In the case of a bowel obstruction, careful technique for initial entry and subsequent bowel manipulation can minimize the risk of inadvertent bowel injury. When reducing an incarcerated loop of intestine, traction on the decompressed distal loop will more likely result in successful reduction and decrease the risk of bowel perforation.
    - **Transabdominal preperitoneal (TAPP) approach.** This is the preferred initial approach for laparoscopic treatment of an incarcerated femoral hernia. Once the hernia contents are reduced, the standard TAPP repair can be performed (see Chapter 15, Laparoscopic Transabdominal Preperitoneal Inguinal Hernia Repair).
    - **Totally extraperitoneal approach.** In most cases, after laparoscopic exploration and reduction of the hernia contents, the surgeon can choose to convert to extraperitoneal approach for the hernia repair, if this is their preferred mode of laparoscopic repair (see Chapter 16, Totally Extraperitoneal Inguinal Hernia Repair).
    - When mesh is contraindicated, the Ruggi primary repair of the femoral defect (Fig. 9.6) can be performed laparoscopically by a skilled surgeon.
    - **The femoral "pseudo-hernia."** It has been noted that laparoscopy has increased the reported prevalence of femoral hernia from 4% to 11%. The important anatomical detail to note is that there is a natural fat pad in the space medial to the femoral vein, and this should not be misdiagnosed as a femoral hernia. This fat pad may include Cloquet's node and should not be disturbed. Also, a true femoral hernia not only has protrusion of contents into the femoral canal (opening), but this herniation extends the length of the femoral canal and through the femoral orifice (exit), which is typically narrower, thus the conical shape of the femoral canal.

In my opinion, the open transabdominal preperitoneal approach described by Nyhus is the preferred open approach to treat inguinal or femoral hernias when intraabdominal contents need to be examined. It is a unique incision that functions as a laparotomy, thus affording the surgeon the liberty to perform any abdominal surgical procedure, while at the same time it is low enough to allow for repair of the inguinal or femoral hernia. The use of mesh is preferred unless contraindicated due to contamination. In situations with minimal contamination, biologic mesh may be implanted, thus reducing the hernia recurrence rate as compared to tissue repair alone.

## POSTOPERATIVE MANAGEMENT

Management of the incision is based on the level of contamination and the size of the herniation. With contaminated or dirty wounds, the choice to close the wound, loosely close and probe the wound, or leave the wound open is dependent on the judgment and practice of the surgeon. With large femoral defects, the empty space remaining in the infrainguinal space will develop into a hematoma or seroma; many advocate placement of a closed suction device for 48 hours, especially after the low infrainguinal approach. As with all hernia repairs, activity level should not be restricted and early ambulation and return to activities should be encouraged.

## COMPLICATIONS

Most patients with femoral hernias are elderly and the majority of the operations are urgent or emergent procedures due to incarceration or strangulation. As a result, postoperative morbidity and mortality is often directly related to sepsis or cardiopulmonary complications due to sepsis or surgery. Early diagnosis and surgical treatment of incarcerated femoral hernias and prevention of strangulation can reduce these serious complications.

Postoperative complications can be expected to occur in approximately 15% of patients, and these include hematoma (29%), surgical site infection (15%), neuralgia (4%), and other (52%). Other complications may include deep vein thrombosis, bladder injury, anastomotic leakage, and cardiovascular compromise.

## CONCLUSIONS

Incarcerated or strangulated femoral hernias are found in the elderly and incur a high morbidity and mortality. With the liberal use of CT scanning and ultrasound, inguinal and femoral hernias can be accurately diagnosed, allowing for preoperative planning. The choice of surgical technique should be dependent on the severity of the illness and the patient's gender. Simple, incarcerated femoral hernias in women are best approached via the infrainguinal approach. Strangulated hernias are best approached via the transabdominal preperitoneal approach. If the patient is stable and the surgeon is skilled, laparoscopy may be used. Mesh repair is superior to tissue repair and should be considered unless there is a contraindication to placement of synthetic material, such as with strangulated intestine.

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# 10 Obturator Hernia

**George C. Sotiropoulos, Arnold Radtke, and Ernesto P. Molmenti**

## History and Anatomy

Reported original descriptions of obturator hernias date back to Le Maire in 1718 and Pierre Roland Arnaud de Ronsil in 1724.

The **obturator area** is delimited superiorly by the superior pubic ramus, inferiorly by the origin of the adductor magnus at the adductor tubercle of the femur, laterally by the hip joint and femur, and medially by the adductor and gracilis muscles, pubic arch, and perineum.

The **obturator foramen** is the largest bony foramen in the human body. It is formed by the rami of the ischium and pubis and, except in the area of the obturator canal, is covered by the obturator membrane. From an embryologic point of view, since the foramen and membrane represent an area of incomplete bone formation, the obturator foramen is a lacuna while the obturator canal is the real lumen (Fig. 10.1).

The **obturator canal** is 2 to 3 cm in length and originates at the obturator membrane in the pelvis. Its course is oblique and downward toward its termination in the obturator region of the thigh. The **boundaries of the obturator canal** are the obturator groove of the pubis above and laterally, and the internal and external obturator muscles and free edge of the obturator membrane inferiorly. The canal contains the **obturator artery, vein, and nerve.** The obturator artery divides to form a ring encircling the foramen and usually irrigates the head of the femur (Fig. 10.2).

The **obturator nerve** originates from the anterior divisions of L2 to L4. It arises beneath the psoas muscle, crosses the pelvic brim to the area where the common iliac vessels divide into external and internal branches, and subsequently travels downward toward the obturator foramen. Within the obturator canal, it travels above the obturator artery and vein. It represents the main nerve supply to the adductor compartment of the thigh and the obturator externus. As it exits the obturator canal, it divides into an anterior and a posterior division. Its anterior division innervates the gracilis and adductor longus. Its posterior division supplies the adductor brevis and anterior part of the adductor magnus. Hernia sacs may associate with either division of the obturator nerve. It provides sensory innervation for the intermediate part of the medial surface of the thigh and some innervation to the knee joint. The accessory obturator nerve (when present) travels over the superior public ramus and behind the femoral sheath to supply the pectineus muscle (Fig. 10.3).

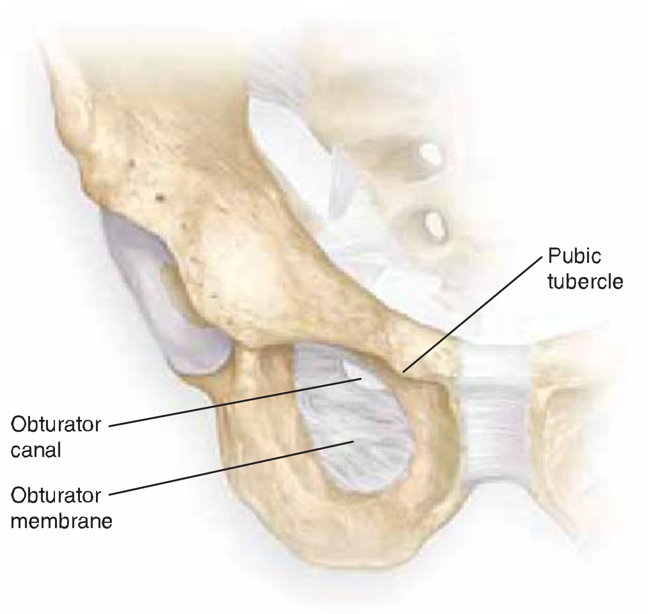



**Figure 10.1** The **obturator foramen** is the largest bony foramen in the human body. It is delimited by the rami of the ischium and pubis and, except in the area of the obturator canal, is covered by the obturator membrane. From an embryologic point of view, since the foramen and membrane represent an area of incomplete bone formation, the obturator foramen is a lacuna while the obturator canal is the real lumen.

The **obturator internus muscle,** supplied by the L5 and S1 nerves, abducts the thigh when flexed, and rotates laterally the extended thigh. Its pelvic surface forms the lateral boundary of the ischioanal fossa. It is joined by the superior and inferior gemelli outside of the pelvis.

# Presentation and Diagnosis

Although much less common than inguinal and femoral hernias (Fig. 10.4), obturator hernias are the most frequent pelvic floor hernias (Fig. 10.5). Obturator hernias represent 0.1% of all hernias. They are small and occur more frequently on the right side. Only 6% are bilateral. Their incidence is 6 times higher in women, especially in middle-aged and elderly individuals. Although the hernia sac usually contains small bowel, hernias encasing omentum, fat, appendix, Meckel's diverticulum, bladder, ureter, Fallopian tube, focus of endometriosis, and ovary have been reported.

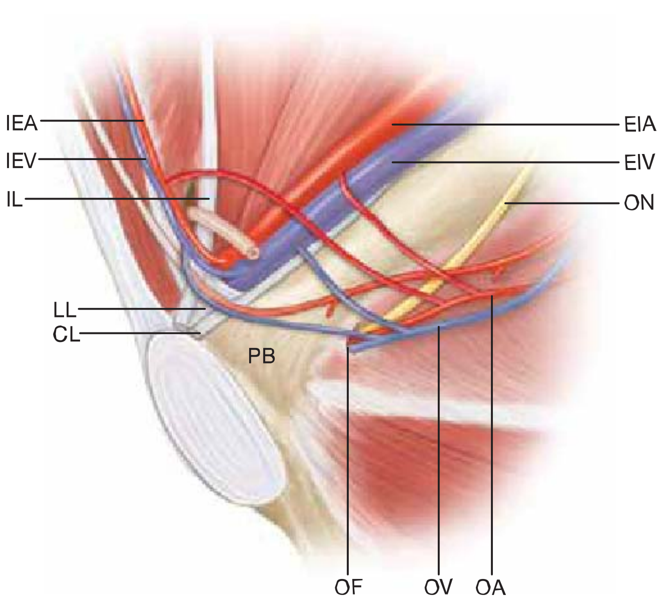



**Figure 10.2** The obturator canal contains the obturator artery, vein, and nerve. Depicted are the obturator nerve (ON), obturator foramen (OF), pubic bone (PB), Cooper's ligament (CL), lacunar ligament (LL), inguinal ligament (IL), external iliac artery (EIA), external iliac vein (EIV), inferior epigastric artery (IEA), inferior epigastric vein (IEV), obturator artery (OA) and obturator vein (OV).

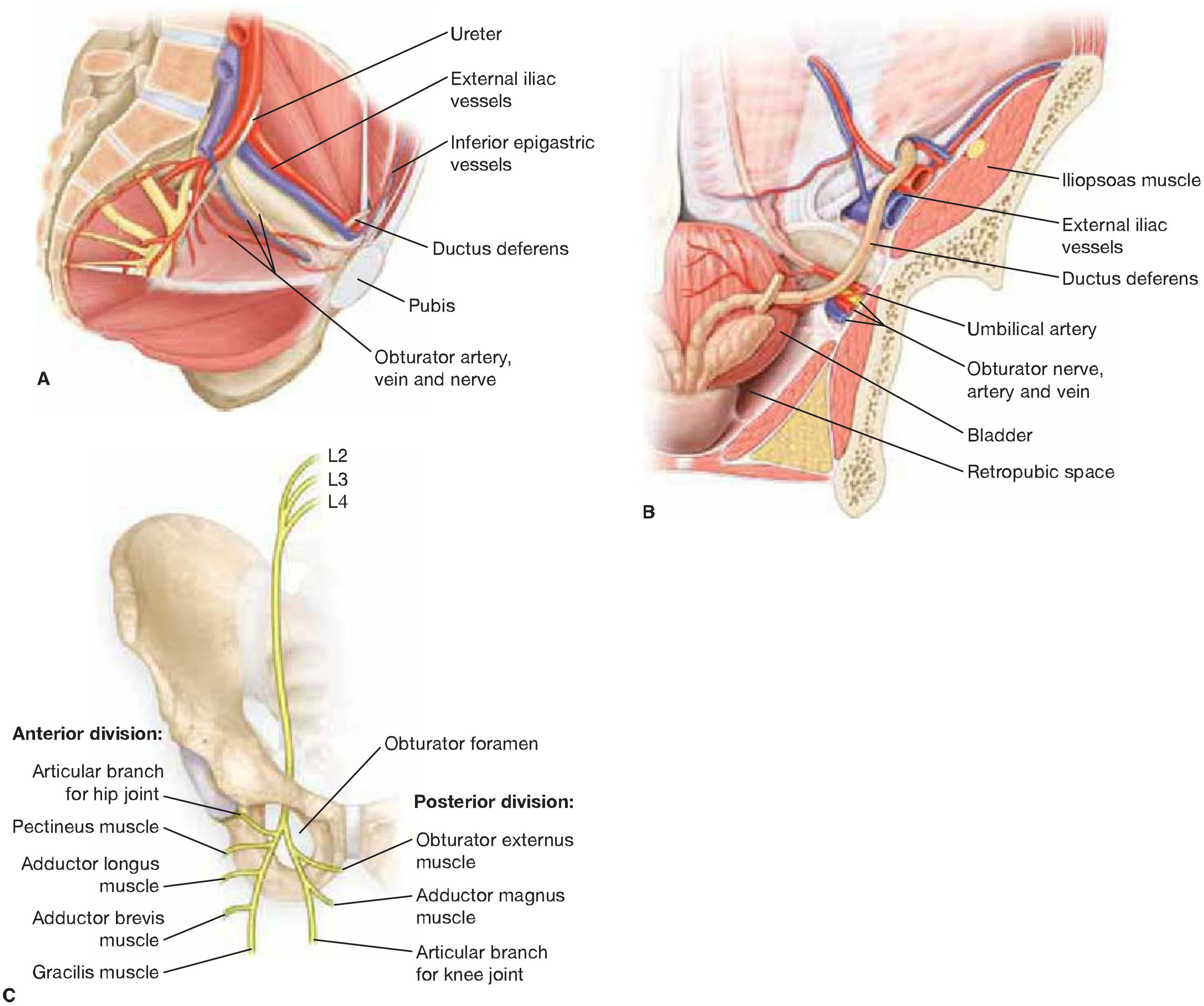



**Figure 10.3** **A:** Obturator canal and the structures within it as seen from within the pelvis. **B:** Coronal section illustrating the obturator nerve, artery, and vein. **C:** Obturator nerve.

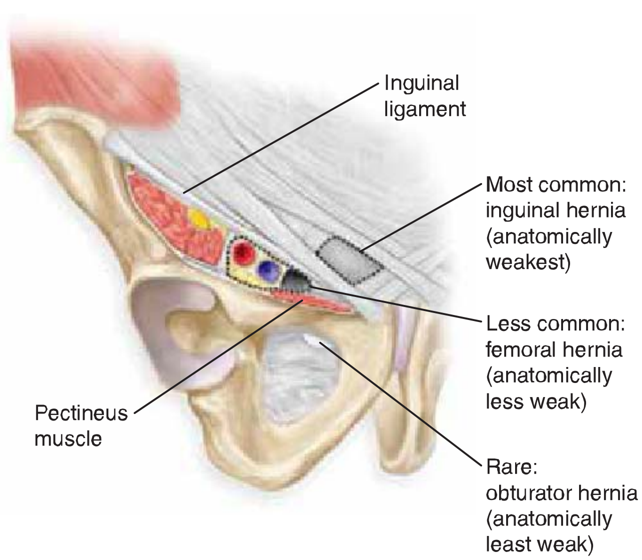



**Figure 10.4** Schematic depiction of inguinal, femoral, and obturator hernias.

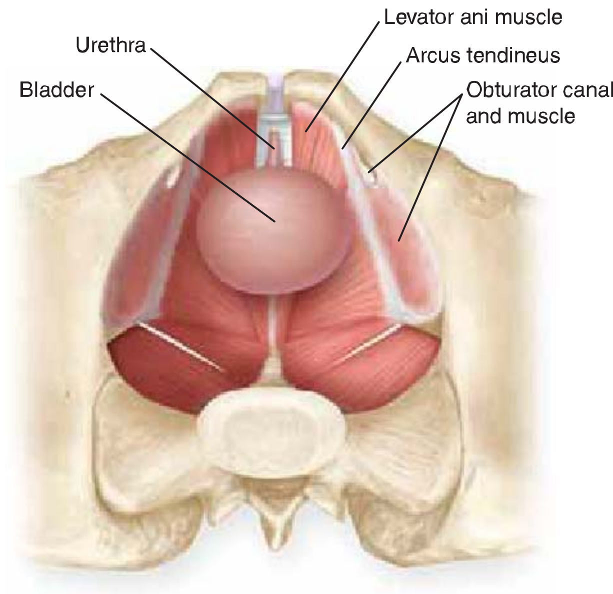



**Figure 10.5** Obturator hernias are the most frequent pelvic floor hernias.

The hernia sac is usually long and narrow within the obturator canal, and expands as it leaves the canal and enters the upper thigh (Figs. 10.6–10.8). Potentially predisposing factors include decreased fat in the obturator canal (usually associated with weight loss), a broad pelvis (commonly found in females) with a larger obturator canal, and progressive laxity of the pelvic floor (frequently due to multiple pregnancies, increased intraabdominal pressure, poor nutrition, and advanced age).

There are **three anatomically possible types of obturator hernias** (Fig. 10.9):

1. The most frequent type is when the hernia traverses together with the anterior division of the obturator nerve through the external orifice of the obturator canal. In these instances, the hernia is located underneath the pectineus and in front of the external obturator muscles.

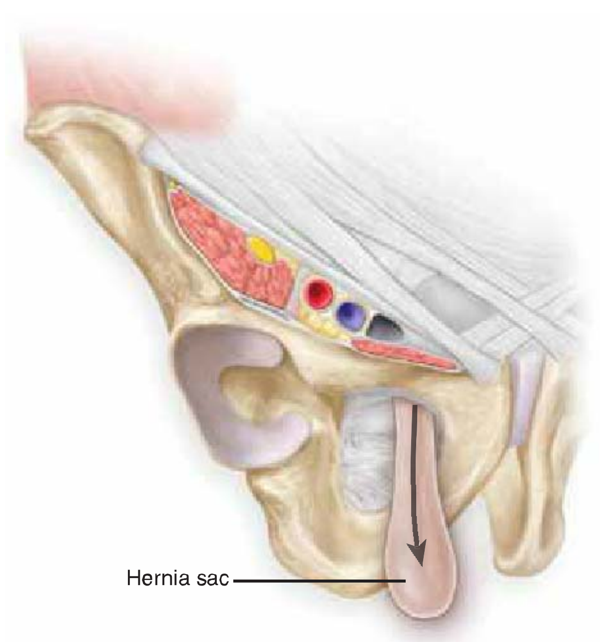



**Figure 10.6** The hernia sac is usually long and narrow within the obturator canal, and expands as it leaves the canal and enters the upper thigh.

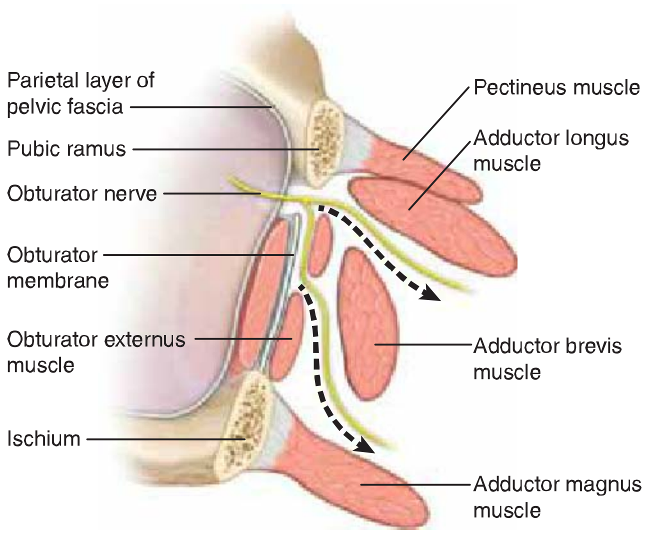
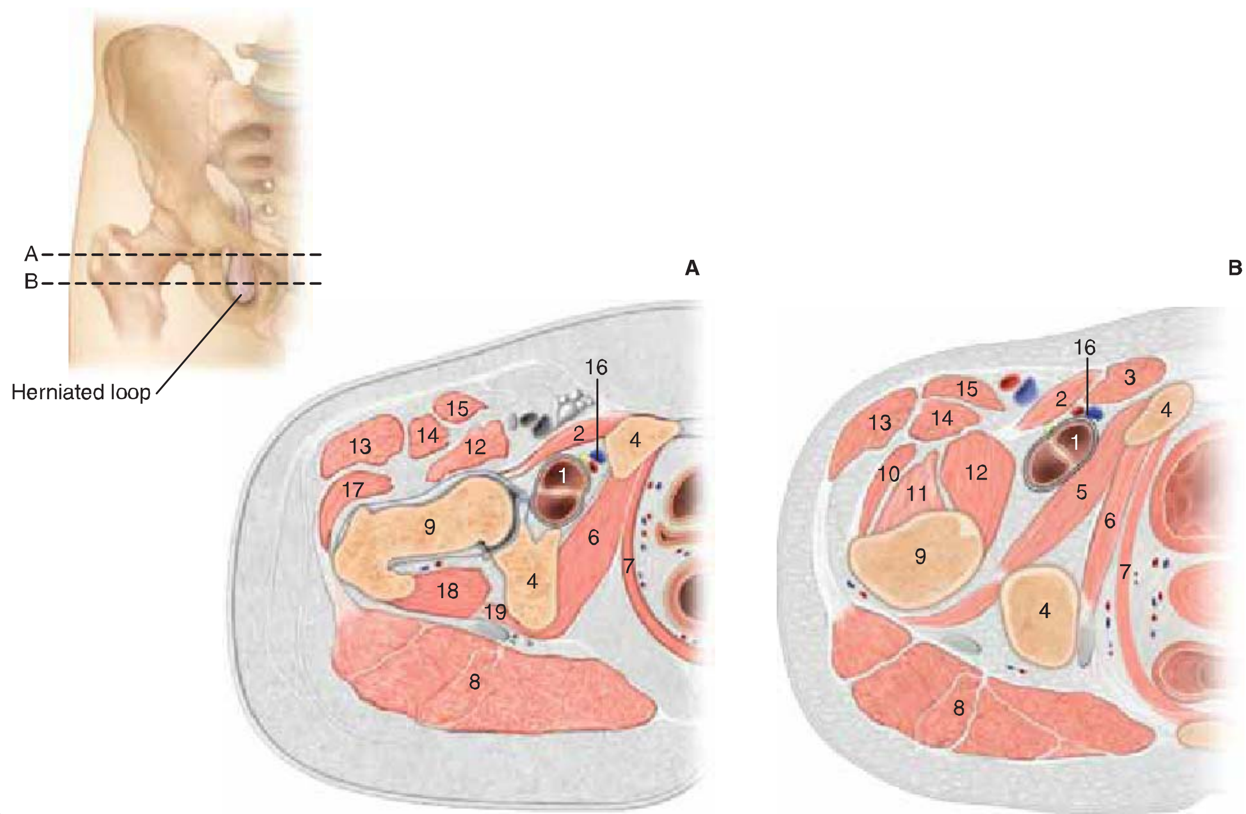



**Figure 10.7** Sagittal section showing possible courses of obturator hernias.



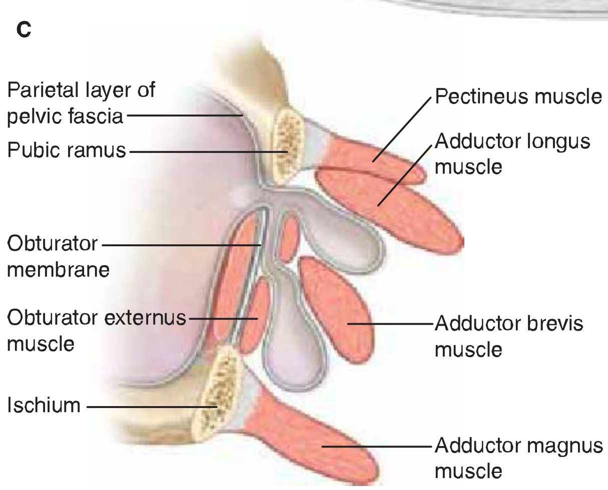




**Figure 10.8** Cross sectional (**A** and **B**) and sagittal (**C**) schematic representations of obturator hernias. 1, herniated loop of intestine; 2, pectineus muscle; 3, adductor brevis muscle; 4, ischiopubic muscle; 5, obturator externus muscle; 6, obturator internus muscle; 7, levator ani muscle; 8, gluteus maximus muscle; 9, femur; 10, vastus lateralis muscle; 11, vastus intermedius muscle; 12, psoas muscle; 13, tensor fasciae latae muscle; 14, rectus femoris muscle; 15, sartorius muscle; 16, obturator vessels and nerve; 17, gluteus medius muscle; 18, gemellus inferior muscle; 19, gemellus superior muscle.

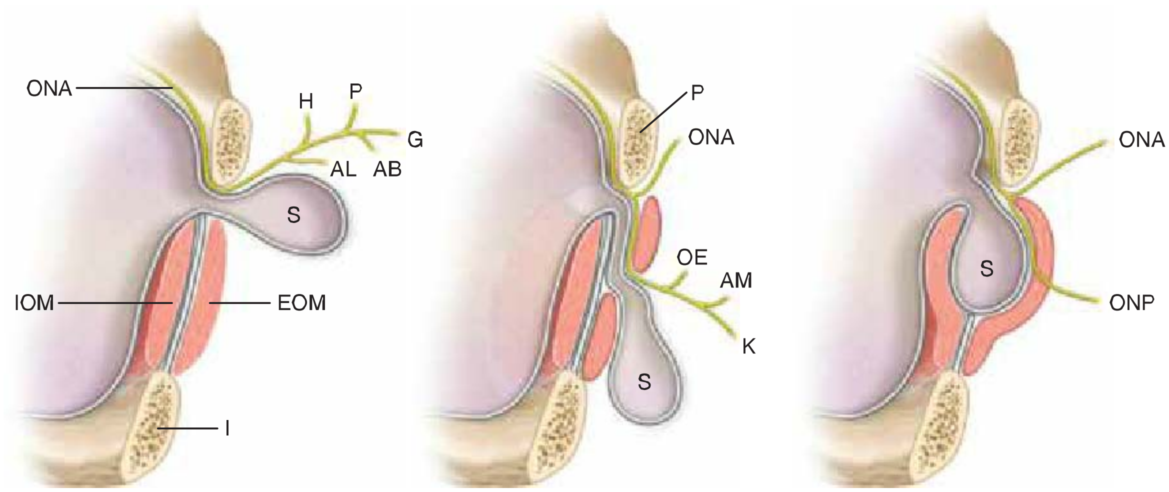



**Figure 10.9** There are 3 anatomically possible types of obturator hernias, as represented in this figure. The most frequent type (figure on left) is when the hernia traverses together with the anterior division of the obturator nerve through the external orifice of the obturator canal. In these instances, the hernia is located underneath the pectineus and in front of the external obturator muscles. The second most common variety (middle figure) is when the hernia is located together with the posterior division of the obturator nerve in between the superior and middle fasciculae of the external obturator muscle, posterior to the adductor brevis. The least frequent variety (figure on right) is when the hernia is located between the internal and external obturator muscles and membranes. S, obturator hernia sacs; ONA, obturator nerve anterior division; ONP, obturator nerve posterior division; EOM, external obturator muscle; IOM, internal obturator muscle; I, ischial bone; P: pubic bone.

2. The second most common variety is when the hernia is located together with the posterior division of the obturator nerve in between the superior and middle fasciculae of the external obturator muscle, posterior to the adductor brevis.
3. The least frequent variety is when the hernia is located between the internal and external obturator muscles and membranes.

There are five signs potentially associated with obturator hernias:

1. **Obturator neuralgia:** Hypo or hyper-esthesia in the anteromedial thigh (supplied by the cutaneous branch of the anterior division of the obturator nerve).
2. **Howship–Romberg sign:** Considered pathognomonic of obturator hernias. Encountered in 25% to 50% of cases. Extension, adduction, or medial rotation of the thigh elicit obturator neuralgia by compressing the obturator nerve against the hernia. Flexion of the thigh relieves the findings.
3. **Hannington-Kiff sign:** Absent adductor reflex in the thigh as a consequence of compression of the obturator nerve. This sign is considered by some to be more specific than the Howship–Romberg sign.
4. Occasionally, in cases of intestinal infarction, exudation of serosanguinous fluid can lead to **purple-red discoloration in the area of the femoral triangle**.
5. In advanced cases, necrosis and perforation of the involved intestinal loop can lead to **infectious manifestations in the ipsilateral thigh**.

Diagnosis relies on a high degree of suspicion and clinical–anatomical knowledge. Over 80% of symptomatic obturator hernias present with partial or complete small bowel obstruction (Figs. 10.10, 10.13). Intermittent abdominal cramps and vomiting are frequent associated findings. About 30% of patients have a history of repeated episodes of bowel obstruction that resolve without intervention. The presence of previous abdominal surgeries usually delays the diagnosis since bowel obstruction due to adhesions prevails within differential diagnoses. Only less than 1% of mechanical intestinal obstructions are from strangulated obturator hernias. All hip motion is painful. The usefulness of rectal examination has been questioned. Vaginal examination can elicit tenderness in the obturator area, and a mass may be palpated laterally. In a limited number of cases (approximately 20%) a mass can be palpated in the proximal thigh at


**Figure 10.10** Axial CT demonstrating multiple fluid-filled dilated loops of small bowel proximal to an incarcerated obturator hernia. Figures 10.11 and 10.12 are caudal images corresponding to the same patient.

the origin of the adductor muscles. Outward rotation, flexion, and abduction of the thigh make the mass more prominent. The Howship–Romberg sign may be confused with osteoarthritis in elderly individuals.

Imaging modalities have a reported accuracy of up to 90%. CT scanning of the abdomen and pelvis constitutes a very useful diagnostic tool, even in the absence of oral contrast (Figs. 10.11, 10.12, 10.14, 10.15). Ultrasound (with experienced operators) and magnetic resonance are also useful. Imaging studies should be obtained in all cases of questionable or uncertain diagnoses.

## SURGERY

Obturator hernias are the most lethal of all abdominal hernias, with a mortality of 5% to 70%. This extremely high rate is attributed to delays in diagnosis and treatment, multiple co-morbidities, debilitated elderly patients, and the high incidence of intestinal gangrene.

Treatment is surgical and should be instituted promptly. Intestinal perforation and ischemia requiring resection can be encountered in up to 50% or more of cases. In all instances the contralateral side must be explored for the presence of a bilateral hernia.

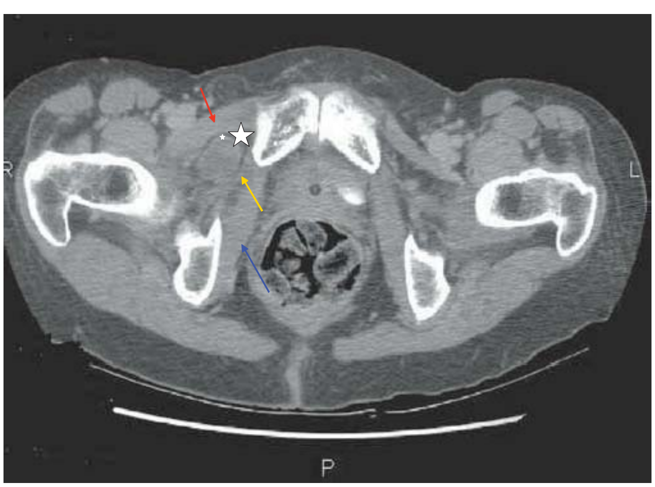



**Figure 10.11** Axial CT demonstrating a small bowel loop in a hernia sac (*white star*) superficial to the right obturator externus (*yellow arrow*) muscle and deep to the pectineus muscle (*red arrow*). The obturator internus is identified by the blue arrow. This represents the most common type of obturator hernia with the hernia sac located anterior to the obturator externus muscle.

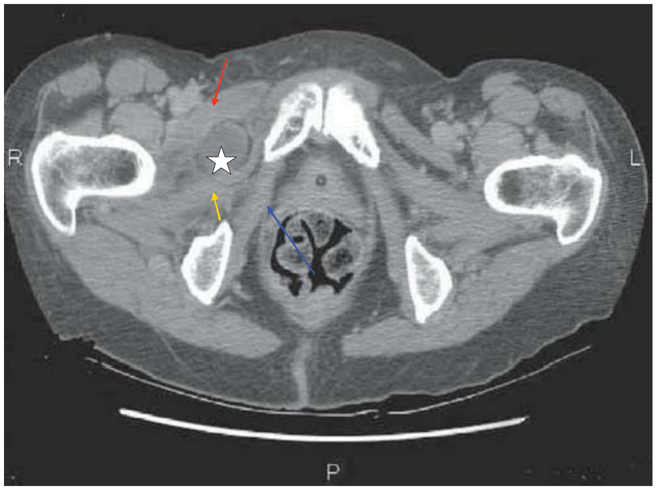



**Figure 10.12** Axial CT demonstrating a herniated small bowel loop (*white star*) located between the right pectineus muscle (*red arrow*) anteriorly and the right obturator externus muscle (*yellow arrow*) posteriorly. The internal obturator muscle is shown with a blue arrow.

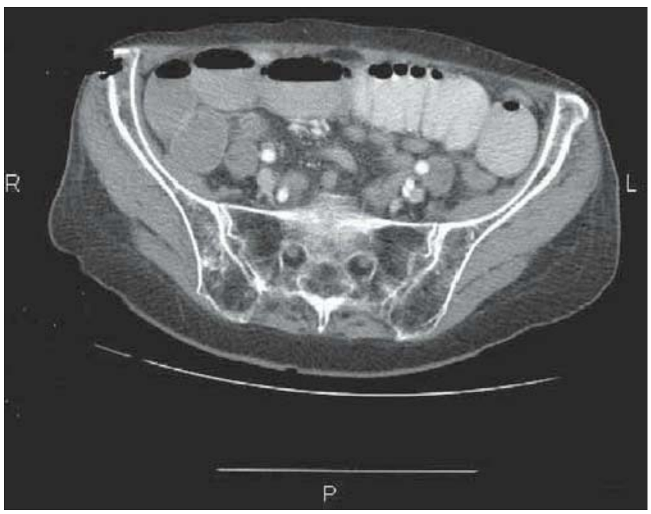



**Figure 10.13** Axial CT demonstrating multiple dilated loops of small bowel compatible with a small bowel obstruction. Figures 10.14 and 10.15 are images corresponding to the same case.

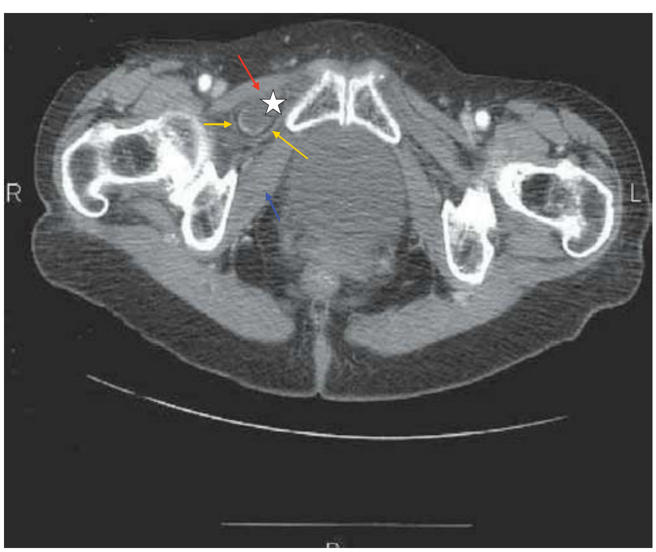



**Figure 10.14** Axial CT demonstrating an incarcerated loop of small bowel (*white star*) that has splayed the fasciculae of the right obturator externus (*yellow arrows*) muscle. The pectineus (*red arrow*) and obturator internus (*blue arrow*) muscles are also identified. This represents the second most common type of obturator hernia with the hernia sac splaying the obturator externus fasciculae.

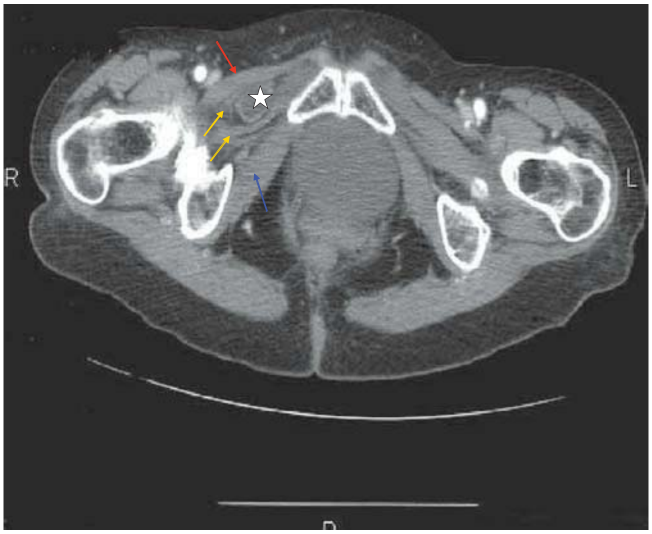



**Figure 10.15** Axial CT showing an incarcerated loop of small bowel (*white star*) with a mildly thickened wall (slight enhancement) compatible with an obturator hernia between the right obturator externus muscle fasciculae (*yellow arrows*). The pectineus (*red arrow*) and obturator internus (*blue arrow*) muscles are also identified.



Surgical approaches to obturator hernias include:

- Abdominal
- Retropubic
- Inguinal
- Laparoscopic
- Hybrid

The **lower midline trans-peritoneal approach** is the most common approach. After entering the abdomen, an initial attempt should be made to reduce the incarcerated intestine. Palpation of the medial inner thigh may help push the hernia sac into the abdominal cavity (usually requires additional sterile preparation of the thigh). If this maneuver does not work, a counter-incision in the medial groin may be required. The obturator membrane may need to be incised in an anterior to posterior way in order to allow for complete reduction of the hernia (the obturator canal has a rigid opening that cannot be manually dilated). When incising the membrane, it is important not to injure the neurovascular obturator complex. Once the hernia is reduced, the intestine is inspected and non-viable segments resected. The hernia defect is closed (avoiding injury to the neurovascular structures) with polypropylene or nylon sutures or (in non-contaminated cases) with mesh. The mesh may be anchored to Cooper's ligament.

The **midline extra-peritoneal approach** involves a midline incision from umbilicus to pubis. It is the approach preferred by many when a diagnosis has been made preoperatively. The pre-peritoneal plane is accessed deep to the rectus muscle. The bladder is dissected away from the peritoneum, allowing for access to the superior pubic ramus and obturator internus. The obturator canal is thus exposed. The hernia sac (found inferior to the obturator canal) is incised and its contents reduced. The remaining sac can be resected. The internal opening of the obturator canal is sutured closed, maintaining the neurovascular bundle intact. The closing sutures encompass the periosteum of the superior pubic ramus and the fascia of the internal obturator muscle. Mesh can be used in the repair.

The **thigh approach** entails a vertical upper medial thigh incision following the adductor longus muscle. The adductor longus is retracted medially and the pectineus subsequently transected. The exposed hernia sac is incised and its contents inspected. If viable, the contents are reduced. If not viable, a midline laparotomy is recommended to perform any necessary resection. The sac can be excised. The canal is then sutured closed.

The **lower transverse suprapubic approach** can be considered in cases with an established preoperative diagnosis.

The **pre-peritoneal approach** provides extra-peritoneal access not only of the obturator but also to the femoral and inguinal regions.

Simple repair of the obturator defect with interrupted or running sutures carries a 10% incidence of recurrence. Mesh is frequently used in instances where the defect is large and there is no gross contamination with enteric contents. Repair with autogenous tissue such as bladder wall, round ligament, uterus, ovary, omentum, hernia sac, pectineal muscle, and peritoneum has also been described.

# Acknowledgments

We would like to thank Drs. Pamela Lombardi, Robin J. Warshawsky, and Mariano Volpacchio, for their contribution with the radiological images and their interpretation, Drs. Jeffrey Nicastro, Gene Coppa, Arnold Radtke, and Massimo Malago for their clinical scientific contribution, and Ms. Hannah Fisher MLS, Mr. Robert Fisher MLS, and Ms. Claudia Cassidy for their invaluable help with the preparation and accuracy of the manuscript.

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# 11 Hernia in Infants

**Robert Acton and Daniel Stephens**

## Introduction

When thinking of hernias in infants primarily three hernias come to mind: Straightforward routine indirect hernias in term infants, giant pantalooning hernias in preterm infants, and umbilical hernias in both. These hernias in infants will present similarly to those in adults; however, the pathogenesis, treatment, and outcomes differ significantly. Both types of inguinal and umbilical hernias are discussed in this chapter.

## Inguinal Hernias

- Introduction
  - Inguinal hernia repair is one of the commonest procedures performed by pediatric surgeons and helps to define the specialty. The incidence ranges from 1% to 3% in children—about 1% in females, but up to 5% to 6% in males, with approximately 80% of hernias occurring in males. There is a right-sided predominance, which is attributed to the later decent of the right testes as compared to the left. The proposed etiology is failure of the processus vaginalis to obliterate. As such, indirect inguinal hernias represent 99% of all hernias in infancy. The incidence is also increased in preterm infants, with an estimated incidence of 12% at 32 weeks and up to 21% at 27 weeks' post-conceptional age. Conditions leading to increased intraabdominal pressure, including chronic cough, ascites, ventriculoperitoneal shunts, and peritoneal dialysis also lead to increased incidence.
  - As the embryonic testis descends from its origin in the lumbar retroperitoneum under the influence of calcitonin gene–related peptide, it is preceded by a diverticulum of the parietal peritoneum. This peritoneum becomes the tunica and the processus vaginalis. The processus normally obliterates by 35 weeks of gestation. This timing of normal obliteration explains the increased incidence of hernias within preterm infants. When obliteration fails or is only partial, the result is either hydrocele or an indirect inguinal hernia.
- Indications/Contraindications
  - The diagnosis of hernia in a child depends highly on the history, generally obtained from the parents or caretakers. The history often includes a report of a fluctuating groin bulge that varies with coughing, crying, sneezing, or valsalva. Office examination may not always reveal this bulge, but a definitive history alone may suffice

as an indication for elective repair. In regards to preterm infants within the NICU the history is very similar, that of an inguinal bulge that quickly becomes very apparent on examination.

- Physical examination may reveal a thickening or slipperiness in the groin, the so-called "silken cord sign." Incarceration or obstruction is generally quite apparent and an indication for attempted reduction. If unsuccessful, exploration and repair should be performed emergently. If attempts at reduction are successful, the hernia should be repaired on a more urgent scheduled basis, often within 24 to 48 hours.
- Hydrocele may be easily confused with an indirect hernia in males and trans-illumination may be deceiving. Hydroceles should not reduce or reduce very slowly depending on the size of the communication. Ultrasound may have utility in this regard if there is confusion about the diagnosis. Hydrocele alone, without a hernia, is not an indication for repair in neonates and small children under the age of 1, as most hydroceles will resolve within 1 to 2 years; however, persistence beyond this age is an indication for repair.
- Timing of repair in preterm and term infants has been a subject of ongoing discussion. In the absence of incarceration or obstruction, some surgeons may elect to wait until the patient is older and better able to tolerate general anesthesia and be repaired as an outpatient, while others may advocate for repair just prior to discharge from the NICU or hospital. The degree of patient co-morbidities must be weighed against the risk of incarceration or obstruction if elective repair is delayed. The risk of incarceration is significantly higher when repair is delayed beyond 40 weeks' gestational age; therefore, repair should generally take place prior to that point (Figs. 11.1, 11.2).

- Preoperative Planning
  - Generally, no preoperative imaging is required if the history or examination supports the diagnosis. If the history or examination is equivocal, ultrasound may be a useful adjunct to differentiate a hydrocele from a hernia.
  - Preoperative laboratory studies may be limited to simply a hemoglobin/hematocrit to rule out anemia in an infant with no other medical issues. Certainly, if the infant has other co-morbidities such as congenital heart disease or bronchopulmonary dysplasia and is on diuretics electrolytes should also be checked. Coagulation studies are almost never needed.
  - Anesthetic consideration should include spinal or regional anesthesia, especially for preterm babies, those who have had prolonged ventilator support, or those

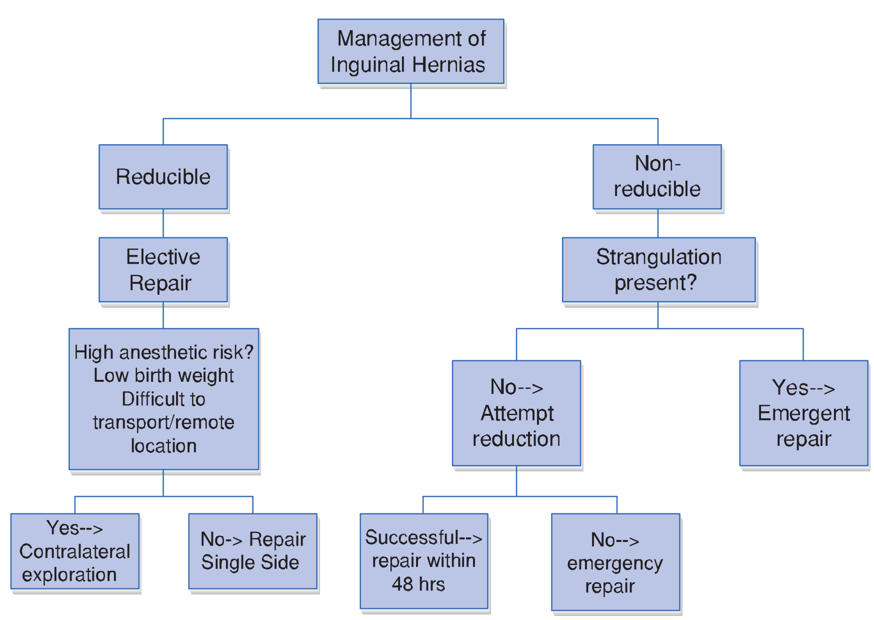


**Figure 11.1** Algorithm on the management of inguinal hernias in infants.

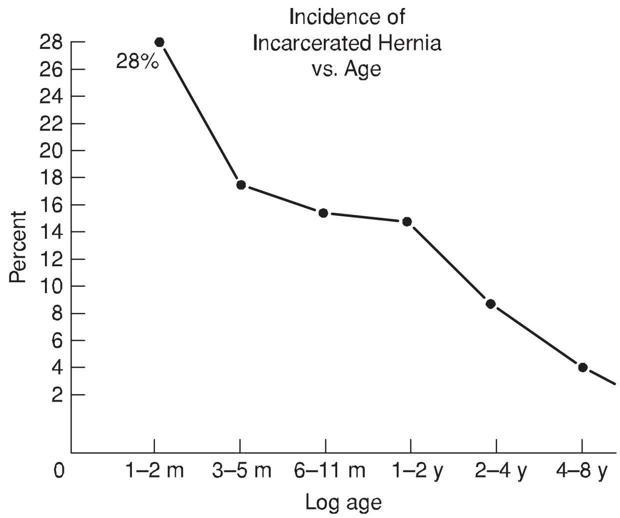


**Figure 11.2** The inverse relationship between age and risk of incarceration supports the practice of early elective repair of inguinal hernias.



with bronchopulmonary dysplasia. Caudal anesthesia can also be useful in postoperative pain control. Local anesthetic as well as narcotic can be administered to compliment intraoperative and postoperative analgesia.

- Prophylactic antibiotics are not routinely indicated unless the indication for the procedure is incarceration or strangulation. In this instance, broad spectrum antibiotics and nasogastric decompression should be considered.
- Routine contralateral exploration in infants is evolving toward selective contralateral exploration as the approach taken by an increasing number of pediatric surgeons. This approach takes into consideration the variably increased risk of an asymptomatic, contralateral hernia associated with left-sided hernias, younger infants, female patients, low birth weight babies, children with the increased intraabdominal pressure problems, and those that are difficult to transport. The action of contralateral exploration must be balanced against the risk of a second general anesthetic if another hernia is found, the risk of possible incarceration or strangulation that may be prevented by prophylactic exploration, and the risk of complication from unnecessary exploration such as injury to the vas deferens. Recent studies have demonstrated that the subsequent risk of developing a contralateral hernia is lower than once believed. This information is the main reason most surgeons are using a selective approach for contralateral exploration.

- Surgery
  - Reduction
    - Incarceration is an indication for more urgent repair. Prior to repair, an attempt at reduction should be made. If the hernia is successfully reduced, the operation may take place in 24 to 48 hours after swelling is reduced and allows the procedure to be performed on an urgent as opposed to an emergent basis. If there is suspicion of strangulation, reduction should not be attempted until the operating room where the two limbs of the bowel can be controlled to prevent intraabdominal spillage of bowel contents.
    - Contrary to the common mashing, pushing, and pressure that are often performed to attempt reduction, traction of the hernia mass, testicle, or scrotal skin should be applied parallel to the inguinal canal with one hand and gentle pressure with the other hand should be applied for reduction. While stretching the scrotum toward the contralateral leg, the other hand should be used to apply pressure along the neck of the hernia near the external ring. Constant pressure should be applied for some time to reduce the amount of edema and empty the bowel luminal contents to aid in reduction. Then, with constant pressure along the inguinal canal with the other hand, pressure is applied to the bottom of the hernia contents until it is reduced. Once the loops are emptied of gas and succus, the loops essentially pull themselves back into the abdomen. A successful

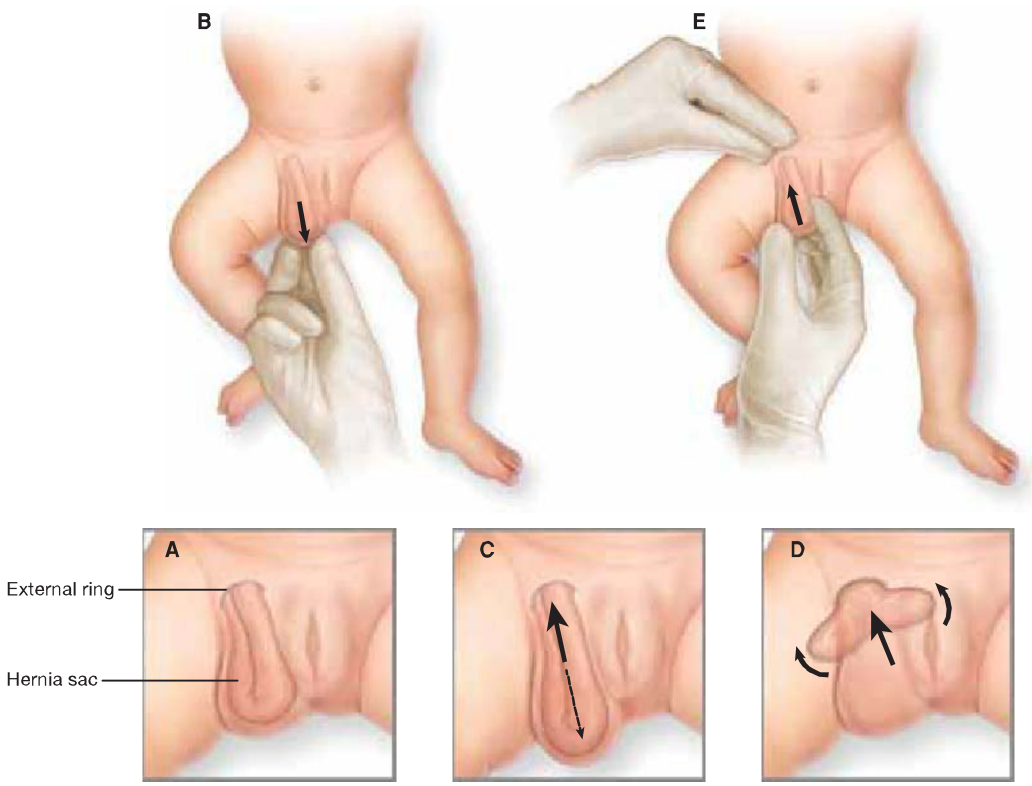


**Figure 11.3** Graphic demonstrating method for reducing an incarcerated inguinal hernia, noting the direction traction should be applied.

reduction always depends on a calm and relaxed infant. If the infant is crying and fighting reduction is more difficult and mild sedation should be considered if another physician is present to monitor the infant's airway and breathing. The technique is the same in female infants, the key is to stretch the hernia sac to the opposite knee to allow the bowel loops to empty. If a hernia cannot be reduced in a female, consider that the ovary may be incarcerated (Fig. 11.3).

- High Ligation
  - The key principle of hernia repair in infants is high ligation of the indirect hernia sac. Many preterm infants may also have a large direct component or significant dilation of both inguinal rings and require repair of the inguinal floor. Preterm infants may also have nonfixation of the testis within the scrotum. Generally, orchiopexy is not required.
  - Routine positioning places the patient in supine position. The lower abdomen, groins, thighs, and scrotum or labia should be prepped in the operative field.
  - A transverse skin incision is made within an existing skin crease with the intent of exposing the underlying cord structures. The medial extent of the incision should lie superior and lateral to the ipsilateral pubic tubercle. With the dermis incised, the subcutaneous tissues are dissected with the scalpel, scissors, or electrocautery down to the level of Scarpa's fascia. This layer is also incised sharply, exposing the underlying fascia of the external oblique muscle. Exposure can be maintained by asking an assistant to hold two small retractors exposing the external inguinal ring.
  - The external inguinal ring is indentified and cleaned. At this point, the surgeon can decide to perform the operation externally to the ring or open the ring slightly to aid with exposure of the inguinal cord. In most infants the entire dissection and repair can be done external to the ring. Opening the ring is primarily used during repair of recurrent hernias to utilize fresh tissue plains (Fig. 11.4A).
  - If the surgeon decides to open the ring then, in the direction of the muscle fibers a small incision is made into the external oblique fascia (Fig. 11.4B). The Metzenbaum scissors are used to extend this incision toward the external ring. The blunt tips of the Metzenbaum scissors can be inserted under the fascia with the curve upward to gently dissect off the underlying structures. The cut edge of the fascia

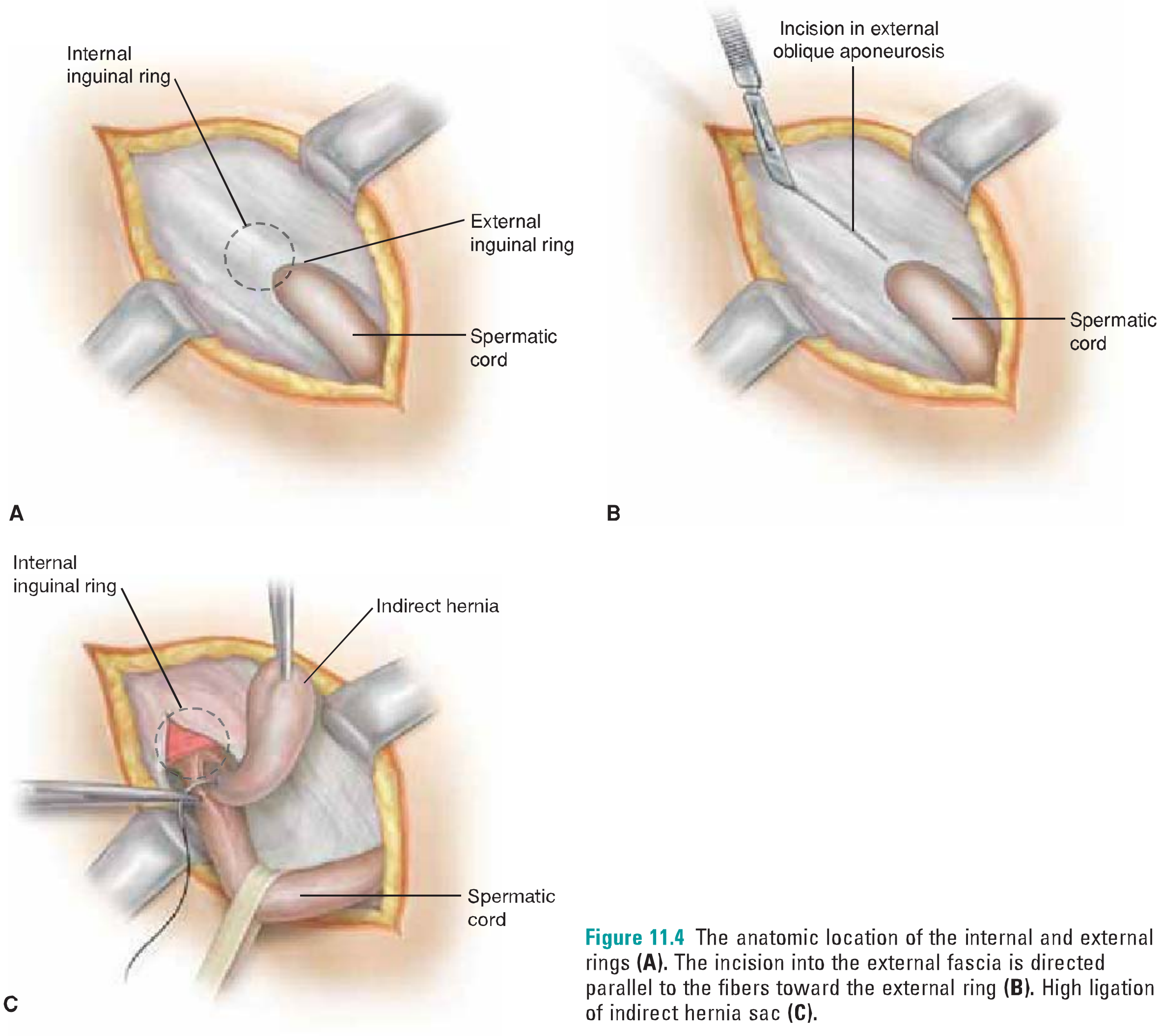


**Figure 11.4** The anatomic location of the internal and external rings **(A).** The incision into the external fascia is directed parallel to the fibers toward the external ring **(B).** High ligation of indirect hernia sac **(C).**

is extended through the external ring. The superior and inferior cut edges of the fascia are grasped with hemostats and retracted. At this point, the ilioinguinal nerve and the iliohypogastric nerve should be identified and preserved.

- The cord structures and hernia sac are now gently grasped, elevated, and the adhesions to the sac are bluntly dissected. When the cord structures are identified they can be gently dissected off the sac and isolated and retracted away from the sac to protect them with an Allis clamp or vessel loop. The remaining adhesions and cremasteric fibers are gently swept away from the sac until the sac is free up to the level of the internal ring.
- With the sac isolated it can be twisted and ligated with an absorbable suture. The sac can then be divided. If there is a question of peritoneal contents, the sac can be opened and explored as indicated. If the contents are bloody or turbid in the case of incarcerated or strangulated hernia, one must confirm that nonviable viscera were not reduced into the abdomen. This may require enlarging the inguinal incision or making a midline laparotomy.
- If there is suspicion for a contralateral hernia, laparoscopic exploration may be performed through the inguinal exposure. An opening in the sac is made and a trochar is inserted into the peritoneal cavity and the abdominal cavity is insufflated. A 70-degree laparoscope is inserted to explore the contralateral internal ring for the presence of a hernia.
- Gentle traction on the testicle can help restore anatomic position of the cord structures. The fascia is approximated with an interrupted absorbable suture. Generally, the floor of the inguinal canal does not require reconstruction, however, if there is

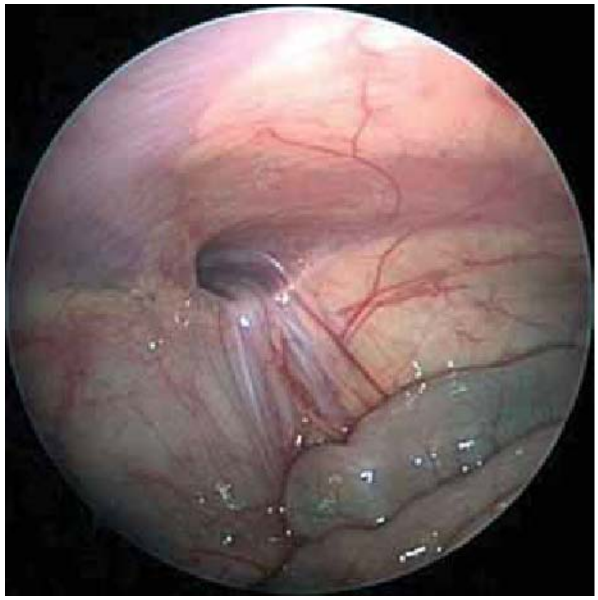

**Figure 11.5** Laparoscopic view of open internal ring.

significant laxity or if the internal ring is enlarged in a former preterm infant, repair of the floor should be performed. The transversalis fascia may be sutured to the inguinal ligament to reinforce the internal ring. A Bassini or modified McVay repair with or without the use of absorbable mesh may also be considered.
    - Scarpa's fascia is closed with a single running absorbable suture.
    - The skin may be closed with a knotless absorbable running subcuticular suture and covered with steri-strips or a dressing.
  - Laparoscopic repair
    - The patient is again placed in the supine position and the entire abdomen, groins, upper thighs, and scrotum are prepped.
    - A 3 to 5 mm infraumbilical incision is made and the abdomen is entered using a Veress needle and the abdomen is insufflated to 6 to 8 mm Hg. After confirming the presence of either unilateral or bilateral hernias, an additional 3 mm port is placed in the contralateral abdomen (Fig. 11.5).
    - A 1 mm skin incision is made in the groin overlying the internal ring. Using a spinal needle a loop of nonabsorbable suture is passed through the needle into the abdominal cavity just lateral to the internal ring. The loop is grasped with the Maryland graspers as the needle is withdrawn. One end of the loop is reinserted into the needle which is then placed medial to the internal ring, but lateral to the vas deferens and vessels. Again using the Maryland graspers, this end of suture is passed through the laterally placed loop of suture then withdrawn and tied down extracorporeally. The knot is buried in the subcutaneous tissues. The port sites are closed with absorbable suture. Other techniques using curved needles and suture instead of spinal needles may also be used. It remains controversial as to whether the remaining hernia sac leads to an increased incidence of recurrent hernia formation. Some authors recommend inversion and laparoscopic suture ligation of the hernia sac.
- Intraoperative findings/considerations
  - Cystic fibrosis: The incidence of inguinal hernia is increased in patients with cystic fibrosis. The absence of the vas deferens is also an associated finding and should prompt an appropriate evaluation for cystic fibrosis.
  - Fallopian tube in the wall of the sac: In many female patients the fallopian tube will lie in the sac as a sliding hernia. The sac should routinely be opened and explored. If the fallopian tube is present, it should not be dissected off the sac to be reduced but should be inverted and reduced through the internal ring.
  - Adrenal rests: Ectopic adrenal tissue may be found at the time of hernia repair. It appears as a yellow tissue in the hernia sac. It is believed that these rests may be removed without consequence.

- Postoperative management
  - Patients undergoing elective hernia repair may be discharged home after a brief period of observation following general anesthesia. Premature infants who are less than 60 weeks' post-conceptional age should be observed overnight for apnea and bradycardia following general anesthesia. Some hospitals may also use these same guidelines for an infant less than 60 weeks' post-conception. Acetaminophen generally provides adequate postoperative analgesia. Normal activities can be resumed within 48 hours and no activity restrictions are indicated.
- Complications
  - Complications are rare in general and include wound infection in 1% to 2% and recurrence in <1% and injury to the vas deferens. Risk factors for recurrence include a tear in the sack, a weakened floor that is not repaired, wound infection, and history of incarceration, as well as conditions that cause increased intraabdominal pressure in the immediate postoperative period. Less commonly there may be injury to the vas deferens or testicular injury. Injury to the vas, if identified intraoperatively, should be repaired by anastomosis with 8-0 absorbable suture. Recognized nerve injuries should likewise be repaired.
- Results
  - Results are excellent for both open and laparoscopic repair. Recurrence is generally less than 1%. The risk of recurrence is significantly higher in those repaired following incarceration, approaching 20% in some series and higher in preterm infants.
- Conclusions
  - Hernias are one of the commonest surgical problems in pediatric patients. In general, inguinal hernias should be repaired as soon as feasible on an elective basis when there is no history of incarceration or strangulation, and emergently when incarceration or strangulation occurs. A high ligation of the sac and reduction with primary closure is adequate in the vast majority of patients unless the floor is significantly weakened. Recurrence is rare. Timing of repair is critical in premature infants and the risk of incarceration must be weighed against the risks of general anesthesia.

# Umbilical Hernias

## Introduction

- Umbilical hernias in children occur when there is failed closure of the umbilical ring. There is a higher incidence among children of African descent. There is no gender predilection. The natural history of hernias <1 cm in size is that of spontaneous closure. Additionally, there is a low risk of incarceration and strangulation.

## INDICATIONS/CONTRAINDICATIONS

- Given the natural history, it is reasonable to wait until at least age 2 prior to elective repair. For smaller hernias, it is reasonable to wait even longer. Most children do not form memories before age 3, thus if repair is before this age the child will not remember the event on the off chance it is not a perfect experience.

## PREOPERATIVE PLANNING

- The preoperative planning is similar to that of inguinal hernia repair.

## SURGERY

- The patient should be placed in the supine position and the abdomen should be prepped and draped.
- An infraumbilical incision within a skin crease of the umbilicus is most commonly made. The skin and subcutaneous tissues are bluntly dissected, encircling the hernia sac.
- The sac is carefully dissected away from the skin, taking caution to avoid any injury to the overlying dermis. With the hernia sac dissected, it is reduced into the abdominal cavity or completely removed. If the defect is small enough to be closed primarily, interrupted sutures are placed. To avoid enterotomy or entrapment of abdominal contents, all sutures are placed prior to tying.

## POSTOPERATIVE MANAGEMENT

- The postoperative management is similar to that of inguinal hernia repairs.

## COMPLICATIONS

- Potential complications are similar to those of inguinal hernias.

## RESULTS

- The risk of recurrence, like that of inguinal hernias is <1%. Recurrence rates typically are higher for larger hernias or those repaired in younger infants versus toddlers.

## CONCLUSIONS

- Umbilical hernias, unlike inguinal hernias, will often close spontaneously. Incarceration and strangulation are rare events, so these hernias may be safely observed for some years. Most children (85%) will close by the age of 3 to 4, so surgery is generally delayed until children are nearing school entrance. Umbilical hernias should be repaired through an open approach if unresolved after 2 to 4 years of age of if they are large, expanding, or incarcerate.

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# 12 Surgical Treatment of Chronic Pain after Inguinal Hernia Repair

**Bruce Ramshaw and Michael A. Fabian**

## Introduction

The incidence of chronic pain or discomfort after inguinal hernia repair is much higher than we have previously thought. Fortunately, the great majority of patients who have experienced chronic symptoms after hernia repair have mild or moderate symptoms and do not require an invasive intervention to maintain good quality of life. However, for those patients in whom the pain does negatively affect their quality of life, this post-hernia repair complication can become a nightmare and threaten a person's livelihood, family, and even their life.

For millennia up until recent times the treatment and management of chronic pain was not only difficult, but forbidden by the church. The inquisition pursued people who attempted to treat pain as witches and heretics, believing they were in alliance with the devil. Those people who ignored the ban on treating pain were tortured, and even killed and burned on funeral pyres.

Queen Victoria was the first woman royalty who ignored the ban and accepted chloroform from her personal physician, John Snow, while she was giving birth to her 8th child. In 1853, in response to this event, The Lancet commented on the use of chloroform for the pain of childbirth, "In no case could it be justifiable to administer chloroform in a perfectly ordinary labour." However, the use of chloroform to manage the pain of childbirth had become an acceptable practice by the end of the 19th century.

At a medical congress on anesthesia in 1956, Professor Mazzoni confirmed with The Pope that medical treatment for pain was no longer forbidden by the church and that these treatments no longer contradict the common law. To clarify this issue, Pope Pius XII gave a speech to about 500 physicians on February 24, 1957, interpreting religious law and supporting the use of pain relief measures.

Despite the ability to diagnose and treat chronic pain, we have not yet had great success in achieving a complete understanding of significant relief of pain for the patients who have suffered from severe groin pain after inguinal hernia repair. The increase of "chronic groin pain" in our society is reflected by the incidence of the phrase in our

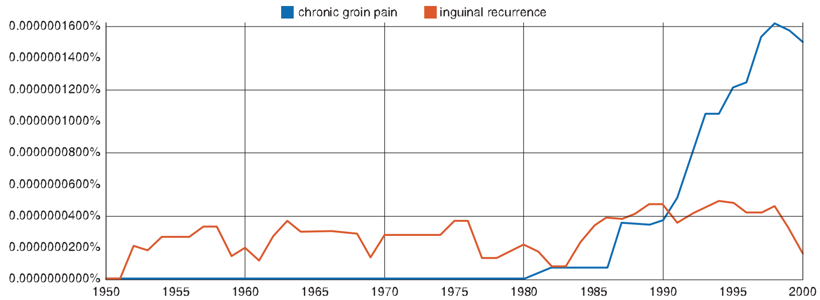


**Figure 12.1** This Google ngram comparison reveals a significant increase in use of the term "chronic groin pain" when compared with "inguinal recurrence" over the past 20 years.

written language compared to the term "inguinal recurrence" (Fig. 12.1). Google ngrams allow the search for words and phrases from all books digitized by Google. This Google ngram comparison of these two terms reveals a significant increase in use of the term "chronic groin pain" when compared with "inguinal recurrence" over the past 20 years. One reason for the emergence of this problem and our lack of success in treating this form of chronic pain is that it is a complex problem. When a problem is complex, it implies that there are many variables involved, both in creating the problem and in managing or solving the problem.

Chronic groin pain after hernia repair can be a result of patient factors, other diagnoses besides inguinal hernia, the surgical technique and quality of the repair, the mesh and fixation materials used, and even the patient's experience and environment in the peri-operative and postoperative recovery period. One single factor such as the hernia mesh may or may not play a role in the cause of chronic postoperative pain in any single patient. Because of this complexity, there are many treatment options, both invasive and non-invasive, which may or may not be effective in any given patient, and a combination of treatment options may be required to achieve optimal pain relief.

This chapter will focus on the surgical approach for management of chronic groin pain although some of the other treatment options will also be discussed. Near the end of the chapter, we will also discuss a new model for health care to attempt to deal with complex problems such as chronic groin pain after inguinal hernia repair.

## Incidence of Pain after Inguinal Hernia Repair

The reported incidence of chronic groin pain after hernia repair varies widely from a low of 0% to a high of over 50%. Many factors, including who asks the questions, can contribute to the reported incidence in pain. Regardless of the actual incidence, this problem is clearly increasing in awareness (even if only from the cumulative number of patients suffering from this complication year after year) by surgeons and other physicians seeing patients looking for help. If there are 1,000,000 inguinal hernia repairs in the United States each year and 10% of patients experience chronic pain that impacts their quality of life, then 100,000 patients per year are added to the growing group of patients suffering from this problem.

## Type of Pain

Not all chronic groin pain after inguinal hernia repair is the same. In general, the pain can be divided into two groups, nociceptive and neuropathic. A third group would include pain that was from another cause that is referred to the groin, such as from a previous back injury. Figure 12.2 lists a variety of potential causes of groin pain not related to a hernia bulge.

Nociceptive pain is due to injury to tissue. It is caused by specialized nerve endings that respond to chemical, mechanical, or thermal factors. There are two main subtypes

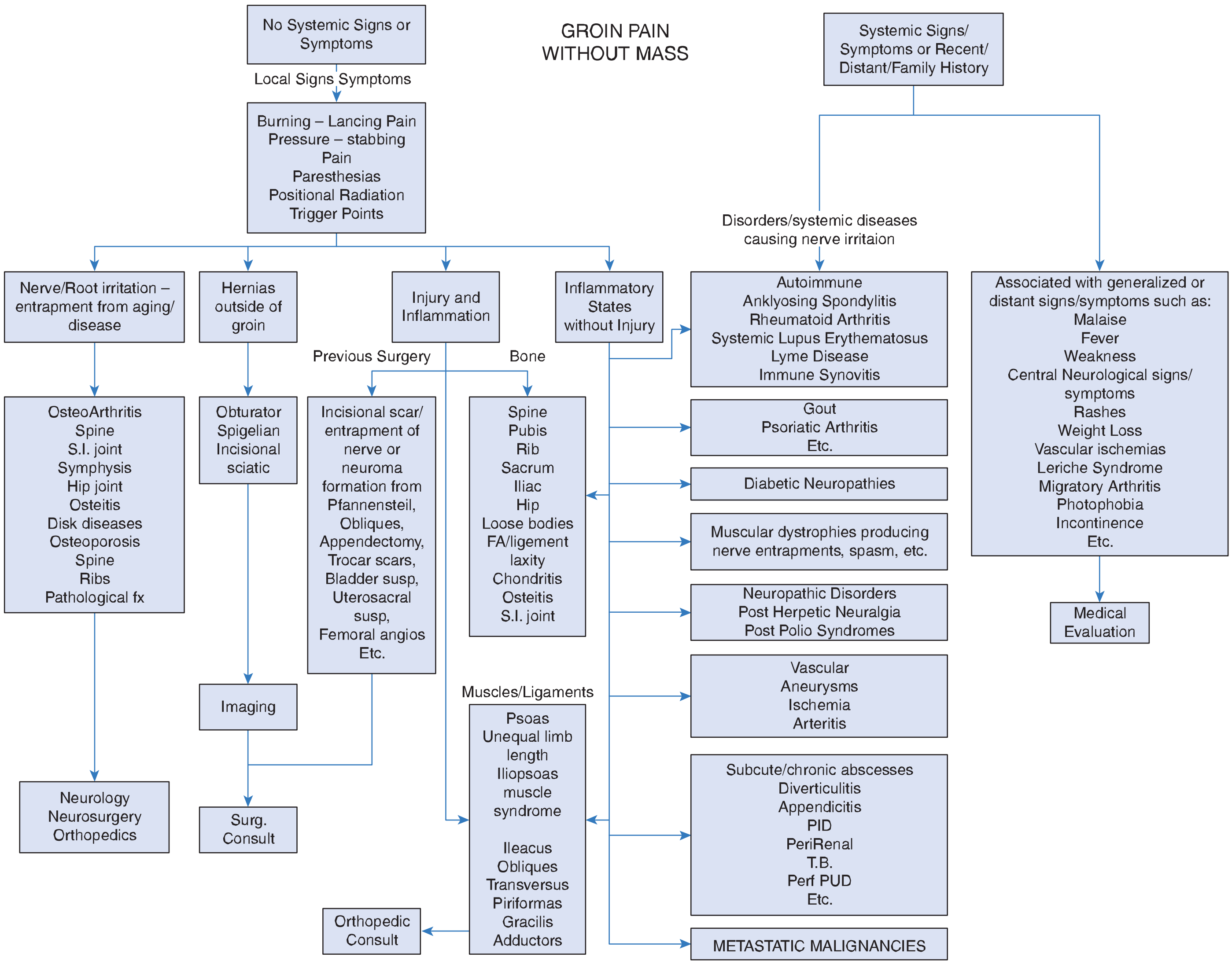


**Figure 12.2** A variety of potential causes of groin pain not related to a hernia bulge.

of nociceptive receptors: Unimodal nociceptors that evoke a sharp, pricking pain, and polymodal receptors that bring about a long lasting dull aching or burning pain.

Neuropathic pain is due to injury to the nerve itself. This type of pain is characterized by partial or complete sensory loss or changed sensory function as a result of damage to the afferent transmission system. Neuropathic pain may be associated with hypersensitivity, including allodynia (a pain response to harmless stimuli), hyperalgesia (an exaggerated response to harmful stimuli) and hyperpathia (a response outlasting harmful stimuli).

In contrast to nociceptive pain, neuropathic pain may persist in the absence of noxious stimuli. It is becoming increasingly recognized that chronic pain can cause long-term changes in the nervous system signaling pathways as well as the processing pathways. This capacity for change in the nervous system, termed neuroplasticity, can result in a perception of pain that persists even after all assumed and previous causes have been removed or alleviated. This is especially challenging and will require a new understanding of managing and treating pain to address this aspect of the pain perception pathway.

Sometimes, especially after laparoscopic inguinal hernia repair, a nerve injury (immediate neuropathic pain) is acutely painful and obvious. Direct injury to the nerve from a mesh fixation device can lead to immediate, excruciating pain and paresthesia in the recovery room as the patient emerges from anesthesia. In this case, it is often appropriate to return to the operating room to remove the offending fixation device.

# Causes of the Pain

As mentioned in the introduction, the cause(s) of chronic postoperative pain after inguinal hernia repair are many and complex. The patient brings many physical and psychologic variables to the operating room that may or may not play a role in the result of the operation. Some of these variables may not be known by the surgeon or even known by the patient themselves. One common factor identified in several studies is the presence of groin pain prior to the operation. Pre-operative groin pain predicts an increased likelihood of postoperative chronic groin pain. A study by Mazin noted that a majority of patients who suffered from chronic groin pain after inguinal hernia repair were patients on workers' compensation, suggesting that secondary gain may play a role in this type of complication.

Some of the most studied and reported factors associated with chronic groin pain after inguinal hernia repair include the surgical technique and the mesh and fixation device(s) used to perform the hernia repair. In many studies, the laparoscopic approach has been shown to have a decreased incidence of postoperative chronic groin pain, although in some reports, the incidence after laparoscopic repair may still be as high as almost 30%. Other studies, including a large prospective, randomized controlled trial, suggest that the incidence of inguinodynia after laparoscopic and open inguinal hernia repair is actually similar.

Another variable studied is the mesh itself. Although chronic groin pain after non-mesh inguinal hernia repair does occur, a variety of mesh products have been implicated as a factor contributing to chronic groin pain. The proposed mechanism for mesh causing pain is the inflammatory response between the mesh and surrounding tissue including nerves, which can become engulfed in chronic inflammation and/or the mesh contraction which can cause traction injury to nerves and surrounding tissue.

It has been proposed that the higher density, smaller pore size foreign body mesh materials, such as heavy weight polypropylene, may have a higher incidence of causing chronic pain due to the relatively higher amount of inflammatory reaction that they might induce.

Another technical factor that can result in chronic pain is the mesh fixation or tissue closure technique. Using sutures in an open hernia repair and using staples or tacks in a laparoscopic inguinal hernia repair have both been reported to cause or at least contribute to chronic groin pain after inguinal hernia repair, primarily by direct injury or entrapment of a nerve.

# Treatment of Chronic Groin Pain after Inguinal Hernia Repair

## Non-invasive

For early postoperative and non-severe pain, the initial treatment is rest, ice and/or heat to the groin, and anti-inflammatory medication. A bowel regimen to prevent constipation and bloating may also be helpful. This strategy is appropriate for the first several weeks after surgery unless the pain is severe or significantly worsens within a short period of time, despite conservative treatment.

# Pain Management

For more severe pain and pain that worsens or persists for more than a few weeks, it is appropriate to offer the patient more aggressive pain management. Most surgeons are comfortable administering inguinal nerve blocks for diagnostic and possibly therapeutic purposes. If results of the injection are good, but pain returns, additional nerve blocks may be appropriate. Some patients will obtain sufficient pain relief to return to a full quality of life after one or more nerve blocks.

Some surgeons are also comfortable managing chronic pain with a variety of medications. Neurontin, narcotics, Tramadol, anti-depressants, and a variety of other medications have been used to attempt to treat this condition and allow a patient to return to most normal activities (however, these treatments may require activity restrictions while taking the medication).

A referral to a pain specialist (usually trained as an anesthesiologist or neurologist) may also be an appropriate option. A pain specialist who is familiar with this problem will utilize a variety of pharmaceutical, non-invasive and invasive therapeutic options in an attempt to return the patient to an optimal quality of life.

There are a variety of other non-invasive treatment options including physical therapy, acupuncture, chiropractic therapy, massage, and many others that have had little or no evaluation in the surgical literature. To obtain optimal treatment success, psychological, emotional, spiritual, and family counseling may also be required due to the psychosocial factors that may have contributed to the development of chronic pain and/or due to the psychosocial damage done by the chronic pain (especially when the chronic pain has been present for a long period of time).

If the pain has persisted for more than 3 to 6 months, and/or the pain is severe or worsening despite other non-surgical therapies, it is appropriate to consider an operation in an attempt to relieve the pain.

## SURGERY

For surgeons who are experienced with pelvic and groin laparoscopy, a diagnostic laparoscopy is an appropriate first step. A laparoscopic view will identify intraabdominal adhesions, and possibly interstitial and/or recurrent hernias. Figure 12.3 shows omental adhesions to a previously placed heavyweight polypropylene plug. With laparoscopic adhesiolysis and plug excision, the patient's pain resolved. An interstitial hernia can occur as a defect through the deeper layers of the groin, but not completely through all layers of the groin or through the mesh placed in an open hernia repair. Sometimes, offending tacks or staples can be viewed and removed without entering the preperitoneal space. A tack is shown just prior to removal in Figure 12.4.

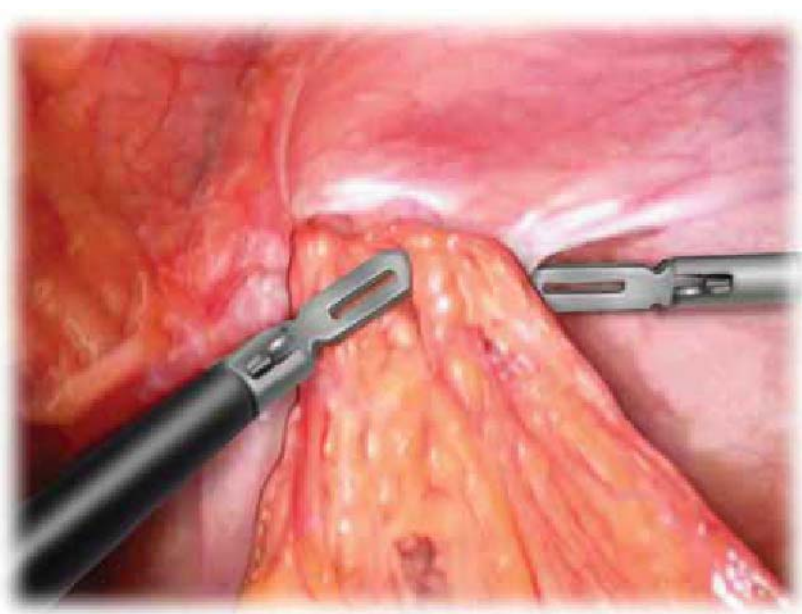

**Figure 12.3** Omental adhesions to a previously placed heavyweight polypropylene plug.

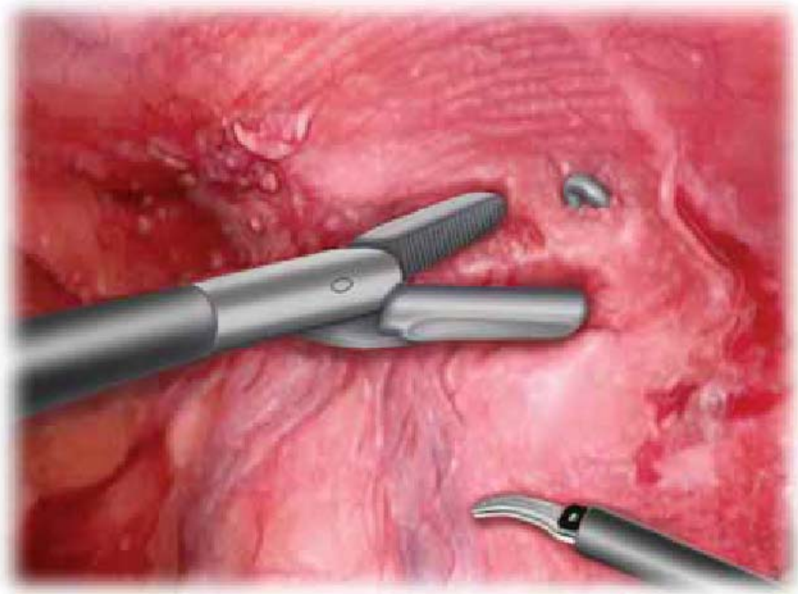

**Figure 12.4** A tack just prior to removal.

After intraperitoneal exploration, the preperitoneal space may be explored laparoscopically to view the cord structures and nerves (femoral branch of the genitofemoral and lateral femoral cutaneous nerves) that course along the psoas muscle lateral to the spermatic cord and internal ring and posterior to the iliopubic tract. Figure 12.5 shows the initial incision into the preperitoneal space, superior to the previous mesh and lateral to the bladder. The location and course of the nerves in the preperitoneal space can be variable, especially in patients with a previous groin operation. Fixation devices, such as sutures, tacks and/or staples, and mesh (placed laparoscopically or through some open techniques) can be identified in the preperitoneal space. In Figure 12.6, a tack is identified in the preperitoneal space penetrating one of the cutaneous nerves located lateral to the cord structures. Figure 12.7 shows a tack being removed from the area of the indirect ring and inferior epigastric vessels. The laparoscopic exploration of the preperitoneal space may include repairing an interstitial or recurrent hernia and/or removal of mesh (including plugs that may be visualized laparoscopically) and/or fixation devices. If a hernia is found and thought

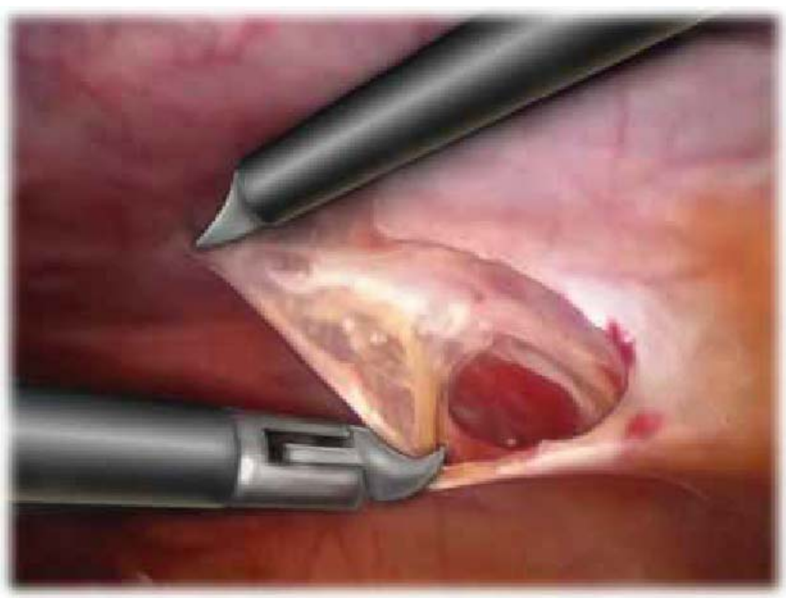

**Figure 12.5** The initial incision into the preperitoneal space, superior to the previous mesh and lateral to the bladder.

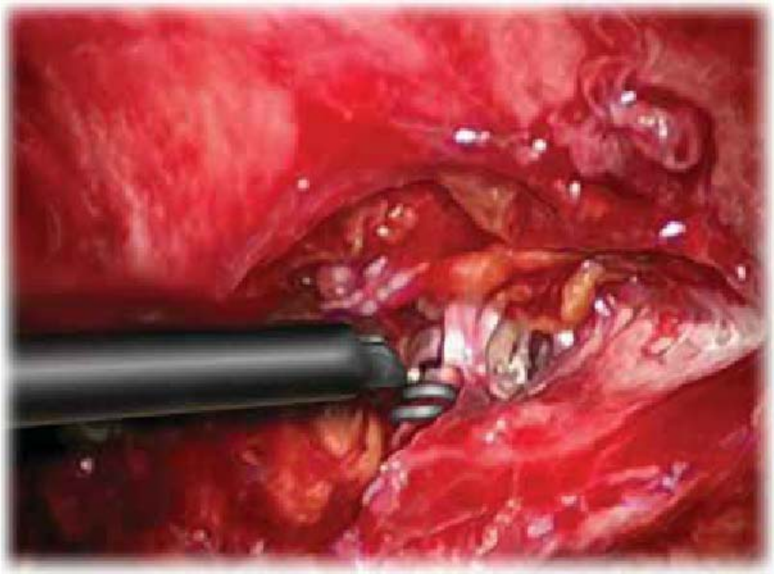

Figure 12.6 A tack is identified in the preperitoneal space penetrating one of the cutaneous nerves located lateral to the cord structures.



to be the cause of the pain, the goal of the operation is to provide a durable hernia repair. If there is no hernia, the goal is to eliminate any adhesions from the groin and to clear the groin of all foreign materials (mesh and fixation devices) freeing up the cord structures and nerves.

The laparoscopic removal of mesh from the preperitoneal space of the groin can be a difficult and potentially dangerous procedure, especially if the previous mesh had been cut and passed behind the cord structures. Injury to the cord structures, the iliac vein and artery, the obturator vessels, the inferior epigastric vessels, and the bladder are all possible. Even inadvertent bowel injury is possible, especially if there are bowel adhesions to the groin or mesh. Sometimes, it is appropriate to leave a portion of mesh on one or more of these structures to minimize the risk of injury. Figure 12.8 shows mesh being removed lateral to the cord structures. Figure 12.9 shows mesh being cut away from the vas deferens. Figure 12.10 shows a plug being excised from the indirect space. Figure 12.11 shows the mesh being excised from behind the cord structures. Figure 12.12 shows the cord structures after complete mesh removal.

If the previous hernia repair was done laparoscopically or using an open approach, where the mesh was placed completely into the preperitoneal space, it is possible that

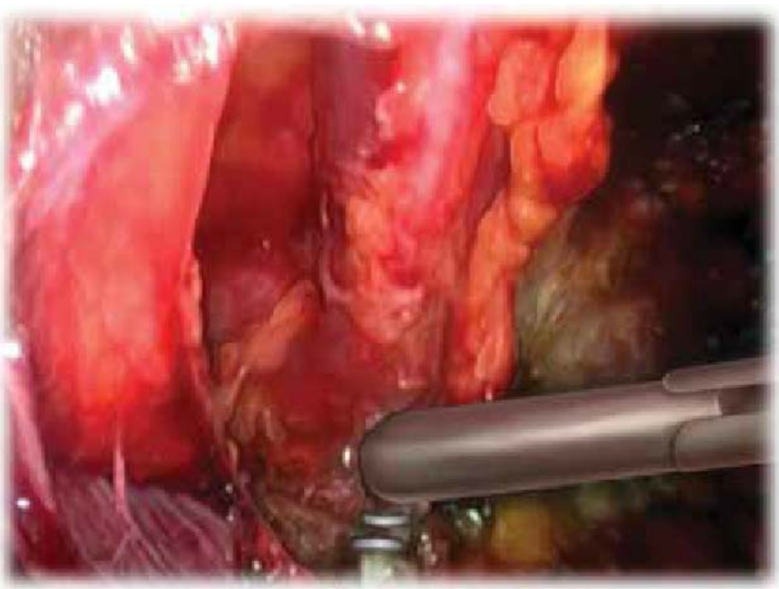

Figure 12.7 A tack being removed from the area of the indirect ring and inferior epigastric vessels.

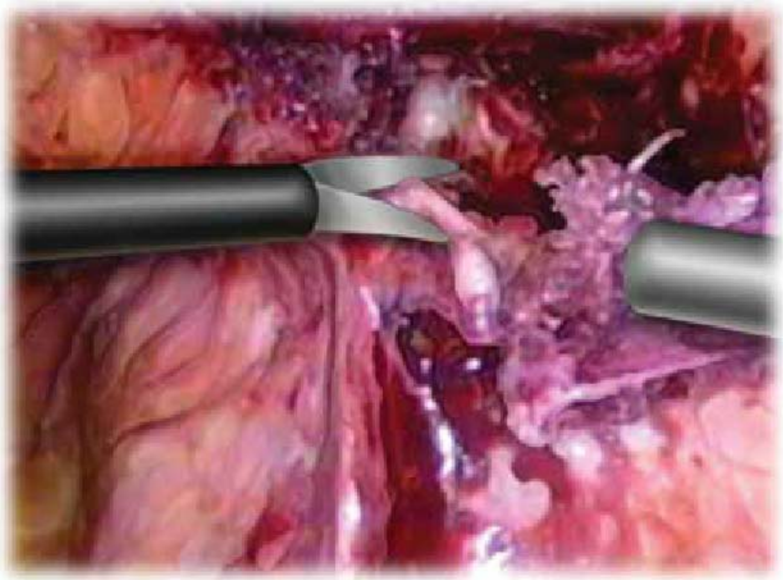

**Figure 12.8** Mesh being removed lateral to the cord structures.

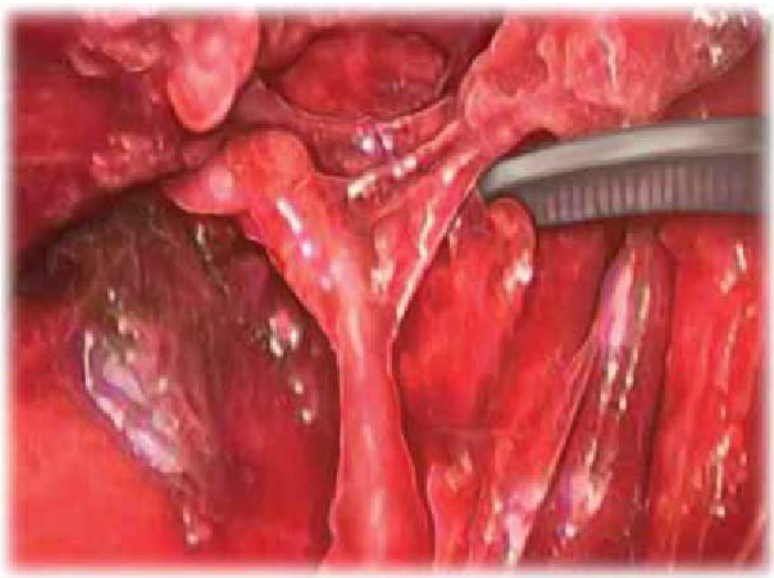

**Figure 12.9** Mesh being cut away from the vas deferens.

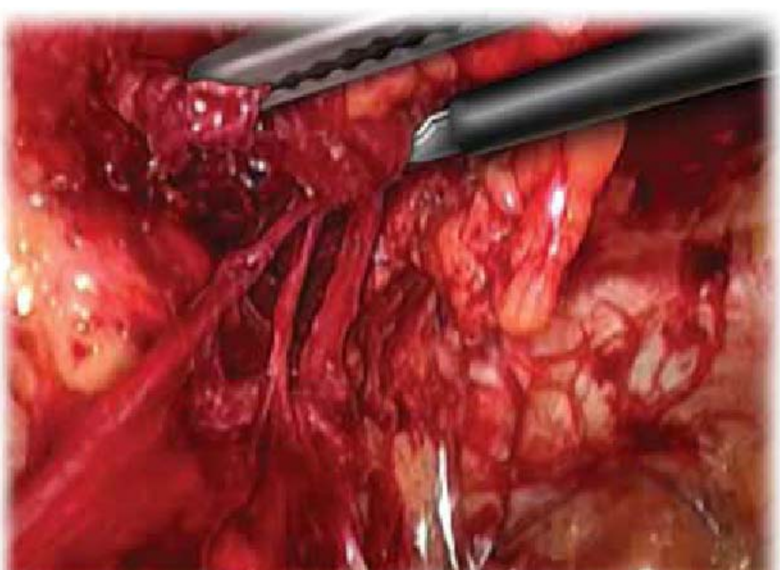

**Figure 12.10** A plug being excised from the indirect space.

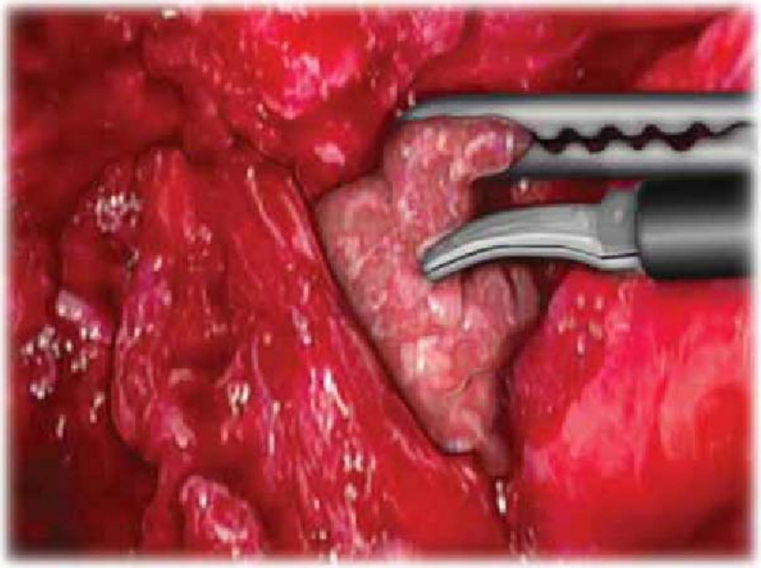

Figure 12.11 Mesh being excised from behind the cord structures.



a laparoscopic approach alone will result in the maximal benefit from an operation. The reason for this is that the nerves in the preperitoneal space are different from those typically involved if the mesh is located in a more superficial tissue plane (as in a Lichtenstein repair). Figures 12.13–10.15 show the nerves in the groin from an anterior view, from a posterior view, and with two meshes in place, one in a typical Lichtenstein position and the other in the preperitoneal location. It is important to note that the nerves typically involved in neuropathic pain are different for these two different mesh locations. An open triple neurectomy (addressing the more superficial nerves) will not likely help relieve the pain from mesh or fixation devices that are located in the preperitoneal space (potentially causing neuropathic pain from the deeper nerves).

For patients who have had an open inguinal hernia repair with a technique including placing mesh in the preperitoneal space and in more superficial locations (plug and patch, Prolene Hernia System, Ultrapro Hernia System, etc.), or a technique where no mesh is placed in the preperitoneal space, it is likely that an open groin exploration will be required to achieve the maximal benefits from a surgical approach. The open exploration includes removal of mesh and any other material that may be causing pain. Nerves that course in the groin in the intermuscular location (the iliohypogastric, ilioinguinal, and

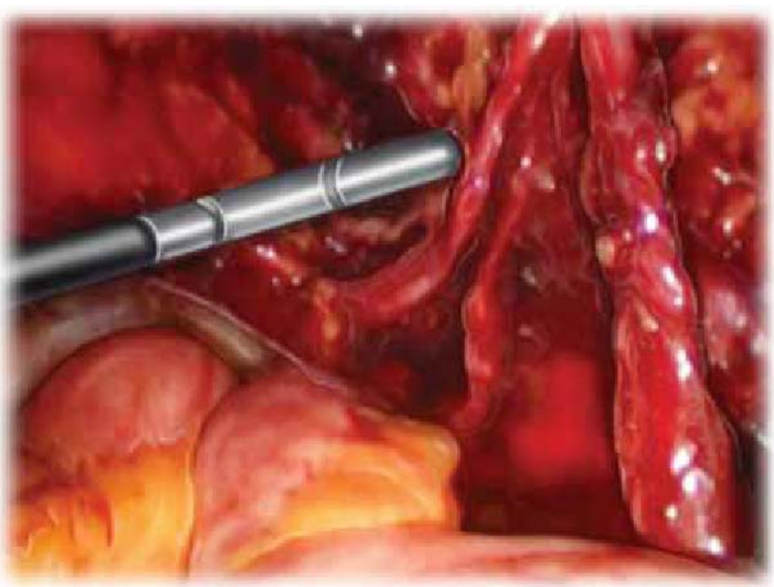

Figure 12.12 Cord structures after complete mesh removal.

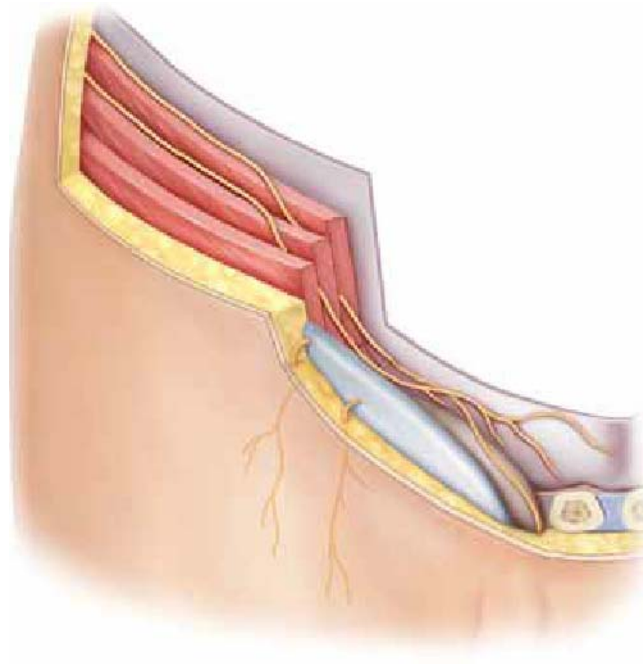

**Figure 12.13** Nerves in the groin from an anterior view.

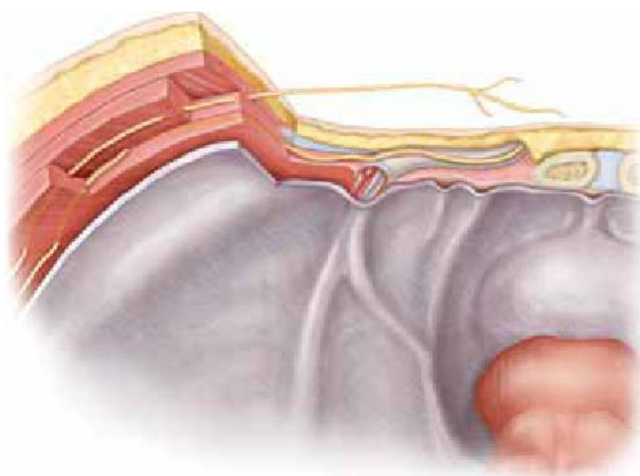

**Figure 12.14** Nerves in the groin from a posterior view.

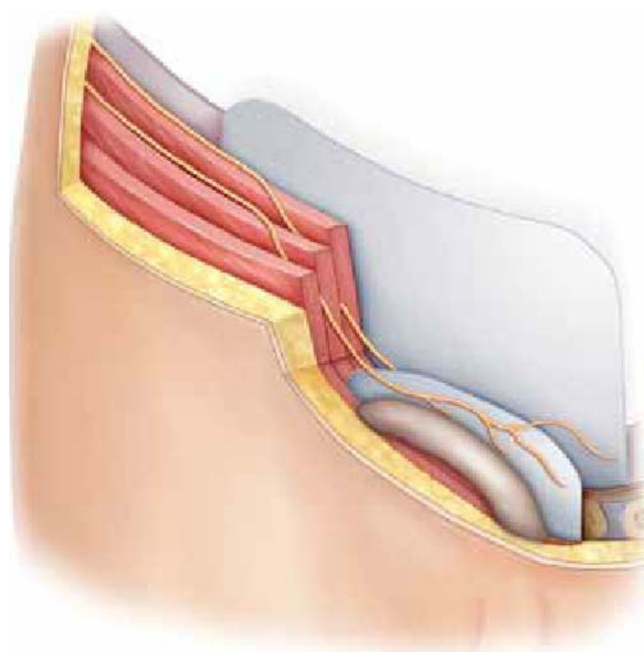

**Figure 12.15** Nerves in the groin with two meshes in place, one in a typical Lichtenstein position and the other in the preperitoneal location.

genital branch of the genitofemoral) may be divided and the distal ends implanted into muscle. There is some debate about whether to search for and divide all nerves or only the nerves involved in the scar tissue, mesh or other fixation devices. Because of the difficulty in finding nerves outside of the field of dissection and the potential to cause complications, it has been our practice to divide nerves involved in the scar tissue, mesh and/or fixation devices, but not to look for additional nerves in otherwise normal appearing tissue. After the open approach is completed, the groin is closed with three layers of absorbable suture and then skin is closed with a subcuticular stitch.

At this point in our experience, we have not placed a permanent synthetic, absorbable synthetic, or biologic mesh after mesh removal for pain, regardless of whether the procedure was laparoscopic only or a laparoscopic and open combined procedure. We have not placed a mesh during this operation in an attempt to minimize the potential of causing additional or new pain from a mesh and/or from mesh fixation, when the goal of the operation is to relieve pain. The exception to this is when an interstitial or recurrent hernia is found at laparoscopy. Figure 12.16 shows the operative steps of the procedure in a flow chart.

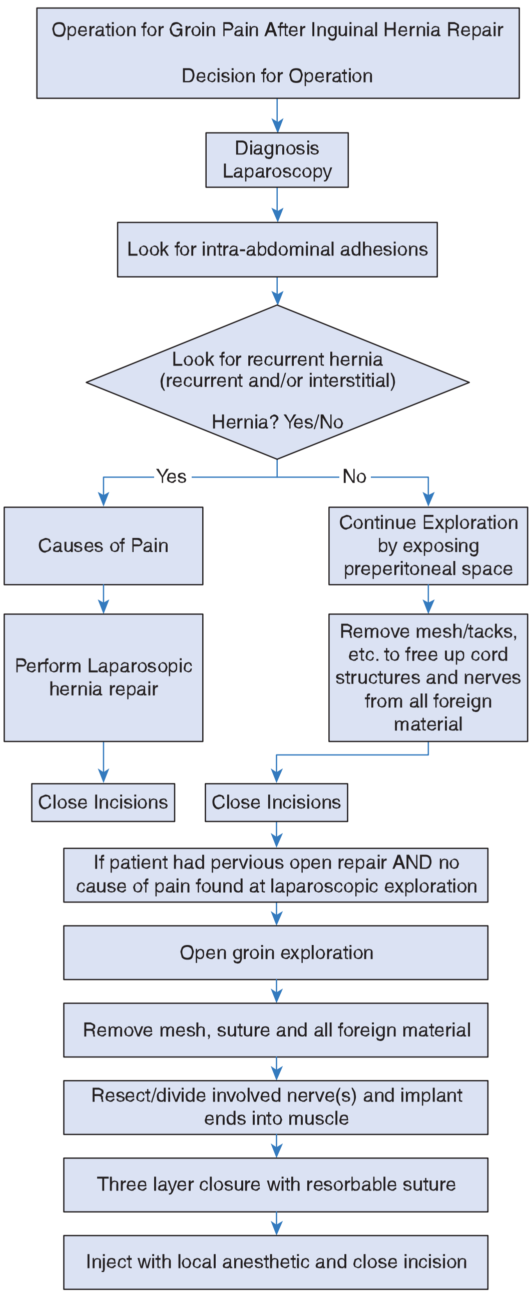


**Figure 12.16** Operative steps of the procedure in a flow chart.

## POSTOPERATIVE MANAGEMENT

The patient will often be discharged the same day or within 24 hours of the operation unless there are complications. However, some patients will have difficulty with pain control, especially if they were taking narcotics for pain control prior to the operation. All of the pain management techniques discussed in the pre-operative preparation section might also be considered in the postoperative course. Typically, as the pain and inflammation from the operation resolves, the patient will become more and more aware of the results from the operation, and will report improvement leveling off approximately 2 to 4 months after the operation.

## COMPLICATIONS

Potential intraoperative complications include injury to bowel, bladder, the vas deferens, and to vascular structures, specifically the cord vessels, iliac vessels, inferior epigastric vessels, and obturator vessels. If bleeding is not able to be controlled laparoscopically, conversion to an open approach is appropriate.

In the postoperative period, early complications include wound infection, seroma, and hematoma. As mentioned, postoperative pain control may be difficult.

The long-term complications pertinent to this procedure include hernia recurrence and inadequate resolution of pain. Non-surgical pain management should be continued for pain that is not resolved in an attempt to improve a patient's quality of life. A continued search for causes of groin pain other than a hernia repair may also be appropriate. For the patient who has a hernia recurrence after an operation to relieve pain from a prior hernia repair, the decision to undergo another hernia repair may be a difficult one. If another repair is performed, the surgeon should consider altering the technique and materials used in an attempt to minimize the chance of causing chronic pain again. Consideration for the use of resorbable synthetic and biologic meshes may also be appropriate. For our hernia program, it is standard to involve the patient in a shared decision process to determine the technique and materials used for a hernia repair in this situation.

# Prevention

There have been attempts to minimize chronic pain over the past decade by altering the approach and/or surgical technique for inguinal hernia repair. Studies have shown mixed results in attempting to prophylactically identify and divide the ilioinguinal, iliohypogastric, and/or genital branch of the genitofemoral nerves during open inguinal hernia repair. Several studies have evaluated lightweight mesh (both open and laparoscopic) to look for a decreased incidence of chronic pain. Often, these studies are inconclusive or they show a modest benefit in terms of pain when using lightweight mesh, but there may be a higher recurrence rate with lightweight mesh. Decreasing or eliminating fixation, or using glue, has also shown some decreased pain, but with a potential for an increase in recurrence rate. The laparoscopic approach compared to open inguinal hernia repair has some of the strongest evidence showing a decrease of acute and chronic pain in several studies. However, some studies have shown a minimal difference in pain after the first 24 to 48 hours.

These attempts to isolate and improve one variable and the limited success with this strategy highlight the fact that this is a complex problem and complex problems are rarely solved with simple solutions. Complex problems require a systems approach that includes identifying and defining processes and variables, including outcome measures, and looking intentionally for anomalies.

# A Systems Solution for Chronic Groin Pain after Inguinal Hernia Repair

In an attempt to improve patient care and identify value in our system of care delivery, we are deconstructing and re-designing the concept of a department of "general surgery". Using principles of systems and complexity science, we are building care teams around definable patient groups. One care team is designed around the patient group with abdominal wall hernia disease and hernia-related complications. Our hernia team includes surgeons, nurses, a clinical manager, care coordinators, a clinical quality improvement manager, a biologic/materials engineer, a mechanical engineer, and other team members. Also, former patients and their family members participate and help provide care for current patients and their family members, who are considered to be the focus of our clinical team. By including others outside of the core hernia team, we are participating in hernia care communities through face-to-face meetings, through video and tele-conferencing capabilities and through internet social networking capabilities. The clinical portion of our team cares for patients through their dynamic care process and allows for shared decision making with the patient at multiple steps in the care process. One process to be defined is the care for a patient who is suffering from chronic pain after an inguinal hernia repair (Fig. 12.17). This includes the first interaction with the clinical manager or care coordinator, who begins to develop a caring relationship with the patient and their family, the process of care during the surgical procedure, and the entire cycle of care until the patient returns to a good quality of life.

The clinical quality improvement portion of the hernia team is focused on objective outcome measures and identification of anomalies to learn and improve. The largest clinical quality improvement project currently ongoing for our hernia team is the analysis of explanted synthetic hernia mesh, many of which have been explanted from patients who have suffered from chronic groin pain after inguinal hernia repair. By defining the dynamic care processes and identifying and measuring quality, satisfaction, and financial outcome measures, the hernia team will generate clinical quality improvement data that will help identify ways to improve the value of care delivered.

# Summary

In summary, chronic groin pain after inguinal hernia repair is a complex problem which has increased in incidence and its impact on our society over the past two decades. The causes and possible treatment options are many and not yet well understood. For patients with severe groin pain or those whose quality of life is impacted, it is appropriate to offer a surgical option for treatment, especially when a period of time has passed with no improvement and if less invasive therapies have not been successful. Surgical treatment includes a diagnostic laparoscopy to look for intraabdominal adhesions, interstitial and recurrent hernias and foreign body materials in the preperitoneal space. For previous laparoscopic repairs and for those open repairs that result in mesh placement in the preperitoneal space, this may be all that is required to achieve maximal improvement from an operation. For most open inguinal hernia repair techniques, an additional open groin incision may be necessary to achieve maximal improvement from an operation. Removal of all foreign body materials and division of involved nerves with a three-layer groin closure with absorbable suture can be accomplished through the open groin incision. Even when the original cause of the pain has been successfully eliminated at operation, complete pain relief may not be achieved and additional pain management (diagnostic and therapeutic) may be required. Because of the complexity of

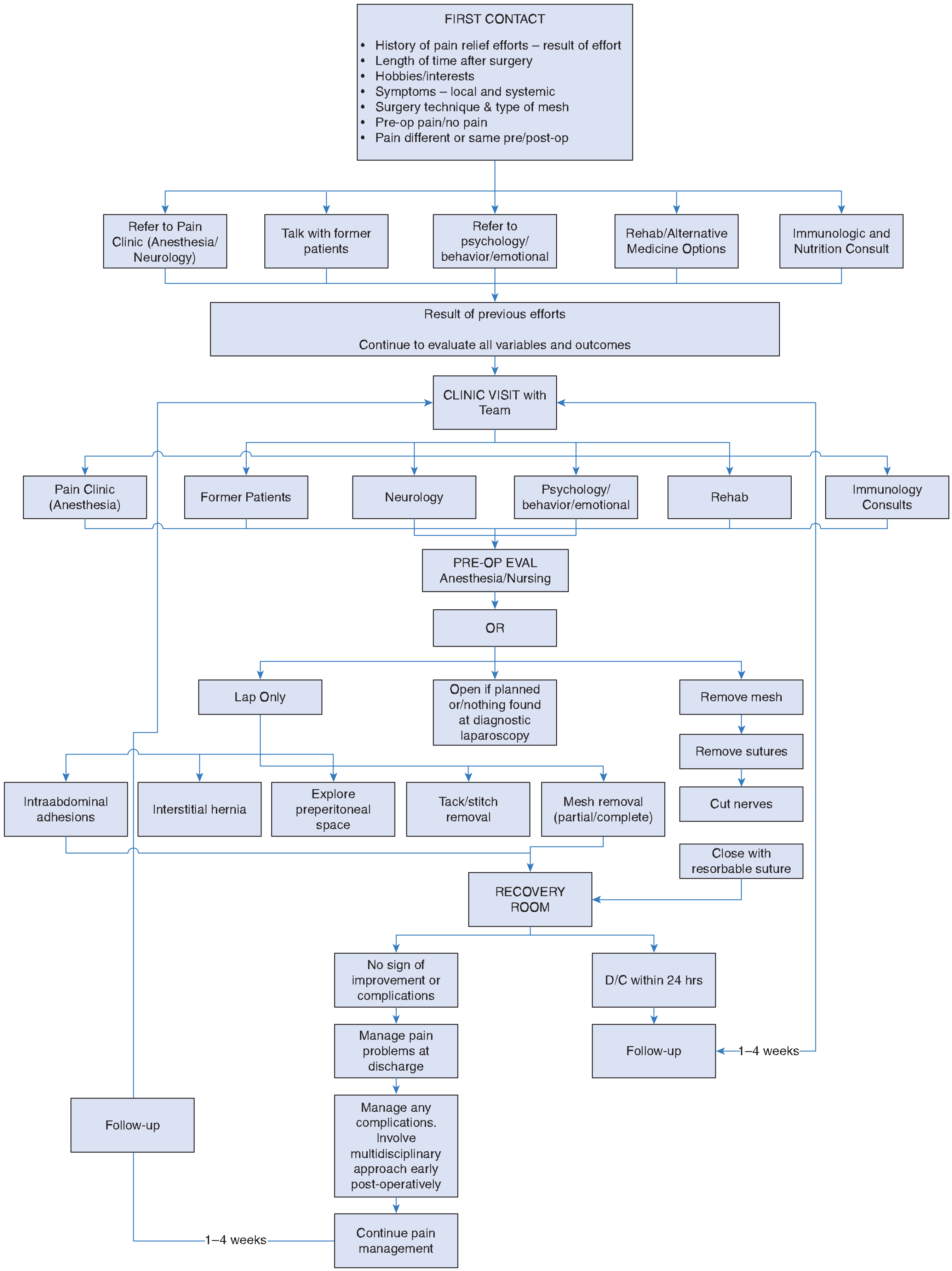


**Figure 12.17** Algorithm showing care for a patient who is suffering from chronic pain after an inguinal hernia repair.

this problem and the psychological and emotional impact that can occur, management of this patient group will likely be the best in the setting of a multidisciplinary team.

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# 13 Inguinal Neurectomy for Nerve Entrapment: Triple Neurectomy

**Parviz K. Amid and David C. Chen**

## Introduction

Although advances in inguinal hernia repair have markedly reduced recurrence rates, chronic pain after hernia repair is a continuing concern. In earlier reports, we have described the causes and prevention of chronic pain and emphasized the key features of groin neuroanatomy and the vulnerability of the intramuscular segment of the iliohypogastric nerve. We also have identified "meshoma" as a pathologic cause of inguinodynia and demonstrated the effectiveness of "triple neurectomy" as the surgical treatment for postherniorrhaphy pain that has not responded to non-surgical pain management.

### Indications for Triple Neurectomy

- Groin pain persisting more than 6 months postoperatively. Pain related to neuropraxia, which may last 6 months postoperatively, is usually a self-limiting condition and does not necessitate surgical intervention.
- Groin pain that did not exist prior to the hernia repair, or if present preoperatively, has a different character.
- Groin pain associated with paresthesia, allodynia, hyperpathia, hyperalgesia, hyperesthesia, hypoesthesia, a positive Tinel sign, radiation of pain to the scrotal skin (distinguishable from testicular pain), and/or to the femoral triangle.

### Contraindications

- General health problems contraindicating general anesthesia.
- Groin pain caused by spine or hip pathology.

## PREOPERATIVE PLANNING

- Review of the original and subsequent operative reports.
- Review of all non-surgical treatment reports.

- Imaging studies should be done before triple neurectomy if the original hernia repair included the use of a plug, two-layer devices such as prolene hernia system/ ultrapro hernia system (PHS/UHS), or mesh implantation in the preperitoneal space to rule out meshoma formation.

## SURGERY

"Triple Neurectomy," pioneered in our institute in 1995, consists of resection of the ilioinguinal, iliohypogastric, and inguinal segment of the genital branch of the genitofemoral nerves. The procedure is performed through the incision of the original hernia repair and does not require mobilization of the spermatic cord. Originally, the iliohypogastric nerve was resected from its emergence from the internal oblique muscle to its point of exit from the external oblique aponeurosis. In 2004, realizing that the intramuscular segment of the iliohypogastric nerve can be injured when the lower edge of the internal oblique muscle (the so-called conjoined tendon) is sutured to the inguinal ligament during tissue repair, or due to fixation of a plug during plug repair, the operation was extended to include the intramuscular segment of the nerve. In 2005, a patient was referred with groin and testicular pain (to be distinguished from scrotal skin pain) and MRI evidence of entrapment of vas deferens within a plug. Since the patient had an earlier vasectomy, the affected segment of the vas was resected during the triple neurectomy. Postoperatively, the patient's chronic groin pain and orchialgia disappeared, which was contrary to our experience with other patients with both orchialgia and inguinodynia.

Histologic analysis showed fibrosis and foreign-body reaction around the paravasal nerves within the lamina propria of the vas. In 18 subsequent patients with inguinodynia and orchialgia, a 2 cm segment of lamina propria was resected (without resecting the vas) as proximal to the inguinal ring as possible. Histology showed perineural fibrosis in these patients as well.

## SURGICAL TECHNIQUE

The incision is made through the original hernia repair and the external oblique aponeurosis is opened. The ilioinguinal nerve (Fig. 13.1) is identified between the internal ring (or the lateral part of the mesh if any was previously placed) and the anterior superior iliac spine. The nerve can be attached to the inguinal ligament or the upper leaf of the external oblique aponeurosis and blocked from the view by a retractor. The nerve can also be hidden within the fat-filled grooves of the internal oblique muscle; therefore, all superficial fat should be wiped from the internal oblique muscle to reveal the hidden nerve. The cut ends of the nerve are ligated to close the neurilemma of the nerve thus avoiding traumatic neuroma formation. The ligated proximal end of the nerve is buried within the internal oblique muscle to keep the stump of the nerve from being incorporated in future scarring of the surgical field.

The iliohypogastric nerve (Fig. 13.1) is located between the external and internal oblique aponeurotic layers. To identify the nerve, the anatomic cleavage between these two layers is opened. The visible part of the nerve over the internal oblique aponeurosis is identified and held by a vessel loop. A slit is made in the internal oblique muscle fibers to locate the intramuscular segment of the nerve (Fig. 13.2), which is then severed as proximal to the surgical field as possible. The cut ends of the nerve are ligated and the proximal cut end is buried within the internal oblique muscle. In fewer than 5% of patients, the normally visible part of the iliohypogastric nerve is under the internal oblique aponeurosis, therefore hidden from the surgeon's view. In these patients, the subaponeurotic course of the nerve must be determined by noting the small point of its simultaneous exit from both external and internal oblique aponeuroses (Fig. 13.3). In these instances the internal oblique aponeurosis, under the above nerve exit point is incised to expose, trace, and resect the hidden nerve as laterally as possible.

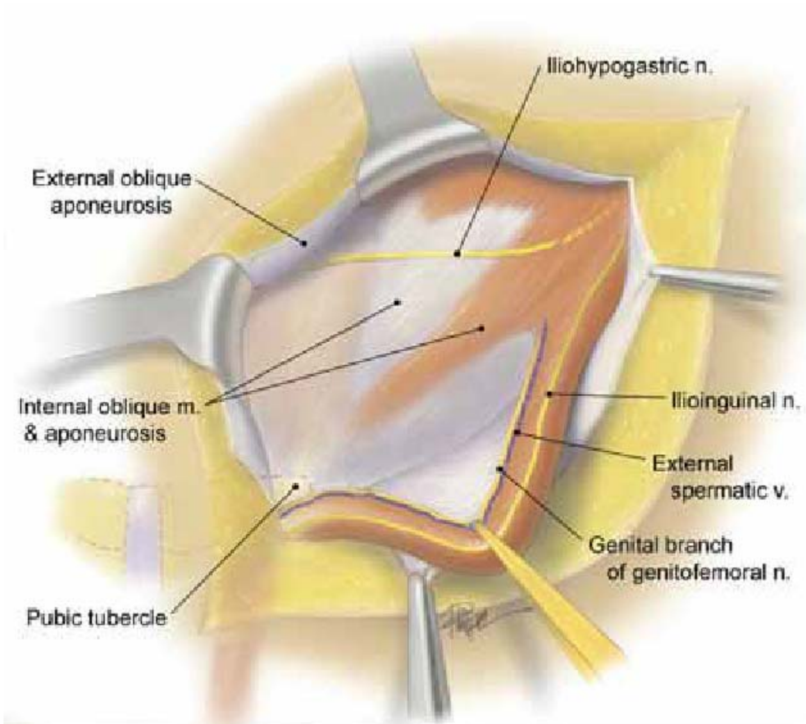


**Figure 13.1** Groin neuroanatomy.



The inguinal segment of the genital branch of the genitofemoral nerve can be exposed by entering the internal ring through its inferior crus, and the nerve is resected with ligation of its cut ends. The proximal ligated cut end of the nerve is allowed to retract into the preperitoneal space. Pain after plug repair and preperitoneal herniorrhaphy (both open and laparoscopic) presents special problems. The preperitoneal nerves, including the main trunk of the genitifemoral, its femoral branch, and the preperitoneal segment of its genital branch, are particularly vulnerable to neuropathy

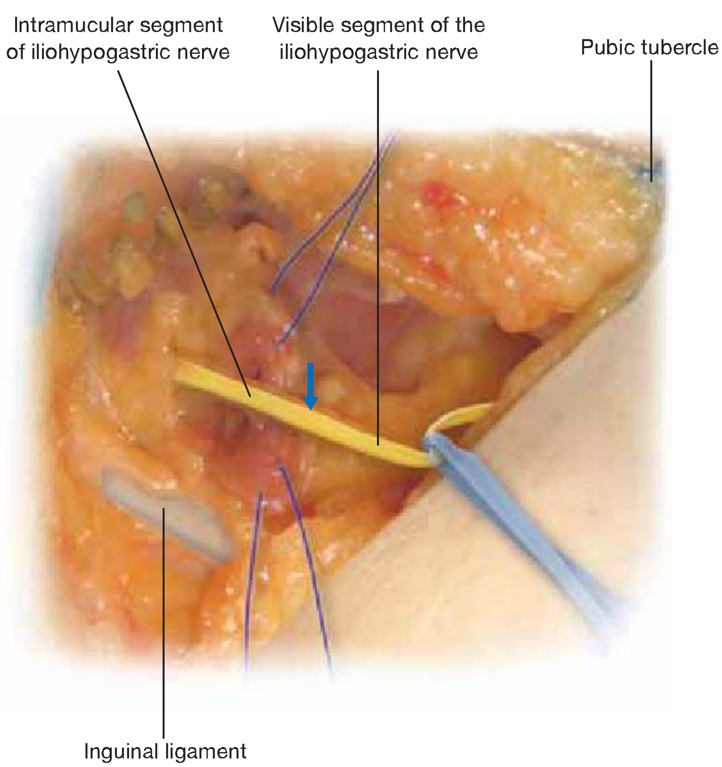


**Figure 13.2** 1: Pubic tubercle. 2: Visible segment of the iliohypogastric nerve. 3: Inguinal ligament. 4: Intramuscular segment of iliohypogastric nerve seen through a slit made in the internal oblique muscle. The two blue sutures are retracting the edges of the slit. The blue arrow points to the junction of the visible and intramuscular segment of the iliohypogastric nerve.

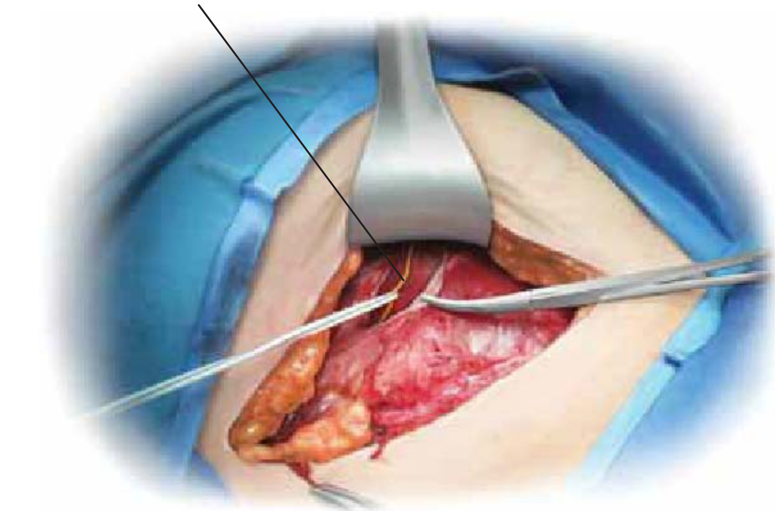


**Figure 13.3** Example of subaponeurotic iliohypogastric nerve shown through a slit made in the overlying internal oblique aponeurosis.

from direct contact with mesh. Contrary to the nerves within the inguinal canal that are covered and protected by a layer of fascia, nerves in the preperitoneal space have no protecting fascia against the mesh. In addition to the above, when fixation devices are used during laparoscopic herniorrhaphy, staples or tacks can penetrate the transversalis fascia and abdominal muscles and entrap nerves within the inguinal canal.

"Triple neurectomy" does not address neuropathic pain caused by neuropathy of the preperitoneal nerves unless the operation is extended to include segmental resection of the main trunk of the genitofemoral nerve over the psoas muscle. Exposure is achieved by splitting the transversus abdominis muscle to access the preperitoneal space through the split made in the internal oblique muscle for resection of the intramuscular segment of the iliohypogastric nerve. Once inside the preperitoneal space, the peritoneum is swept toward the midline to expose the psoas muscle and the main trunk of the genitofemoral nerve overlying it (Fig. 13.4). In addition to the above, plugs and meshomas are removed from the preperitoneal space. The latter requires repair of the resulting defect in the inguinal floor using the following step:

- Mobilization of the cord, but only when a repair is needed.
- Handling of the hernia sac. The indirect hernia sac is separated from the cord and inverted into the preperitoneal space. In the event of a large direct hernia, the sac is inverted with an absorbable suture using the transversalis fascia.
- **Implantation of mesh**

A sheet of 7 × 15 cm of lightweight mesh is used. With the cord retracted upward, the medial corner of the mesh is sutured with a nonabsorbable monofilament suture to the

**Figure 13.4** Main trunk of the genitorfemoral nerve over the psoas muscle.

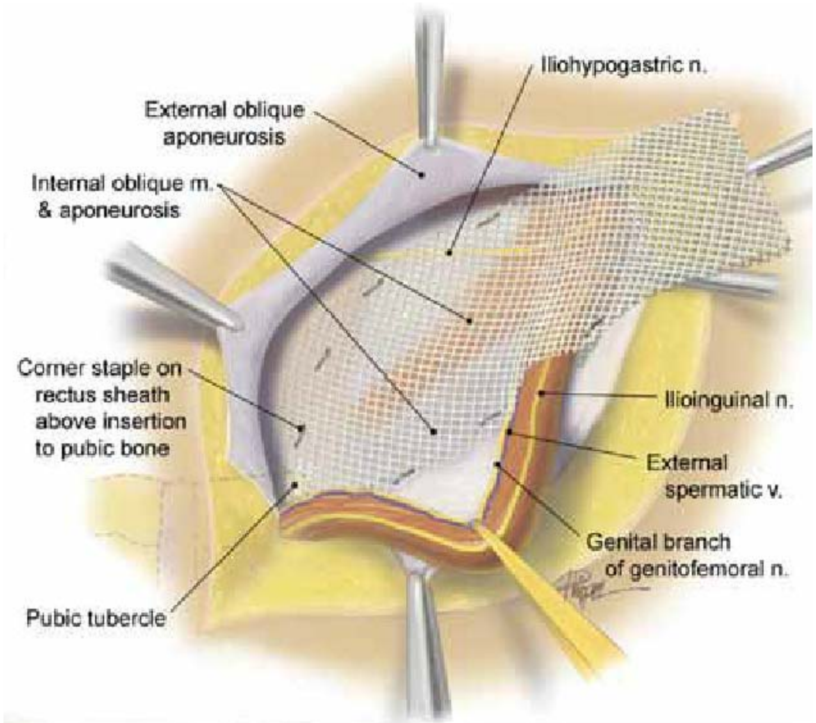


**Figure 13.5** Extension of mesh medial to the pubic tubercle, above the inguinal floor, and lateral to the internal ring, and fixation of the medial corner of mesh to the rectus sheath above its insertion to the pubic bone.

rectus sheath above its insertion to the pubic bone and overlapping the bone by 1 to 2 cm (Fig. 13.5). This suture is continued (as a continuous suture with up to four passages) to attach the lower edge of the patch to the inguinal ligament extending to a point just lateral to the internal ring (Fig. 13.5). The upper edge of the mesh is fixed to the rectus sheath and aponeurosis of the internal oblique muscle using two interrupted absorbable sutures (Fig. 13.5). Using a single nonabsorbable monofilament suture, the lower edges of each of the two tails are fixed to the inguinal ligament just lateral to the completion knot of the running suture, leaving adequate space for passage of the spermatic cord.

The excess patch on the lateral side is trimmed, leaving at least 5 cm of mesh lateral to the internal ring. This is tucked underneath the external oblique aponeurosis, which is then closed over the cord with an absorbable suture.

A recently introduced stapling device (Amid Stapler for inguinal and ventral hernias, and skin closure, SafeStitch, 4400 Biscayne Blvd. Miami FL 33137) can make the operation simpler and faster, with less acute postoperative pain. Fixation of the lower edge of the mesh to the inguinal ligament can be simplified and made faster by using the stapling device that delivers staples to the inguinal ligament over and in a parallel plain to the femoral vessels (Fig. 13.6), thus avoiding the risk of staples penetrating

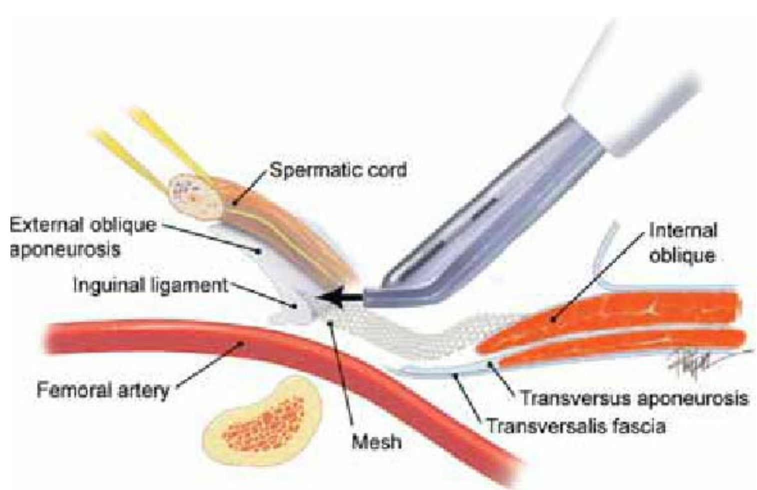


**Figure 13.6** Cross section of the inguinal canal. Stapler drives the staple parallel to the femoral vessels with no risk of vascular injury.

**Figure 13.7** Stapler mesh manipulators engage the mesh and move it to its precise location before stapling the mesh in place.

the vessels. In addition, the stapler mesh manipulators engage the mesh and guide it to its precise position followed by staple placement making application of even difficult to handle ultra-thin meshes easy (Fig. 13.7). According to laboratory measurements, retraction of the external oblique aponeurosis, subcutaneous adipose tissue, and skin for suture fixation of the upper edge of the mesh to the rectus sheath and the internal oblique aponeurosis requires 12 lbs of retraction force. Staple fixation of the upper edge of the mesh is simpler, faster and requires only 2 lbs of retractor force, resulting in less soft tissue contusion; a factor that contributes to acute postoperative pain. Finally, staple fixation easily creates the passage of the spermatic cord through the mesh by fixing the lower edge of the upper tail together with the lower edge of the lower tail to the inguinal ligament.

## COMPLICATIONS

Numbness of the groin, scrotal skin, and labium majus is expected, and female patients need to be informed of its sexually-related consequences. Two percent of patients experience superficial wound problems. No other complications have been encountered.

## RESULTS

We have now performed operations on 500 patients for chronic postherniorrhaphy inguinodynia. Recent observations of groin neuroanatomy and experience with meshomas prompted extension of standard triple neurectomy to include resection of intramuscular segments of the iliohypogastric nerve and explantation of meshomas. Previously, we reserved the triple neurectomy operation for pain after laparoscopic or open preperitoneal hernia repair only in cases in which fixation devices were used or when an imaging study showed a meshoma. With extension of the operation to include segmental resection of the genitofemoral nerve, the procedure can be offered to all patients with pain after preperitoneal repair. In this select group, 5% of patients continue to experience persistent pain. Eighty-five percent of patients have complete resolution of pain; in 15% there is substantial improvement, with no functional impairment, and no need for narcotics.

## CONCLUSION

Chronic postherniorrhaphy pain complex, that according to Danish nationwide study is independent of the method of the hernia repair, is a combination of nociceptive and neuropathic pain. There is no sharp delineation between the two and the issue becomes more complicated by social, genetic, and patient-related factors.

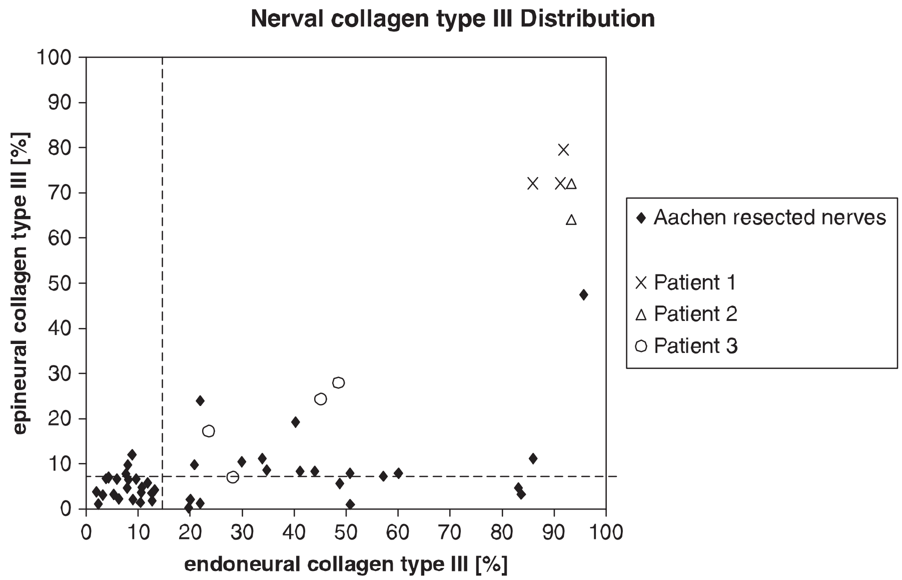


**Figure 13.8** Higher level of collagen-3 in nerve tissue harvested from patients with chronic inguinodynia, compared with control. "Xs" and "triangles" are nerve tissue from patients with chronic pain. "Os" nerve removed electively for being in the way of a primary hernia repair in a patient without chronic pain. "Solid black diamonds" denote Aachen's control.



In addition, according to our ongoing study in association with Klinge U. from the Aechen group in Germany, there may also be some biochemical factors such as increased collagen type-3 in the nerve tissue harvested from patients suffering chronic pain (Fig. 13.8). There is no universally agreed-upon definition, etiology, or treatment for chronic postherniorrhaphy pain. Therefore, the best we can now do for our patients is to avoid this disabling complication by paying careful attention to the pathophysiology of pain and provide careful identification and protection of nerves during hernia repair. On the basis of level "A" studies, the latter can reduce the postoperative pain rate from 5% to less than 1%.

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# 14 Inguinal Anatomy: Laparoscopic View

**Maurice E. Arregui**

## Introduction

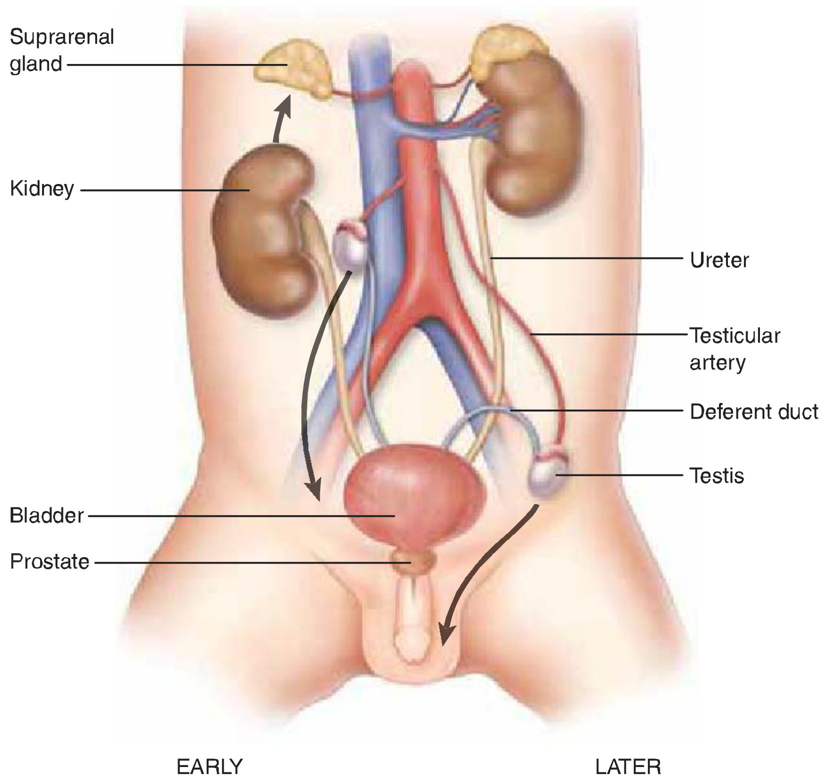
The intraperitoneal view of the pelvis and inguinal area is quite deceptive when looking at it through the lens of a laparoscope. It is a two-dimensional view that gives the impression that there is a peritoneal layer, a preperitoneal layer in which all structures of the inguinal area lie and the abdominal wall with a portal for exit of the cord structures.

In fact, the inguinal area is quite three-dimensional and is made up of various layers with intertwining fascial planes that serve as conduits for blood vessels, lymphatics, ureters, muscles, tendons, and nerves. To really understand the anatomy of the preperitoneal spaces of the inguinal area, one must know the embryology and migration of structures with their surrounding fascia. These fascial layers define the planes and create conduits for these structures. From the intraabdominal perspective, the laparoscopic view gives an *opaque* picture of the various layers of the inguinal structures with encompassed contents. A more clear view is obtained during laparoscopic inguinal hernia repair. This chapter will attempt to perform a laparoscopic dissection of the preperitoneal and inguinal spaces to identify the anatomy of the structures in their various encompassing fascial spaces.

### Embryology of the Inguinal Area

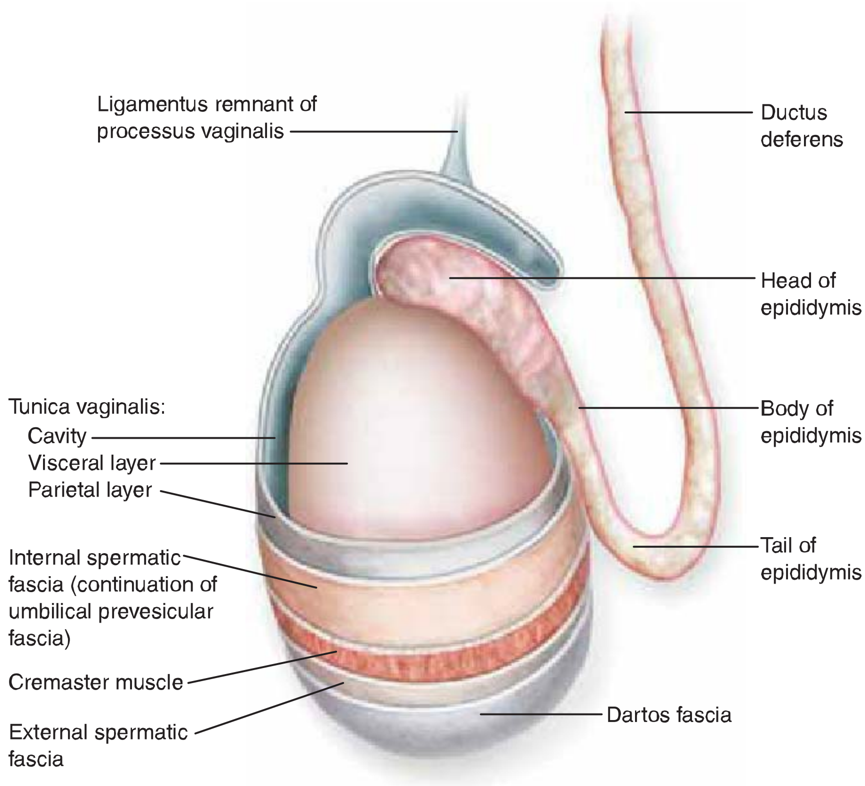
Key to understanding the fascial layers of the lower abdominal wall is understanding the embryology of the genitourinary tract with development of the bladder, ascent of the kidney, and descent of the testis. The bladder, ureters, kidneys, testicular vessels, testicles, and vas deference begin as intraperitoneal and extraperitoneal organs possibly covered by a continuous anterior and posterior fascia. During descent of the testicle between the seventhth and twelfth weeks, the gubernaculum contracts to pull the testicle and vas deference down toward the scrotum. Between the third to seventh months, the testes lie in the inguinal canal and it descends into the scrotum around the time of birth (Fig. 14.1). As this occurs, it drags the testicular structures with the peritoneum. The fascia that surrounds these structures likely includes the umbilical

Figure 14.1 Descent of the testicle.




prevesicular fascia and or the transversalis fascia. After decent the tunica vaginalis obliterates proximally to form the peritoneal vaginal ligament that attaches to the tunica vaginalis testis. A serous bilaminar layer forming the parietal and visceral layers of the testis (Fig. 14.2). The internal spermatic fascia forms the layer surrounding the testis and tunica vaginalis. The internal spermatic fascia is described as being the

Figure 14.2 Tunica vaginalis testis.



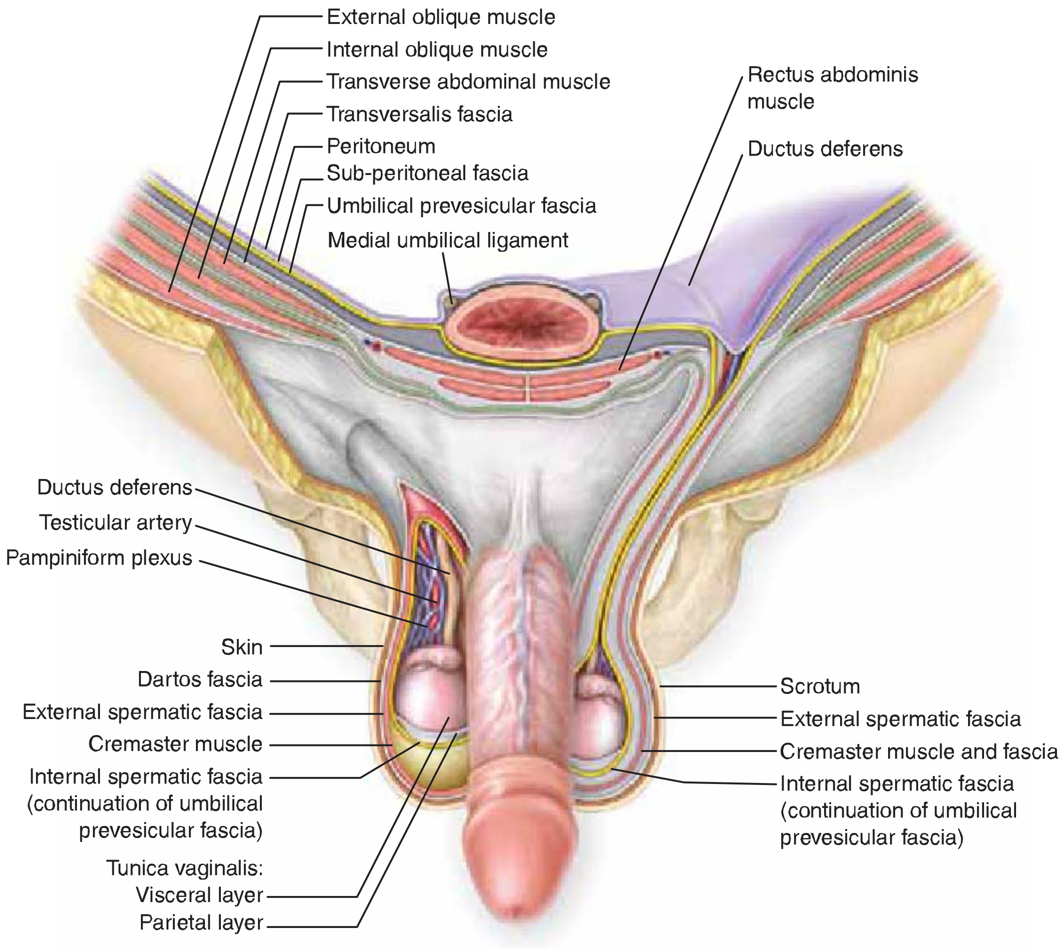



**Figure 14.3** Internal spermatic fascia enclosing the testis and tunica vaginalis testis.



evagination of the transversalis fascia by some but may also have components of the umbilical prevesicular fascia (Fig. 14.3).

## Intraperitoneal View of the Anatomy of the Inguinal Area

The structures include the bladder and umbilical ligaments in the midline and inguinal structures laterally. The bladder is at the base and at its apex is the median umbilical ligament which connects the bladder to the umbilicus. This is the median umbilical ligament which represents the obliterated urachus. On either side of the bladder are the medial umbilical ligaments which are remnants of the umbilical arteries that returned de-oxygenated blood from the fetus. This structure is connected to the internal iliac artery (Fig. 14.4A). The lateral umbilical fold is made up of the inferior epigastric vessels. This is probably a misnomer since these vessels do not have anything to do with the umbilical structures and provide blood supply to the anterior abdominal wall. The inferior epigastric vessels are enveloped by the trasversalis fascia shortly after exit from the external iliacs. Lateral to this is the internal inguinal ring. Entering this is the vas deferens and spermatic vessels in males (Fig. 14.4B, C) and round ligament in females (Fig. 14.4D). This is also the entry of an indirect hernia sac or remnant of the processus vaginalis. This is a fairly complex area that serves as portal for structures exiting the abdomen in transit to the scrotum.

## Layers of the Abdominal Wall

Transperitoneal view of the lower anterior abdominal wall shows converging of the median and medial umbilical folds as it enters the umbilical ring. Lateral to the medial

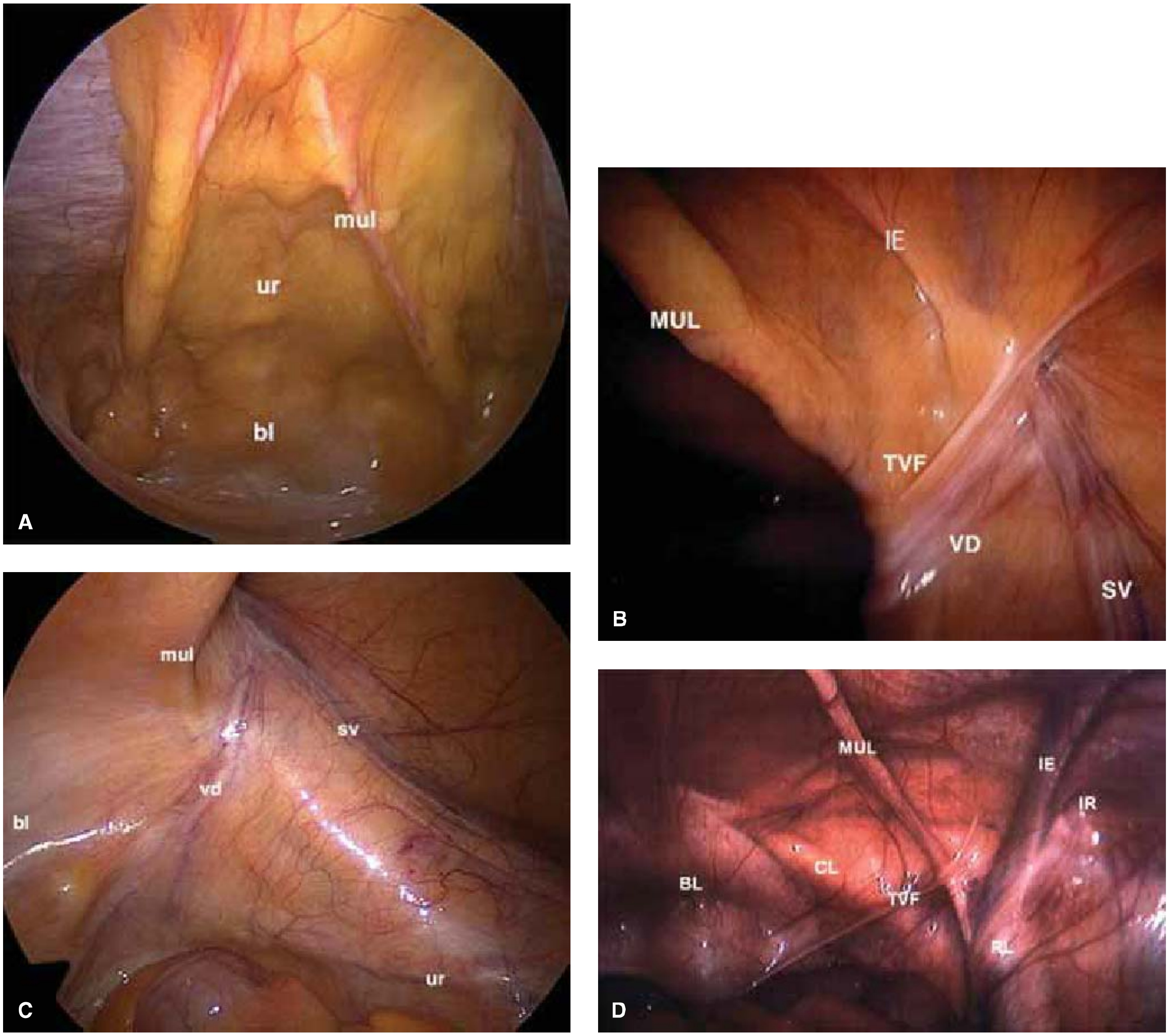



**Figure 14.4** **A:** Laparoscopic views of the lower anterior abdominal wall. ur—obliterated urachus or median umbilical ligament, bl—bladder, and mul—medial umbilical ligament. **B:** View of the inguinal area in a male. MUL—medial umbilical ligament, IE—inferior epigastric arteries which form the lateral umbilical ligament, TVR—transverse vesicular fold, VD—vas deferens, and SV—spermatic vessels. With kind permission from E. Arregui. Surgical anatomy of the preperitoneal fasciae and posterior transversalis fasciae in the inguinal region. *Hernia.* Springer Science+Business Media; 1997;1:101–110. **C:** Intraperitoneal view of the right flank and pelvis in a male. bl—bladder, mul—medial umbilical ligament, vd—vas deferens, sv—spermatic vessels, and ur—ureter. **D:** View of inguinal area in female. BL—bladder, CL—Cooper's ligament, TVF—transverse vesicular fold, IE—inferior epigastrics, and RL—round ligament. IR—internal ring. With kind permission from E. Arregui. Surgical anatomy of the preperitoneal fasciae and posterior transversalis fasciae in the inguinal region. *Hernia.* Springer Science+Business Media; 1997;1:101–110.

umbilical fold the peritoneum is void of fat and therefore quite transparent. The posterior rectus sheath is well seen above the arcuate line and it thins out but does not disappear below (Fig. 14.5). Fibers of the layers of the posterior rectus sheath can be seen all the way to the pubis in many patients. A transverse view of the abdominal wall will show the rectus muscle, followed by the inferior epigastric vessels and deep to this is the posterior rectus sheath. Although the posterior rectus sheath is attenuated, all three fascial layers of the abdominal wall can be present to a variable degree. This includes the fascial layers of the external oblique, internal oblique, and transversus abdominus muscle which forms the transversalis fascia.

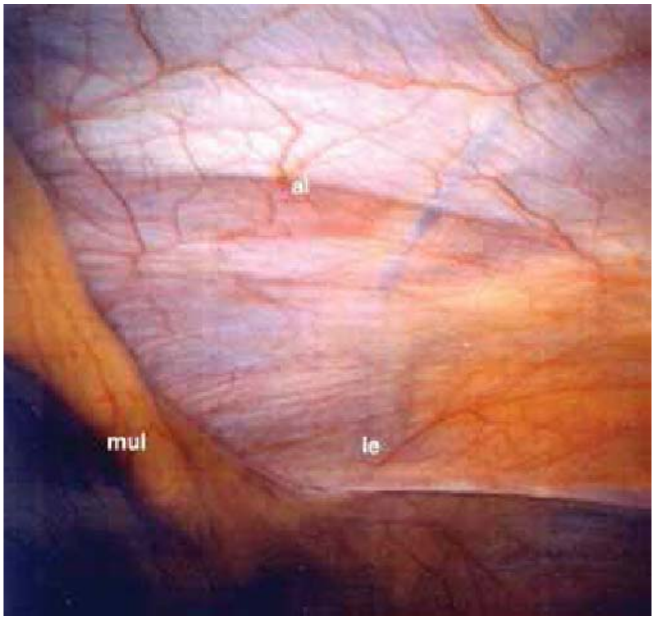



**Figure 14.5** Intraperitoneal view of the abdominal wall. The arcuate line can be seen but below there is a coninuation of the layers of the posterior rectus sheath. mul—medial umbilical ligament, al—arcuate line, and ie—inferior epigastrics. With kind permission from E. Arregui. Surgical anatomy of the preperitoneal fasciae and posterior transversalis fasciae in the inguinal region. *Hernia*. Springer Science+Business Media; 1997:1:101–110.

Between the posterior rectus sheath and the umbilical prevesicular fascia is the true preperitoneal space (Fig. 14.6) which is in continuity with the space or Retzius below the pubic bones.

Posterior to this space is the umbilical prevesicular fascia which covers the bladder and obliterated urachus (median umbilical ligament) and medial umbilical ligaments. Deep to this layer is another fascial layer between the bladder, ligaments, and the peritoneum which is the final layer of the anterior abdominal wall (Fig. 14.7).

Between the pelvic wall and the umbilical prevesicular fascia covering the bladder is the space of Retzius (Fig. 14.8). The obturator foramen with nerve, vessels, and preperitoneal fat are found anteriorly and laterally in the space of Retzius below the pubic bone (Fig. 14.9). Also the vessels of the corona mortis are overlying Cooper's ligament and connecting the obturator vessels with the inferior epigastric vessels.

## Fascial Planes in the Inguinal Area Deep to the Transversalis Fascia

The umbilical prevesicular fascia which is anterior to the bladder and umbilical ligaments extends laterally to encompass the vas deferens and spermatic vessels. This

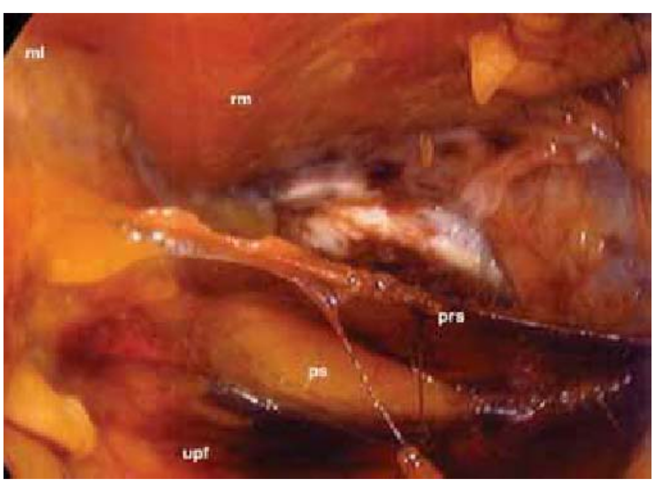



**Figure 14.6** Attenuated posterior rectus sheat (prs), preperitoneal space (ps) and umbilical prevesicular fascia (upf). ml—midline attachment of the posterior rectus sheath and rm—rectus abdominus muscle. Cooper's ligament is seen as the white structure covering the pubic bone. With kind permission from E. Arregui. Surgical anatomy of the preperitoneal fasciae and posterior transversalis fasciae in the inguinal region. *Hernia*. Springer Science+Business Media; 1997:1:101–110.

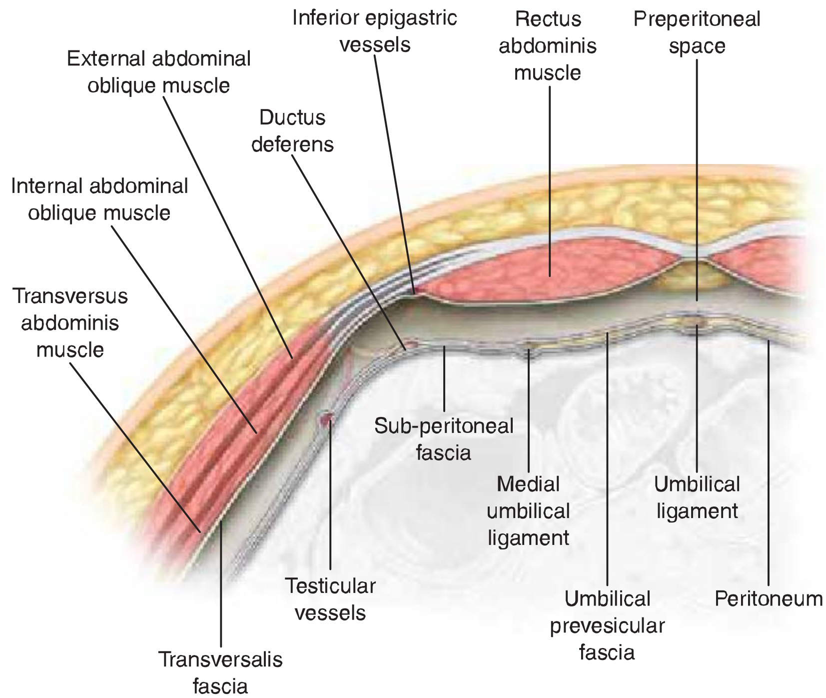



**Figure 14.7** Transverse view of the anterior abdominal wall compartments below the umbilicus.

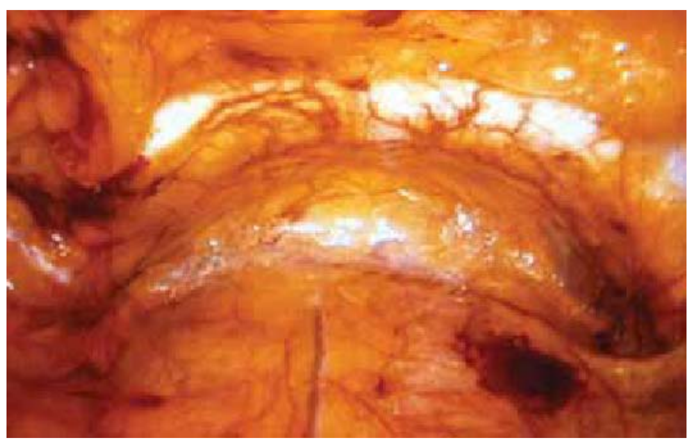


**Figure 14.8** Space of Retzius.

**Figure 14.9** Obturator nerve with vessels and fat entering the obturator foramen in the space of Retzius.

forms a conical sheath that penetrates the internal inguinal ring and is continuous with the **internal spermatic fascia** (Figs. 14.10A, B and 14.11A, B, C). This structure not only encompasses the cord structures but also the peritoneum that makes up the indirect inguinal hernia sac or a patent tunica vaginalis (Fig. 14.10B). Others have described a separate layer of fascia encompassing the vas and spermatic vessels separate deep to the peritoneum. The fascia surrounding the cord and obliterated tunica vaginalis may

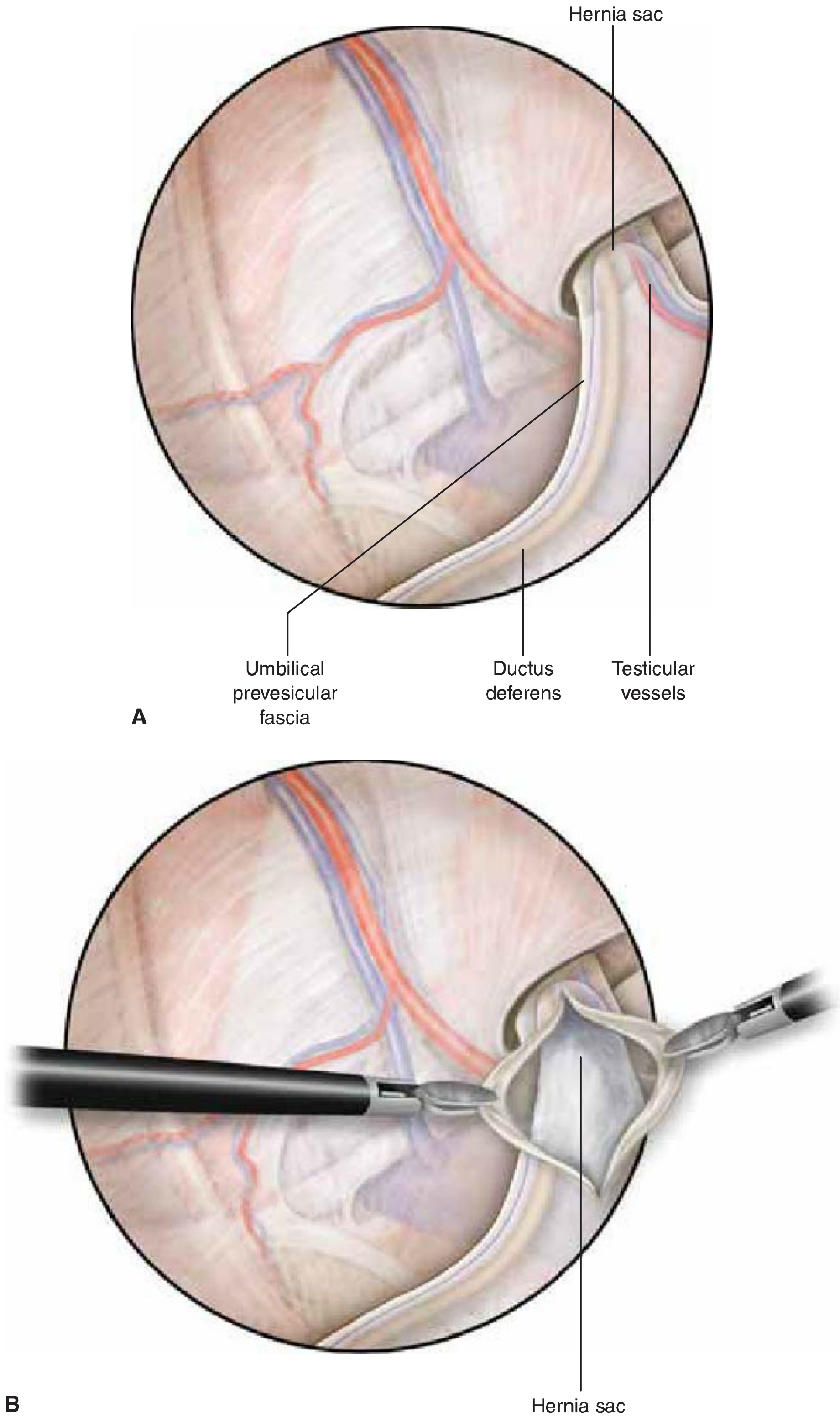



**Figure 14.10** A drawing of the lateral extent of the umbilical prevesicular fascia which is deep and is separated from the transversalis fascia. **B:** Drawing depicting separation of the fibers of the umbilical prevesicular fascia which in this case shows the peritoneum forming an indirect hernia sac.

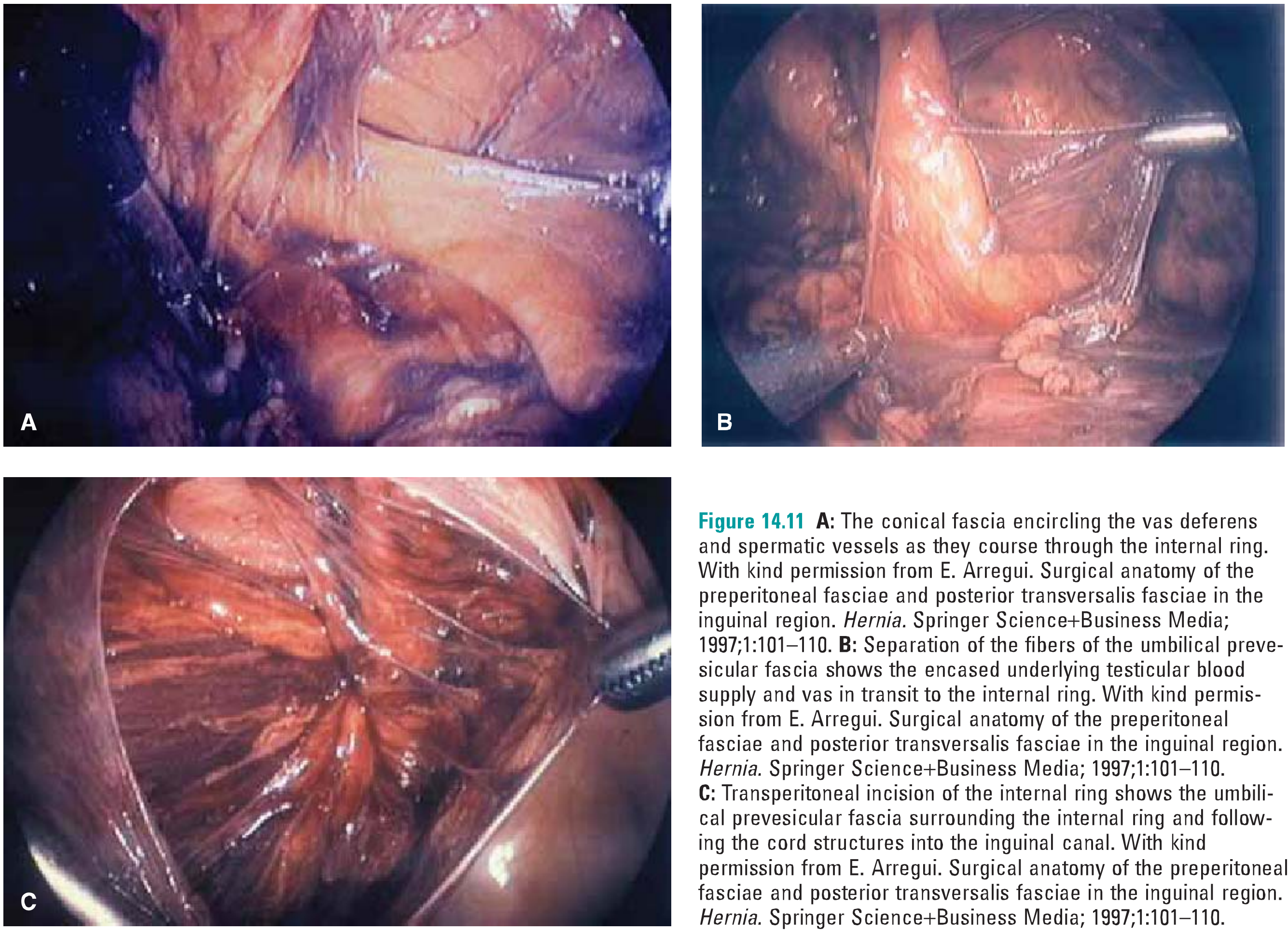



**Figure 14.11** **A:** The conical fascia encircling the vas deferens and spermatic vessels as they course through the internal ring. With kind permission from E. Arregui. Surgical anatomy of the preperitoneal fasciae and posterior transversalis fasciae in the inguinal region. *Hernia.* Springer Science+Business Media; 1997;1:101–110. **B:** Separation of the fibers of the umbilical prevesicular fascia shows the encased underlying testicular blood supply and vas in transit to the internal ring. With kind permission from E. Arregui. Surgical anatomy of the preperitoneal fasciae and posterior transversalis fasciae in the inguinal region. *Hernia.* Springer Science+Business Media; 1997;1:101–110. **C:** Transperitoneal incision of the internal ring shows the umbilical prevesicular fascia surrounding the internal ring and following the cord structures into the inguinal canal. With kind permission from E. Arregui. Surgical anatomy of the preperitoneal fasciae and posterior transversalis fasciae in the inguinal region. *Hernia.* Springer Science+Business Media; 1997;1:101–110.

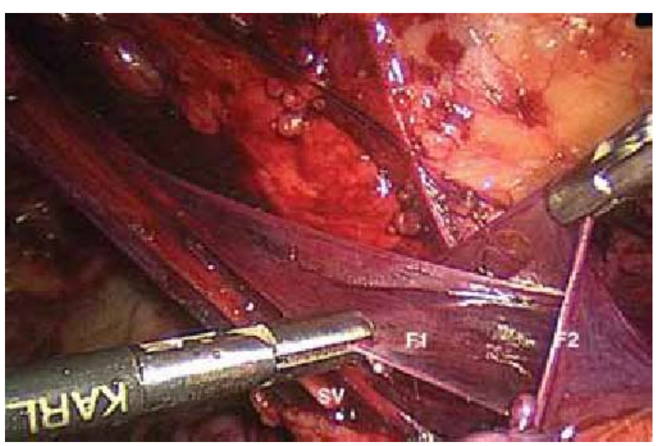
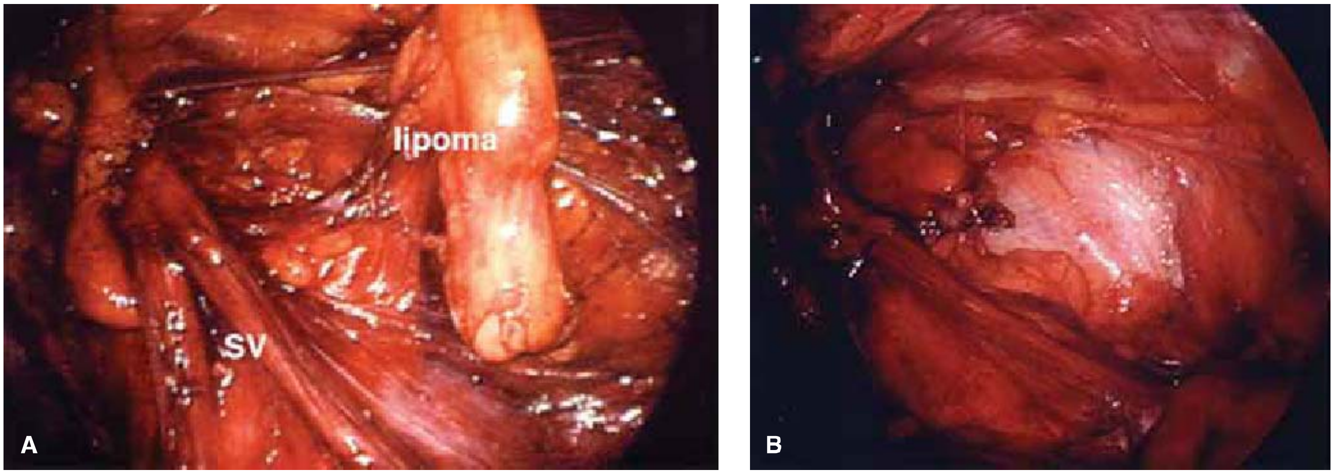



**Figure 14.12** Dissection showing two (F1, F2) or more fascial layers surrounding the cord structures in the patient with an indirect hernia that has been dissected off the cord structures. SV—spermatic vessels.



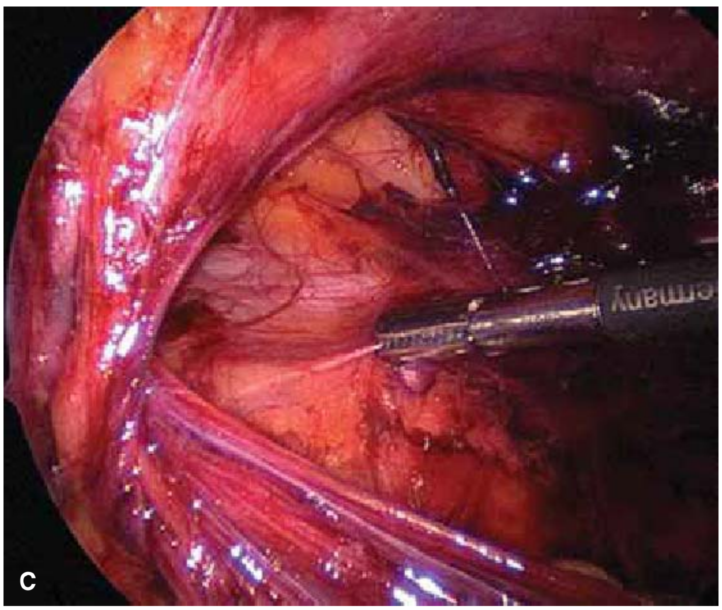




**Figure 14.13** **A:** Reduction of a lipoma of the cord from the lateral internal ring. The base is the retroperitoneal tissue lateral and deep to the cord structures. SV—spermatic vessels. **B:** The lipoma from **A** has been resected and beneath this fat is fascia overlying the psoas muscle. Beneath this fascia lie the nerves. **C:** After reduction of a herniated lipoma of the cord, the lateral iliopubic tract is clearly seen and is being held by the grasper.

be multi-laminate (Fig. 14.12). This may also be in continuity with the fascia of the spermatic cord and the ureter as these structures proceed upward in the posterior abdominal wall encompassed along with the kidney and perinephric fat by Gerota's fascia. This relationship is not well understood. Lateral and posterior to this fascial plane is a thin fascial layer covering the fat, nerves, and lymphatics overlying the psoas muscle. The lateral fat pad anterior to the nerves is outside of the perinephric fat encompassed by Gerota's facia. This fat that is lateral to the cord structures can break through its thin facial layer to herniate lateral to the cord structures but outside of the spermatic fascia to form a lipoma of the cord (Fig. 14.13A, B, C). The blood supply for this fatty tissue comes from the retroperitoneal vessels. Posterior to the cord structures and the retroperitoneal fat is the psoas fascia. Deep to this lie the nerves which include the genitofemoral nerve, the lateral femoral cutaneous nerve, and the lumbar fascia (Fig. 14.14).

## Completed Dissection During a TEP

A completed dissection required prior to placement of the mesh requires parietalization of the cord structures. This involves separating the peritoneum and overlying

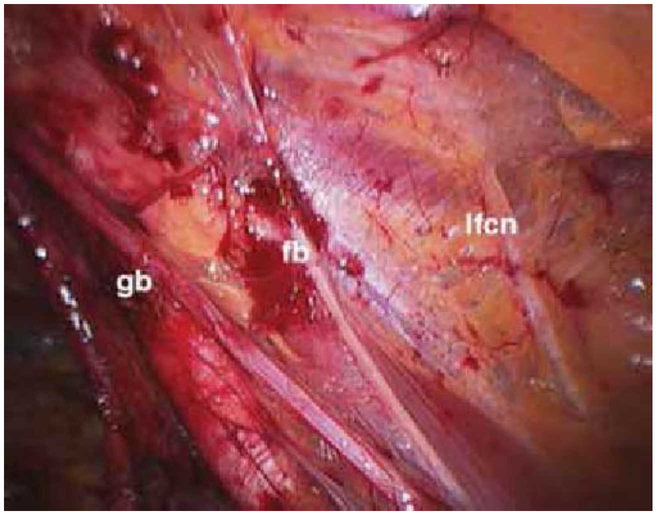



**Figure 14.14** Deep to the cord structures and fat lie the nerves which include the genitofemoral nerve with the medial genital branch (gb) and lateral femoral branch (fb). The lateral femoral cutaneous nerve (lfcn) is seen lateral to the genitofemoral nerve.

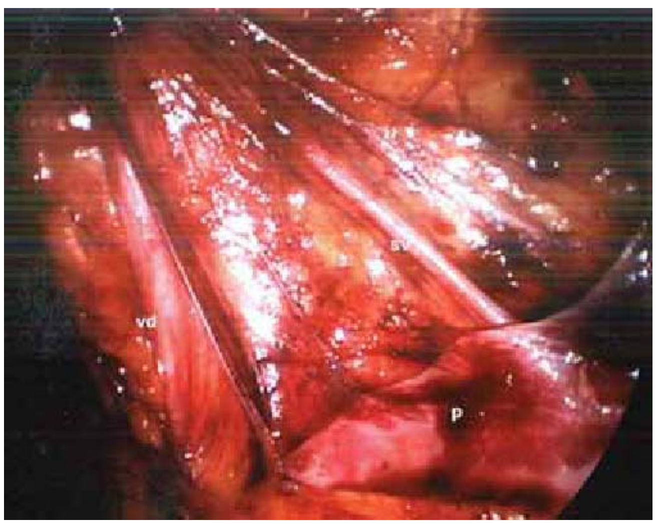



**Figure 14.15** Parietalization of the cord. vd—vas deferens, sv—spermatic vessels, and p—peritoneum.

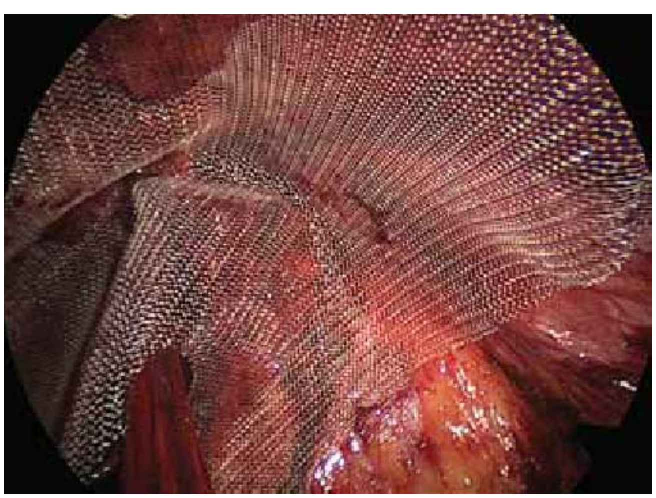


**Figure 14.16** Mesh draping over the cord structures extending laterally over the internal ring and going medially to cross the midline.

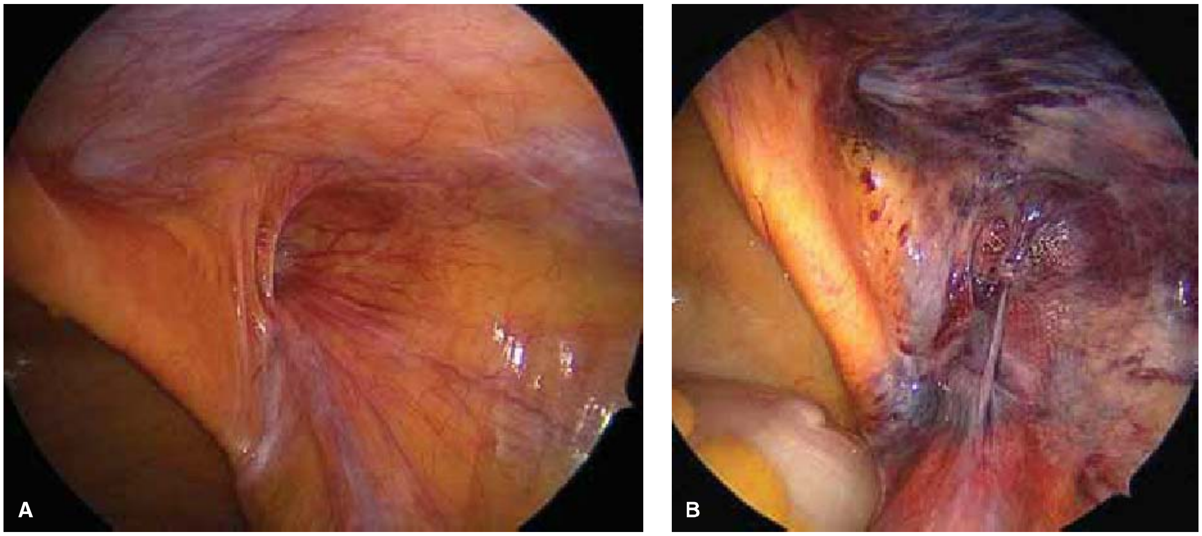



**Figure 14.17** **A:** Indirect inguinal hernia before repair. **B:** Transperitoneal view of the indirect inguinal hernia (**A**) after repair. The mesh is seen lying between the peritoneum and retroperitoneal structures.



fascial layers off the testicular vessels and the vas deference (Fig. 14.15). Lateral dissection requires clearing the lateral iliopubic tract and reducing any lipoma of the cord which may be obscuring this (Fig. 14.13C). The mesh then needs to be placed over the direct, indirect, and femoral defects. In other words, the mesh must be completely covering the myopectineal orifice of Fruchaud with at least 4 cm overlap at all edges (Fig. 14.16). Care must be taken that the mesh does not fold when the extraperitoneal air is released and the peritoneum expands to cover the inguinal space (Fig. 14.17A, B).

## CONCLUSION

The anatomy of the inguinal area is complex and proper repair of inguinal hernias requires a knowledge of the relationship between structures and the many overlapping fascial planes. Key to this is understanding the migration of the genitourinary structures during embryogenesis. Proper exposure and knowledge of anatomy reduces the chances of injury to nerves, vascular, and other structures and improves the chances of a successful repair with an extremely low risk for recurrence.

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# 15 Laparoscopic Transabdominal Preperitoneal Inguinal Hernia Repair

**Antonio Garcia-Ruiz and Alejandro Weber-Sanchez**

## Anatomy

Being the site of highest incidence of abdominal hernias that require surgical management, the groin is one of the most relevant anatomical regions for the laparoscopic surgeon (Fig. 15.1). The groin is limited cephalically by the horizontal plane passing through the anterior superior iliac spine, medially by the midline, and inferolaterally by the inguinal ligament (running from the superior iliac spine to the pubic symphysis). In our judgment, the laparoscopic surgeon does not face an anatomical view more complex than the anterior approach. Instead, he or she observes the same anatomical structures from a different perspective, which may not be familiar to all. Nonetheless, detailed knowledge of this anatomical aspect is essential to safe and effective laparoscopic repair.

The anatomy of this zone has few variants; the reference points are mostly constant and can be summarized in relatively simple terms. Observed from inside the abdomen with the peritoneum intact, the lower part of the anterior abdominal wall is usually divided into three fossae, separated by the same number of folds or ligaments formed by different protruding structures. These may be more or less evident, depending on the patient's constitution and the quantity of preperitoneal fat. On the midline we find the urachus, also called median umbilical ligament. Lateral to the urachus is the lateral umbilical ligament, usually the most prominent of the three folds. This ligament is a remnant from the obliterated umbilical artery leading from the iliac artery toward the navel. Finally, the most lateral fold, corresponding to the deep epigastric vessels, is the least prominent. The most common classification of the inguinal hernias still uses these three folds as reference points. Indirect inguinal hernias are those that protrude laterally to the epigastric vessels (Fig. 15.2), direct inguinal hernias are those that are medial to them (Fig. 15.3), and supravesical hernias are those protruding in between the median and lateral umbilical ligaments. Femoral hernias are located below this plane, in a position inferior to the iliopubic tract and through a space around the femoral sheath. On very rare occasions, we have found obturator hernias (defect of the obturate membrane of the iliac bone). Due to

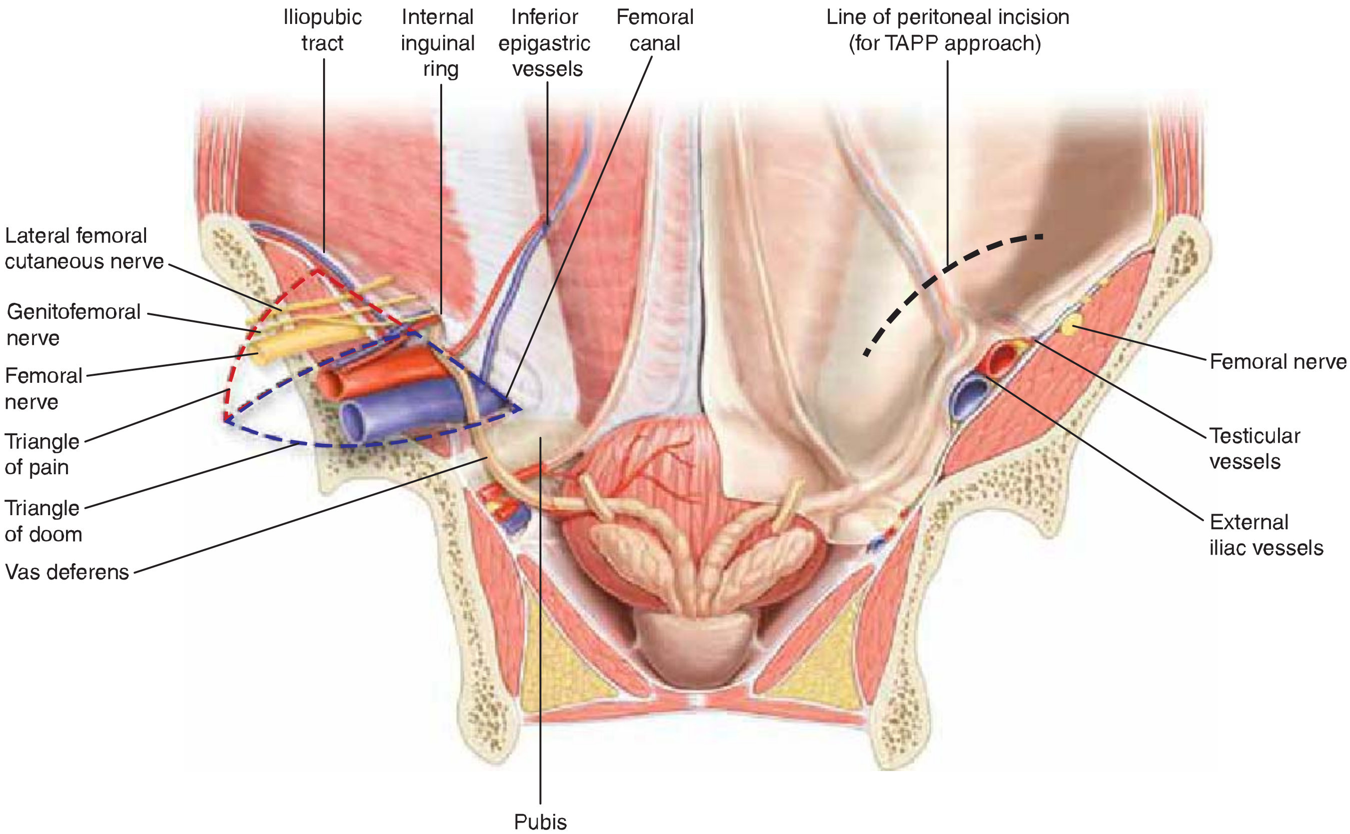


**Figure 15.1** Anatomy. Triangle of Pain. Triangle of doom.

their anatomical location, these hernias are not considered inguinal hernias. However, we have approached and managed them laparoscopically with almost the same principles as inguinal hernias, except that we shape the prosthetic mesh to fully cover the hernial defect, in this case considerably deeper into the pelvic space.

The transabdominal preperitoneal laparoscopic hernioplasty requires elevating a very wide peritoneal flap. In order to do so, it is of outmost importance to recognize and be familiar with the extraperitoneal spaces of the pelvis. Medially, between the peritoneum and the trasversalis fascia, is the space of Retzius, which has a variable quantity of fat.

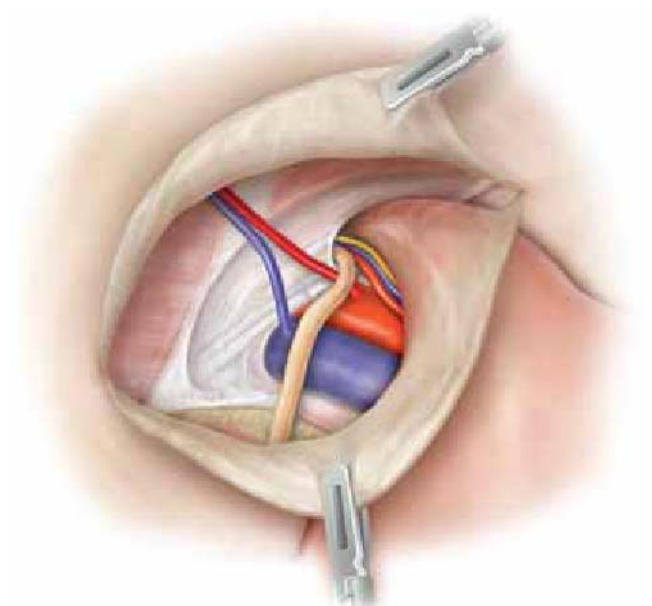

**Figure 15.2** Indirect inguinal hernia.

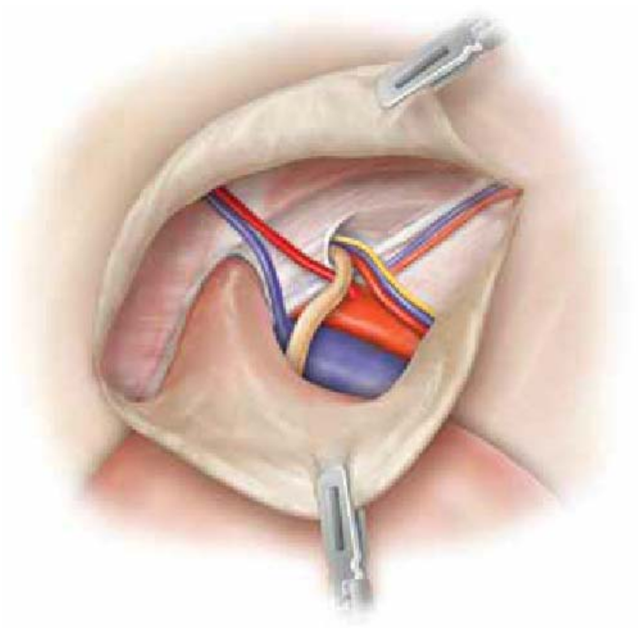

Figure 15.3 Direct inguinal hernia.



Usually it is an avascular space, except in the lower part which contains the venous anastomoses between the obturate, epigastric, and iliopubic vessels. From this perspective behind the wall it is impossible to observe the inguinal ligament which is in an anterior position concealed by the muscles of the abdominal wall. However, Cooper's ligament is visible in this space. Even in obese subjects with large quantities of fat it can be palpated with laparoscopic instruments as a hard edge. This important reference point is located 1 cm medial and inferior to the origin of the epigastric vessels. Also visible in this space is the iliopubic tract, a band of thickened fascia running parallel to the inguinal ligament, is attached to the superomedial part of the pubic bone medially and laterally its fibers are dispersed with the trasversalis fascia and the iliac fascia, with no attachment to the iliac spine. Through the intact peritoneum, it is possible to identify the round ligament in females and the vas deferens in males. Both have a trajectory running from the deep part of the pelvis upward and from inside outward, to exit the abdomen through the internal inguinal orifice crossing the epigastric vessels. In males, the spermatic vessels, which have a downward trajectory, join at an obtuse angle with the deferent conduct, and also exit through the internal inguinal orifice, to form outside it, with the fasciae and muscular fibers enveloping it, the spermatic cord. On joining in the internal inguinal orifice, the gonadal vessels and the iliac vein form a triangle with its apex upward, area of the iliac vessels; this anatomical area, called "triangle of doom," as well as the so-called "triangle of pain," located between the anterior superior iliac spine and the gonadal vessels, warrants special attention. Familiarity with these two regions is crucial during laparoscopic inguinal hernioplasty because they are areas with high potential for severe complications such as transoperative vascular lesions or painful postoperative sequelae.

Given that in the early days of laparoscopic hernia repair nerve injuries were among the most serious complications due to the intense pain and disability they caused, knowledge of the nerve structures present in the zone is crucial. The nerves with greatest risk of injury are the lateral femoral cutaneous nerve and the femoral and genital branches of the genitofemoral nerve. Both follow almost parallel trajectories always positioned inferior to the iliopubic tract. The most medial is the genitofemoral nerve; from its origin in the lumbar region it crosses the psoas muscle and exits through the anterior face of that muscle near its inner edge. It then descends, covered by the fascia of the same muscle, and is positioned in front of the external iliac artery. At this point it divides into its two terminal branches: One genital and the other crural. The genital branch penetrates the inguinal duct, while the crural branch exits the abdominal cavity and passes below the inguinal ligament, accompanying the anterior face of the femoral artery. The femoral cutaneous nerve descends on the anterior face of the psoas muscle, continues downward behind the fascia on the anterior face of the iliac muscle, and exits the abdomen below the iliopubic tract, very close below the anterior superior iliac spine. Usually, the voluminous femoral nerve is not observed during dissection of this region; however, it is important to bear in mind that it is between the psoas muscle and the iliac muscle—lateral to the external iliac artery and separated from it by the iliopubic tract—to avoid injuring it when dissecting more deeply in this area.

The crural region, where the iliac vessels cross, is limited above by the iliopubic tract, below by Cooper's ligament, medially by Gimbernat's lacunar ligament, and laterally by the psoas muscle. Finally, it is also highly advisable to recognize the importance of the spermatic fascia and dissect it carefully, to avoid injury to the genito-reproductive apparatus in male patients. The surgeon must have a very clear understanding of this region to develop the ample space that will house the prosthetic mesh and will be the support for a successful repair.

## Clinical Presentation and Diagnosis

Diagnosis of an inguinal hernia is usually simple. It is based fundamentally on clinical aspects, and requires only a detailed clinical history and an adequate physical examination. Once established, there is no need for additional diagnostic or image studies. However, the evident clinical signs of a reducible, painful inguinal mass, with occasional signs of entrapment or with signs of intermittent intestinal obstruction are not always found. In such cases, a much more meticulous or sophisticated evaluation is required. Examples include the patient who seeks medical attention due to chronic or recurrent inguinal pain without an evident mass or hernial defect, in whom the Valsalva maneuver causes inguinal pain, but does not cause protrusion of tissues in the groin, or the morbidly obese patient who complains of nonspecific inguinal discomfort which can be particularly difficult to diagnose. In such patients, image studies (USG, CT, or even NMR) may help to document the presence of a hernia. Notwithstanding, even those studies may not be 100% sensitive or specific. Similarly, there may be patients with masses in the inguinal region that do not coincide with the usual sites for hernias and may be due to defects over prior surgical scars (cesarean section or prostatectomy) or uncommon true hernias such as supravesical or Spiegel's hernias. Occasionally, a patient may present symptoms of acute intestinal obstruction because an intestinal loop has become trapped in the hernial orifice. In such cases, the surgeon will have to rely on image studies such as ultrasound, computerized axial tomography, and magnetic resonance or may even recur to laparoscopic exploration to achieve a more accurate diagnosis on the basis of which to plan the best possible surgical treatment for the patient. When laparoscopic examination confirms the presence of a hernia with peritoneal sac, there is no doubt that a laparoscopic inguinal hernioplasty should be performed. However, we have found cases where the peritoneum does not present hernial defect. In such cases, we have opted specifically to explore the corresponding inguinal region performing peritoneal dissection as described below, as in most of these cases we have found lipomas of varying size accompanying the spermatic cord or extending through the space between the femoral sheath and the corresponding blood vessels. The presence of such lipomas obliterates the hernial defect and makes the peritoneum appear intact during diagnostic laparoscopy. Another finding we have seen in rare cases is the presence of inguinal adenopathies which are distinguished laparoscopically by their greater consistency. In such rare cases, we recommend taking a tissue sample for histopathologic study without resection, as it could condition postoperative lymphedema.

## Treatment

To date, the only definitive treatment for inguinal hernias is surgery. However, recently published studies have evaluated conservative medical management for reducible and relatively asymptomatic inguinal hernias. Most cases of inguinal hernia can be surgically treated on an elective basis.

In the case of an incarcerated inguinal hernia, treatment should be started immediately due to the risk of necrosis and intestinal perforation. In such cases, in the emergency ward, parenteral hydration and reclining the patient in the Trendelenburg position may allow the trapped intestinal loop to be released and management may then be semi-elective. However, some patients will require hospitalization and nasogastric decompression in an attempt, still conservative, at emergency management. If the patient's clinical status worsens or conservative management does not produce results in a period of 48 to 72 hours, surgery will be the most indicated option. The decision to approach the case by laparoscopy or by conventional means should be based on the conditions of the patient and the experience and capabilities of the surgeon (see section on "Transoperative Complications").

## INDICATIONS/CONTRAINDICATIONS

With very few exceptions, the indications for the transabdominal preperitoneal laparoscopic approach are the same as for conventional hernioplasty (by anterior approach). With considerable satisfaction, in recent years we have observed a strongly justified tendency to refer recurrent inguinal hernias for laparoscopic management. However, some cases may constitute a contraindication, relative or absolute, to the laparoscopic approach.

- Patient does not tolerate capnoperitoneum (severe cardiopathies or severe neumopathies, for example).
- Strangulated and perforated inguinal hernia with intercurrent sepsis.
- Patient with severe ascitis.
- Recurrent inguinal hernia following prior laparoscopic treatment.
- Patient under age 15 years—pediatric.
- Pregnancy, after the second trimester.
- Patients with severe clotting disorders.

## PREOPERATIVE PLANNING

Learning curve. Unquestionably, after having the laparoscopic equipment and inputs necessary for the procedure, the most important aspect of preoperative planning for laparoscopic inguinal hernioplasty is the surgeon's training in the technique. Detailed anatomical knowledge, bimanual dissection technique, suitable knowledge of the relevant technology (power sources and clip applicators) and biocompatible prosthetic materials and skilled use of angular laparoscopes are essential, both for successful surgery and to avoid complications for the patient.

Specific instrumentation for the laparoscopic approach. We use a 30° and 5 mm diameter angular laparoscope, 2 Maryland dissectors, 1 Grasper, 1 Metzenbaum scissors, 1 irrigation/aspiration cannula, 1 polypropylene mesh (15 cm × 15 cm) (3D-Max, Davol), and a helical titanium clip applicator (ProTack, Covidien). Although it is not used routinely, it is advisable to have available in the operating room a hemostatic clip applicator, a laparoscopy needle holder, and in some cases—particularly with female patients—it may be desirable to split the round ligament with ultrasound scissors.

Patient preparation. It is highly recommendable, to avoid the need to decompress the urinary bladder with a catheter, so the patient is indicated to urinate immediately before entering the operating room. Antibiotic prophylaxis is used for only 24 hours. Although some surgeons have reported successful cases of laparoscopic inguinal hernioplasty under conduction anesthesia with peridural blockade, and even under deep sedation, as a general rule we prefer general anesthesia for the patient. This offers at least two advantages: (1) Due to the effect of the neuromuscular blockade, the space formed in the peritoneal cavity is greater, improving visibility and the capacity for surgical maneuvers, and (2) as an effect of orotracheal intubation, the patient's airway is secured and protected, as the increase in intraabdominal pressure can predispose to regurgitation or vomiting which can cause bronchoaspiration.

As regards the patient's position on the operating table, we recommend securing both arms on their respective sides to avoid their slipping during the surgery and causing injuries due to stretching of the brachial plexus; some surgeons recommend the use of a sterile protective barrier (steridrape) covering the patient's skin to reduce the risk of contamination of the prosthetic mesh with skin flora; however, it is not our practice given that the mesh practically never touches the patient's skin because it enters the abdominal cavity through the umbilical trocar. Similarly, we do not consider it necessary to shave the patient's inguinal hair. In any case, when it is required we depilate only the periumbilical zone or the areas surrounding the site where incisions are to be made in the flanks. But, in the latter two sites, it is important to perform depilation when the abdomen has been insufflated with the capnoperitoneum, as abdominal distension may change the site where the incisions will ultimately be made.

Position of the surgical team members. The surgeon is positioned on the side contralateral to the hernia to be repaired and the camera operator is positioned on the same side as the hernia. The patient's arms, arranged on either side, can be placed comfortably in their positions around the operating table. It is recommendable that the scrub nurse begins the procedure next to the camera operator, near the patient's feet. During most of the procedure, the position of the operating table is kept in 15° Trendelenburg with a 15° lateral rotation to the side opposite the hernia. The laparoscopic monitors are placed laterally near the patient's feet. In cases of bilateral inguinal hernioplasty, to repair the second hernia, the surgeon and the assistant switch positions when they have finished the first hernia.

# SURGERY

## Establishment of Capnoperitoneum and Trocar Placement

Although many surgeons create capnoperitoneum with a Verress needle, we prefer an open technique, using a 12 mm Hasson trocar, through an incision starting precisely at the center of the umbilical scar and ending at its lower edge. This incision has given us better cosmetic results than subumbilical incisions. We place the two accessory 5 mm trocars on the patient's right and left flanks respectively (lateral to the abdominal rectus sheath) and their position varies depending on the laparoscopic findings, especially the size of the hernia; the larger the hernial orifice, the higher we place these two trocars. It is important to recall that a fair number of patients are found to have a contralateral inguinal hernia not diagnosed in preoperative examination. In cases of unilateral inguinal hernia, we insert the trocar on the side of the hernia around 2 cm above the umbilical level and the trocar on the opposite side 2 cm below. But in cases of bilateral inguinal hernia, both trocars are 2 cm above the umbilical plane. This distribution allows the surgeon to work more ergonomically, as on each side, the optical trocar will be on the flank corresponding to the hernia being repaired.

## Peritoneal Incision

We start the peritoneal incision with the Metzenbaum scissors at the level of the anterior superior iliac spine and continue horizontally, in medial direction to the lateral umbilical ligament. In the laparoscopic view, this ligament almost always "hangs" from the abdominal wall and allows us to continue the peritoneal incision over its insertion in the abdominal wall, finally directing the cut in the cephalic direction toward the umbilical scar. For this step we have found that most times there is no need to use

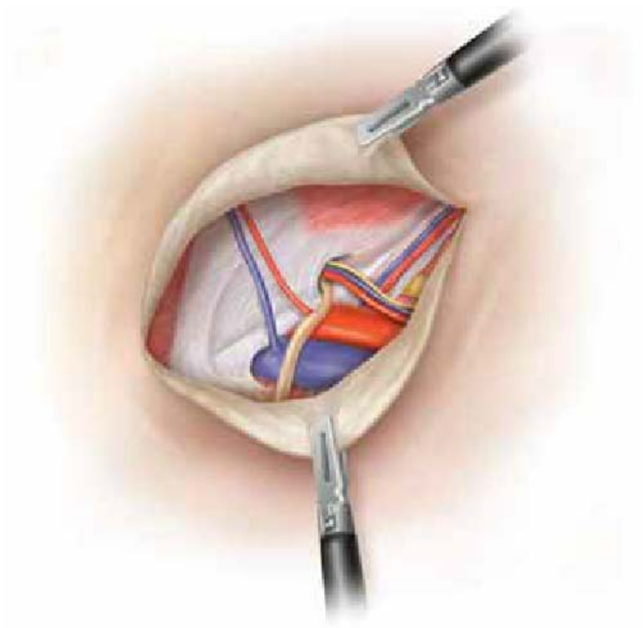

Figure 15.4 Creation of peritoneal flaps for indirect hernia.



electrosurgery, which can help reduce injuries to small nerves in the abdominal wall. However, it is very important to heighten precautions to avoid damaging the deep epigastric vessels when the peritoneal incision crosses the posterior sheath of the rectal muscle. Likewise, we have observed that when we keep the peritoneal incision at the level of the anterior superior iliac spine and not below it, we almost never need to lift the upper peritoneal flap, as the mesh fits perfectly in the space created by dissection of the lower flap alone (Fig. 15.4).

## Dissection of Lower Peritoneal Flap

We divide this step into three phases: (1) Lateral dissection on the space of Bogros, (2) medial dissection over the space of Retzius, and (3) central dissection over the site of the hernia and its hernial sac. We usually start with the lateral dissection (Bogros' space), tractioning the peritoneum in the medial direction, using the Maryland dissector to separate all the preperitoneal fat, leaving it resting against the abdominal wall. Thus, the small nerves and capillaries in the fat are "parietalized." Continuing the dissection of this plane in the caudal direction, we find the gonadal vessels, which we also separate with the same blunt technique to leave them resting in place against the posterior abdominal wall. If we continue caudally along this totally avascular plane, we find the other elements of the spermatic cord at the level of the neck of the hernial sac. Here we stop the lateral dissection.

Next, we start medial dissection to approach Retzius' space. For this purpose we retract the medial peritoneum pulling it posteriorly avoiding the deep epigastric vessels and, with mixed technique (blunt and fine cutting), the almost invariably loose adherences of the areolar preperitoneal tissue are dissected from this plane. In the deep part of this space, before uncovering the horizontal branch of the pubis and Cooper's ligament, prevesical fat may pose a difficulty in dissection. With experience one learns to distinguish the correct dissection plane to expose Cooper's ligament, which we almost invariably find on dissecting 1 cm medial and 1 cm inferior to the origin of the deep epigastric vessels. The key to this step is to achieve a sufficient medial dissection (1 or 2 cm beyond the pubic symphysis) and a very cautious lateral dissection (near the iliac vein), as there is almost always a communicating vein (from the external iliac to the obturate) lying against the horizontal branch of the pubis, which is part of the "corona mortis." Injuring it can cause profuse bleeding with variable consequences.

After completing the above, we continue the dissection of the hernial sac per se. Personally, we try to dissect it from the lateral to the medial aspect, tractioning it and first releasing it from the gonadal vessels, then from the lipoma of the cord, and finally from the tissue containing the pampiniform plexus and the testicular artery. In this step it is highly important to maintain as hemostatic a technique as possible, especially in indirect inguinal hernias and even more in inguinoscrotal hernias. In our view, it is best to advance slowly in this step, trying to avoid tears in the tissue. Our practice is to try to reduce the entire hernial sac in all cases. Nevertheless, occasionally total dissection of the hernial sac proves impossible or risky; in such cases, we opt to leave the most adhered part of the peritoneal sac in the inguinal channel. Dissection of the tip of the hernial sac can also present difficulties. Another useful maneuver in case of deep sacs is to cut longitudinally to improve traction and follow its edge to continue dissection as far as possible. This area's peritoneal adherences to the other spermatic cord structures require cautious maneuvering and experience. During dissection of the sac, almost always at the level of the neck, we find the deferent duct. Gentle dissection of this duct is particularly crucial in patients of reproductive capacity. In general terms, we define the hernial sac as fully dissected when on releasing traction it does not retract toward the inguinal channel, it remains in the peritoneal cavity, and the hernial orifice is clearly visible in its entirety.

Finally, we end up separating the lower peritoneal flap by dissecting it completely from the spermatic fascia. This final part of the dissection ensures that the space for the mesh will be sufficient, as if it is not the lower edge of the prosthesis may "roll" on itself when the peritoneal flap is closed at the end of the surgery, which can favor a recurrence of the hernia. In male patients, dissection of this fascia is usually simple. However in women, the adherences of the peritoneum to the round ligament are very firm and often require splitting the round ligament in order to develop this plane.

## Treatment of the Trasversalis Fascia in Direct Inguinal Hernias

In order to reduce dead spaces and potential formation of postoperative seromas in direct hernias, after dissecting the peritoneal sac the fascia that is visible deep in the space previously occupied by the hernia can be pulled inside the abdominal cavity through the hernial orifice with a Maryland dissector and then tacked to the pubic bone with a helical titanium clip. Unfortunately, this maneuver cannot be performed on hernias of other types.

## Tailoring, Insertion, and Placement of the Prosthetic Mesh

One of the most constant issues in the laparoscopic approach to inguinal hernioplasty is the need to use a prosthetic mesh to fully cover the hernial defect and all possible herniation sites in the area. In this regard, depending on the patient's configuration, our recommendation regarding mesh size is for it to measure 12 to 15 cm transversely and 11 to 13 cm vertically. Considering the anatomical shape of the dissected space, we cut the inferolateral corner of the mesh so that it fits better over the iliac vessels. A recent advantageous alternative is the use of an "anatomically pre-shaped" polypropylene mesh (3D-Max, Davol), which comes in three sizes and fits extraordinarily well in the preperitoneal space (Fig. 15.5).

To introduce the mesh in the abdominal cavity through the Hasson trocar, we roll it as compactly as possible over a Maryland dissector. The "rolling and unrolling" technique is fundamental to expedite the maneuvers. We roll it from the bottom up along the inner face of the mesh. On introducing the mesh, we point its distal tip (medial end) toward the pubic symphysis so that when it passes through the trocar the mesh tends to unroll exposing the lateral end. With the other Maryland dissector, we take the lateral end and point it toward the anterior superior iliac spine allowing the mesh to finish extending and settle in its place. These maneuvers may not be particularly simple, but with practice they become easier. Before starting to fix the mesh it is essential to check that its placement extends well beyond (at least 3 cm around) the hernial defect, that its bottom edge extends below Cooper's ligament, and that the lower peritoneal flap can be lifted without rolling it.

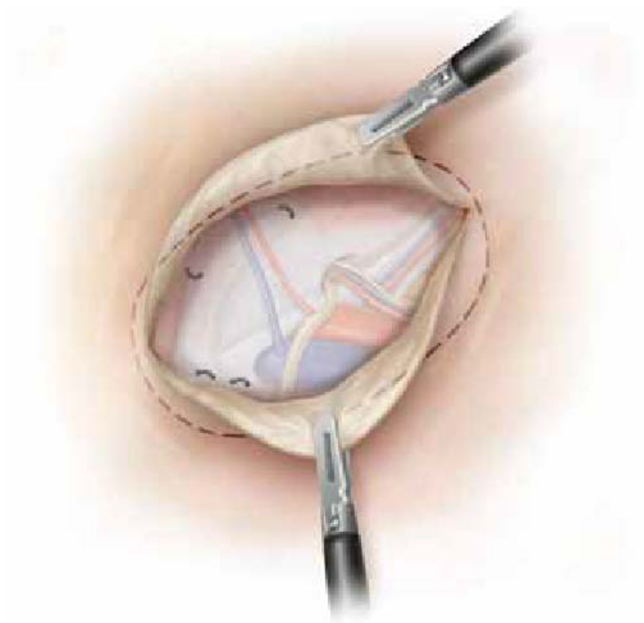

**Figure 15.5** Placement of mesh and tack.

## Mesh Fixation

Although some authors and companies promote the idea of not fixing the mesh to the abdominal wall, in our opinion not doing so can lead to migration of the mesh and potentially cause recurrence of the hernia. On the other hand, like others, it concerns us that the helical titanium clips used to fix it can cause painful sequelae for patients. Therefore, our mesh-fixing technique is limited to using only two helical clips over Cooper's ligament, taking care not to injure the corona mortis vessels. Occasionally, if needed, we use a third clip on the upper edge of the mesh, near its lateral end, to fix the mesh to the anterior abdominal wall. When we use the third clip, we make sure that under no circumstances is it positioned on a plane behind and below the anterior superior iliac spine. For this purpose, with one hand we palpate on the patient's abdominal wall feeling where the tip of the clip applicator protrudes before firing it. As a general rule, if we palpate the applicator's movement through the anterior abdominal wall we are in front of the anterior superior iliac spine in a site with less potential for postoperative pain.

## Closing the Peritoneal Flap

Our routine is to close the peritoneal flap with the aid of helical titanium clips. This maneuver is expeditious and cost-effective, as there are more than 15 clips left in the applicator. Before starting to close the flap, we lower capnoperitoneum pressure to 8 mm Hg to facilitate the approximation of the edges of the peritoneum under less tension. Usually, five to seven clips are sufficient to close the flap at intervals of 15 to 20 mm between clips. Alternatively, we also close the flap with continuous suture (2-0 monofilament) (Fig. 15.6). However, suturing maneuvers can be difficult for the inexperienced due to the position of the camera and because the suture is over the anterior face of the abdomen (upwards). Finally, we try to invert the peritoneal hernial sac and also fix it to the anterior abdominal wall with two more clips.

## Closing of Incisions

After releasing the greatest possible quantity of capnoperitoneum (in inguinoscrotal hernias scrotal sac emphysema can be excessive), we proceed to withdraw the trocars under laparoscopic vision and to close the incisions. We close the aponeurosis of the umbilical incision with polyglactin-0. We close the cutaneous plane of the incisions with inverted Polyglactin 4-0 stitches.

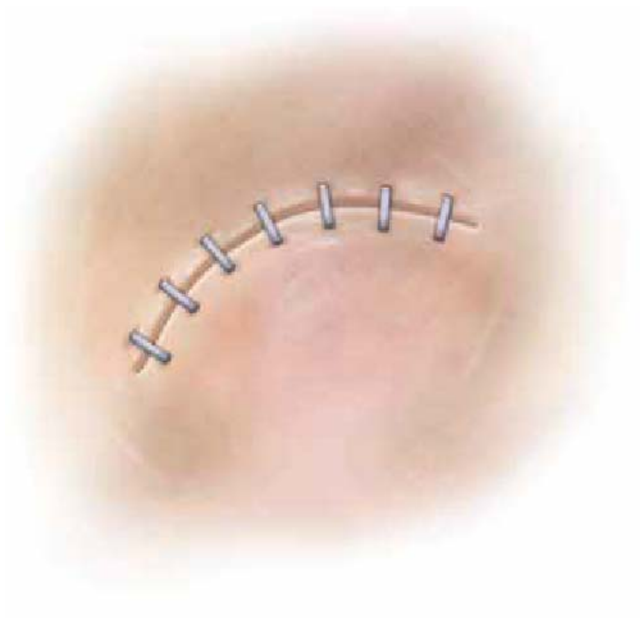

**Figure 15.6** Closure of peritoneum.

## POSTOPERATIVE MANAGEMENT

In the immediate postoperative period the patient's anesthetic recuperation is monitored maintaining traditional measures of parenteral hydration and analgesic (ketorolac 30 mg IV every 6 hours). We watch for spontaneous urination within the first 8 hours after surgery. Otherwise, we evaluate the use of a urinary catheter to prevent vesical over distention. Antibiotic prophylaxis is continued only for 24 hours. We routinely indicate keeping an icepack over the repaired groin for the first 48 hours after surgery. The patient may ambulate as soon as s/he has recovered from the anesthesia. Depending on the presence of postoperative nausea or vomiting, we resume diet almost always within the first 12 hours and patients can usually be released within 24 hours after surgery. Recommendations for physical activity are light activities (walking, even climbing one or two flights of stairs) from the first day after surgery, regular activities (walks and resumption of work that does not require strenuous physical exertion) from day 7 or 10, and strenuous activities only from the third week after surgery.

At home, patients continue taking oral analgesics as necessary, and we usually prevent constipation with a mild oral laxative (hydroxide gel or plantago). In the consulting room, we examine the patient around 7 days after surgery, then 1 month after surgery, and then every 6 months for long-term follow-up.

### Special Cases

When dealing with a trapped inguinal hernia that could not be reduced under initial conservative management, we decide to take the patient to the operating room for emergency treatment. Such cases are particularly difficult as they are associated with variable degrees of proximal intestinal distension due to the blockage of intestinal transit. This intestinal distension can seriously compromise the patient's safety during laparoscopic treatment. However, as our experience grows, always maintaining a low conversion threshold, our initial approach of choice remains laparoscopic. Particular recommendations for these cases are:

1. Maintain strict visual laparoscopic control of all maneuvers to avoid inadvertently injuring the intestine.
2. Locate the intestine distal to the obstruction and, very gently, perform release maneuvers on that intestinal segment, as the intestinal wall proximal to the obstruction is

usually edematous and liable to tear easily. Gentle external compression on the palpable inguinal mass can facilitate release of the loop.

3. If the released intestinal loop presents clear signs of ischemia, resection and anastomosis should be performed. In most cases this can be done through the umbilical incision enlarged to 5 cm (minilaparotomy).
4. When an intestinal lesion is detected, it will depend on the degree of peritoneal contamination and the abilities of the surgeon whether to continue laparoscopically or convert the explorative laparotomy to properly complete the patient's treatment. In some of these cases, the use of prosthetic material will be contraindicated due to the risk of bacterial contamination. An alternative we consider viable has been to make a provisional repair with sutures of the hernial defect (repair "under tension") and leave the definitive repair with prosthetic mesh for a second surgery, when the risk of contamination has disappeared.

Sliding inguinal hernias are truly rare, and in our experience have found them predominantly on the left side. The urinary bladder and the colon have been the organs occupying the hernial defect. Notwithstanding, we have been able to resolve even those cases laparoscopically. Our recommendation is to cautiously keep the dissection plane retroperitoneal in the case of the colon and over the abdominal wall in the case of the urinary bladder, with ample mobilization until total reduction of the sliding viscera is achieved and create sufficient space to accommodate a prosthetic mesh of the necessary size. Only on two occasions we have found sliding of the cecal appendix in right inguinal hernias. In such cases, dissection has required an incidental laparoscopic appendectomy.

Dissection maneuvers to separate the lower peritoneal flap can occasionally tear it and make complicate the complete coverage of the prosthetic mesh with peritoneum. At times we have used the redundant peritoneal sac to cover the mesh with peritoneum and in other cases we have sutured peritoneal defects with intracorporeal sutures. Lowering capnoperitoneum pressure can help join the edges of the peritoneum with less tension preventing major tears.

Considered by many a formal contraindication for laparoscopic treatment, the inguinal hernia with loss of domain inside the abdominal cavity is one of the most complex problems when attempting laparoscopic management. Such cases require the greatest experience and expertise, as dissection of peritoneal flaps usually needs to be much greater than in the customary technique in order to accommodate a mesh of dimensions suited to the defect. Diagnostic laparoscopy allows us to evaluate the possibility of treating such cases by laparoscopy or making an early decision to switch to open surgery.

## COMPLICATIONS

### Transoperative Complications

Transoperative bleeding is one of the potential complications of laparoscopic inguinal hernioplasty. It is essential to prevent such events. Obviously, we must avoid and recognize injuries to the iliac vessels that can cause exsanguinate bleeding and force immediate conversion for vascular control and the corresponding repair. But those that occur most frequently and may be susceptible to laparoscopic management are those leading from the deep epigastric vessels, the testicular artery, the gonadal veins, or the corona mortis veins. Such bleeding can be controlled with hemostatic clips or the use of a power source (electrosurgery or ultrasound). However, conversion may be necessary and should not be delayed if bleeding is persistent or abundant.

### Postoperative Complications

These include seromas, hematomas, postoperative pain, infection of wounds, rejection or infection of the mesh, postoperative adherential blockage, recurrences, testicular atrophy, and infertility. In our experience only the first two occur significantly for the patient, and we have not observed a case of the others. Seromas can occur more frequently following repair of indirect inguinal hernias and are the result of an accumulation of serous secretion in the space previously occupied by the hernia over the inguinal canal, which cannot be obliterated laparoscopically. In cases of direct inguinal hernias, with the technique described above to fix the trasversalis fascia protruding through the hernial defect, the incidence of postoperative seromas has been practically eliminated. Less than 5% of our patients have presented a postoperative seroma. Our management of such cases has involved percutaneous aspiration with a hypodermic needle. In most of them one aspiration has been sufficient, but one of our patients required up to four aspirations, given that the volume aspired was smaller and lighter in color. Two patients have required scrotal exploration to manage a large postoperative hematoma which posed a risk to ipsilateral testicular viability. The surgical finding in both cases was persistent bleeding due to tearing of the pampiniform plexus.

The complications that can cause the patient the greatest discomfort include the appearance of persistent postoperative pain. Such pain can have several origins, but the most relevant due to the need for aggressive treatment is neural lesion due to the fixation with a clip. Usually the patient complains of highly localized neuropathic pain at a point in the lower quadrant of the abdomen, and in some cases with characteristic irradiations. Our initial conservative management, using local heat and NSAID analgesics, has proven successful in most cases. However, some cases have required the use of advanced neuromodulating drugs (gabapentin and/or antidepressants) or the use of specific neural blockades. To date we have not had to reoperate any patient due to this kind of complication.

The other complication that severely affects the patient is the recurrence of the inguinal hernia. In our experience this has occurred in less than 1% of cases (all in the first 50 cases of the series). Notwithstanding, reoperation was by conventional means. In all these cases, we found that the hernia recurred through the inferolateral edge of the mesh. Resolution of these patients was achieved with Lichtenstein's technique. In a retrospective analysis of these cases, we have found significant and repetitive increases in intraabdominal pressure as a predisposing factor for recurrence (chronic cough in asthmatic patients, use of orthopedic devices surrounding the abdomen in a paraplegic patient, or recurrent hernia with "loss of domain" in a chronically constipated patient).

## CONCLUSION

Detailed anatomical knowledge, refined surgical technique, and experience are the decisive factors in successful treatment of inguinal hernia by transperitoneal laparoscopic means.

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# 16 Totally Extraperitoneal Inguinal Hernia Repair

**Kinga A. Powers and Daniel B. Jones**

## Introduction

Laparoscopic inguinal herniorrhaphy was initially described by Ger in the early 1980s. Since that time, laparoscopic herniorrhaphy has evolved on the basis of traditional open approaches introduced in the 70s by Stoppa, Nyhus, and Wantz utilizing a posterior placement of mesh over the entire inguinofemoral region. Initially laparoscopic intraperitoneal onlay mesh was used; however, exposed intraabdominal mesh raised concern for adhesions. Now, most laparoscopic hernia repairs use the placement of synthetic material into the preperitoneal space. The two laparoscopic inguinal herniorrhaphies performed today are the transabdominal preperitoneal approach (TAPP) and the totally extraperitoneal (TEP) approach. In these repairs, the myopectineal orifice is approached posteriorly and allows for inguinal, femoral, and obturator hernia repairs to be performed simultaneously.

McKernan and Laws were first to report a successful TEP repair in 1993. In the TEP hernia repair the preperitoneal dissection allows for surgical mesh placement over all potential groin hernia defects without entering the abdominal cavity. Although more difficult to master and more costly, there are several advantages of the TEP repair as compared to traditional open techniques of inguinal herniorrhaphy. With TEP, there is less postoperative and long-term neurologic pain and hence shorter convalescence, fewer hematomas, and deep space infections while the recurrence rates remain equivalent to open techniques. When compared to TAPP, TEP offers shorter operative times, especially for bilateral hernias, and decreases the risks of vascular, bowel, and bladder injuries as well as bowel obstructions, adhesions, or fistula formation potentially associated with intraperitoneal dissection and intraperitoneal mesh exposure. It is understandable, therefore, why laparoscopic surgeons often choose TEP as their approach to inguinal herniorrhaphy.

### Anatomy of the Inguinal Preperitoneal Space

Clear understanding of the inguinal preperitoneal space anatomy is fundamental in performing the TEP repair. Initial careful anatomical studies of the inguinal region by Bassini, Halsted, Chester, and McVay allow for the current detailed understanding of the groin anatomy, critical in preventing neurovascular and organ injuries.

The preperitoneal space is bounded internally by the peritoneum and externally by the transversalis fascia and the rectus abdominis muscle. Fat, blood vessels, lymphatics, nerves, and the spermatic cord or the round ligament of the uterus all course through this space. The spermatic cord contains the cremasteric muscle fibers, the testicular artery and veins, the genital branch of the genitofemoral nerve, the vas deferens, the cremasteric vessels, the lymphatics, and the processus vaginalis. The vas deferens arises from the seminal vesicle and tracks medial to lateral in the preperitoneal space. The vas deferens courses over Cooper's ligament, the external iliac vessels, and the iliopubic tract, joining the spermatic cord medially at the deep inguinal ring just inferior and lateral to the inferior epigastric vessels. These three structures form the so-called "Mercedes-Benz" sign.

The peritoneum drapes over the deep aspect of the abdominal wall covering the remnant of the urachus, the obliterated umbilical arteries, and the inferior epigastric vessels to form the median, medial, and lateral umbilical ligaments, respectively. Between and in close proximity to the inferior aspect of lateral umbilical ligaments lies the bladder.

The inferior epigastric vessels branch from the external iliac vessels and lie medial to the internal inguinal ring serving as an important landmark during the TEP repair. From the preperitoneal perspective one recognizes indirect inguinal hernias as lateral to the inferior epigastric vessels, whereas direct hernias occur medial to the inferior epigastrics. When preperitoneal fat herniates through the internal inguinal ring it is known as a cord lipoma and may mimic an indirect hernia. A femoral hernia can also be easily identified in the femoral canal bound laterally by the femoral vessels, medially by the lacunar ligament, anteriorly by the iliopubic tract, and posteriorly by Cooper's ligament.

Entering the internal ring laterally are the testicular vessels. The testicular vessels and the vas deferens at the internal ring form the apex of a theoretical triangle commonly referred to as the "triangle of doom." Within this triangle lie the external iliac artery and vein, as well as the genital and femoral branches of the genitofemoral nerve, hidden under peritoneum and transversalis fascia, placing them at high risk of injury. The so-called "triangle of pain" lies lateral to this and its apex is formed inferomedially by the testicular vessels and superolaterally by the iliopubic tract. Within this triangle lie the femoral branch of the genitofemoral nerve, the femoral nerve, and the lateral cutaneous femoral nerve. Stapling of these structures during a laparoscopic hernia repair results in painful neuralgias and should be avoided.

## INDICATIONS/CONTRAINDICATIONS

Laparoscopic approaches with TEP and TAPP offer an advantage to open inguinal hernia repairs in bilateral hernias as well as in recurrent hernias status post-open mesh repair. In recurrences from open hernia repairs, scar tissue can be avoided, and dissection in fresh tissue planes from the preperitoneal approach may allow for better inspection of the entire myopectineal orifice for defects. In contrast, recurrences from prior laparoscopic repairs should be repaired through an open approach.

The TEP approach is especially useful in patients who seek an early return to vigorous physical activity. Any increase in intraabdominal pressure post-repair will push mesh into position rather than increase any wound complications as the case may be with open repairs.

Patients with unilateral, bilateral, or recurrent inguinal hernias who can tolerate a general anesthetic are candidates for a TEP repair. On the other hand, patients with comorbidities who are poor candidates for a general anesthetic may be best served by an open inguinal hernia repair under spinal or regional anesthesia. Nonetheless, TEP has been successfully performed under spinal anesthesia when it is possible to sufficiently relax the rectus muscle and allow for preperitoneal $CO_2$ insufflation with low pressures.

Contraindications to a TEP repair include any local or systemic infections that preclude synthetic material use as the risk of mesh infection and need for further surgery to evacuate the infected material is too great under such conditions. Another relative contraindication is a planned or high future risk of a pelvic or extraperitoneal procedure such as radical prostatectomy.

Previous lower abdominal surgery may present a challenge for a laparoscopic surgeon, however is not an absolute contraindications to a TEP repair. If performed carefully, TEP is still feasible even with a lower midline, a right lower quadrant appendectomy, or Pfannenstiel incisions. Since scaring may render separation of the posterior rectus from the peritoneal surface more difficult, a higher rate of conversion to TAPP or open procedures needs to be anticipated under those circumstances. In addition, a higher rate of visceral injuries must be taken into consideration. In patients with lower abdominal scars, any resistance during initial dissection of the preperitoneal space should alert the surgeon of a potential problem and lead to altering or aborting the TEP procedure.

In cases of strangulated, incarcerated, or large scrotal hernias, an open or a TAPP approach may be a better alternative to TEP. With the blind balloon dissection required for the TEP technique there is a risk of injury to the contents of the incarcerated hernia sac. In such cases, a modified approach of the TEP technique can be used and has been described; however, a more conservative approach is to use an open or TAPP technique if a hernia does not reduce itself spontaneously with a full relaxation of the abdominal wall.

Currently both, TAPP and TEP laparoscopic approaches are acceptable methods of inguinal hernia repair. The conversion from TEP rate has been reported at around 5%. Consequently, surgeons who use the TEP approach need to be equally as proficient with the alternative TAPP and open methods of inguinal hernia repair.



## PREOPERATIVE PLANNING

A complete history and physical examination allows for a proper hernia diagnosis and delineation of possible comorbidities and contraindications to a TEP repair. The patient is examined while standing and supine for both inguinal and femoral hernias on both left and right sides. Masses other than hernias in the groin must be ruled out. This can usually be done by physical examination or with the aid of computed tomography or ultrasound imaging. In the case of associated symptoms of fever, tachycardia, exquisite tenderness on groin palpation, erythema of the overlying groin skin, leukocytosis, and/or obstructive symptoms, the incarcerated hernia is likely strangulated and warrants immediate open operative intervention instead of any laparoscopic exploration.

Once a diagnosis is made surgical management of inguinal hernias is discussed with the patient. A clear disclosure of the benefits, pertinent risks of both open and laparoscopic approaches is critical. The possibility of conversion of the TEPP to a TAPP or open repair needs to be explained to the patient. The major intraoperative risks common to both laparoscopic and open inguinal hernia repairs include neurovascular injury (such as lateral femoral cutaneous nerve or common iliac artery injury), injury to other organs such as bladder, bowel, or spermatic cord and its structures. Postoperative complications include urinary retention, groin hematomas, transient or chronic neuralgias, testicular injury, postoperative wound or mesh infections, and hernia recurrence. More specific to the laparoscopic repair as opposed to the open repairs are trocar site complications (hernia or hematoma), and rare risks from $CO_2$ insufflation (hypotension due to elevated intraabdominal pressure, hypercapnea, subcutaneous emphysema, air emboli, pneumothroax, and increased peak airway pressures during surgery). With the TEP approach, the intraperitoneal dissection is avoided and the risks of bowel obstruction secondary to intraabdominal adhesions, mesh adhesions, or visceral injury are minimized as compared to the TAPP procedure. In theory, TEP may avoid the cardiorespiratory alterations associated with creating a pneumoperitoneum, but there have been reports of respiratory acidosis associated with a pneumopreperitoneum.

### Operating Room Setup and Patient Preparation

The operating room and equipment are prepared with the appropriate laparoscopic instrumentation and surgical mesh of various sizes available as chosen by the surgeon. In addition to standard open surgical instruments, laparoscopic equipment routinely required for the TEP procedure includes a balloon dissecting device for preperitoneal dissection, a structural balloon trocar or a Hasson type trocar, a 30° laparoscope, two 5 mm trocars and two atraumatic graspers, laparoscopic scissor, a 5 mm clip applier, cautery and a tacking device. Also available, but rarely needed, should be suction irrigator, endoloops, and a Verres needle.

A motorized operating room table is used with capability of placing the patient in Trendelenburg position when required. Two video monitors are positioned at the foot of the patient's bed and at eye level of the operating surgeon and their assistant. The surgeon stands opposite to the side of the hernia being repaired. One assistant is required and typically holds the camera from the same side of the hernia being repaired. The patient is positioned supine with both arms tucked; alternatively, one arm is tucked on the opposite side to the hernia for a unilateral procedure. This allows the surgeon adequate mobility throughout the case and room to maneuver while placing and fixing the surgical mesh. Generally, the larger or more symptomatic hernia is repaired first before the opposite side is explored.

Although antibiotic prophylaxis has been controversial in both open and laparoscopic hernia mesh repairs, the authors favor prophylactic antibiotics to cover skin flora as to minimize skin and mesh infections (cephalosporin is the most common choice). Preoperatively, the patient empties their bladder; alternatively a Foley catheter is placed under sterile conditions and generally removed at the end of the procedure prior to reversal of anesthesia. The abdomen is prepped and draped from just above the umbilicus to below the pubis. Some surgeons prefer to prep the scrotum as well for the possibility of manipulation during the procedure. Should the spermatic cord be difficult to distinguish, gentle traction on the scrotum may aid in bringing it into view.

The procedure as mentioned is performed under a general anesthetic with full relaxation of the abdominal wall. An appropriate time-out should be performed to identify the patient and the side of the procedure correctly prior to making a skin incision.

## SURGERY

A horizontal 10 mm incision is fashioned just below the umbilicus, slightly off the midline towards the side of the hernia being addressed first. The subcutaneous fat is cleared with a combination of cautery and blunt dissection down to the anterior rectus sheath fascia. The anterior fascia is then incised without injuring the belly of the rectus muscle or the small blood vessels often located just anterior to it. Metzenbaum scissors are used to extend the incision in the anterior sheath to approximately 10 mm. The belly of the muscle is bluntly separated from the posterior sheath using a Kelly (Fig. 16.1). Two S retractors are used to gently sweep the muscle laterally and separate any muscle attachments to the posterior sheath thus creating space in the preperitoneal location for the introduction of the dissecting balloon. It is important to remember that in the midline, anterior and posterior rectus sheaths fuse and it is easy to penetrate the posterior rectus into the peritoneal cavity. In the case that the peritoneum is breeched during the initial incision or passage of the dissecting balloon, one may attempt to salvage the TEP procedure by initiating preperitoneal dissection on the opposite side with a bilateral dissection balloon. Alternatively, conversion to a TAPP is an acceptable option preferable to an open conversion.

Prior to the balloon dissection of the preperitoneum the patient is fully paralyzed and positioned in mild Trendelenburg position. The balloon trocar is passed aiming at the anterior part of the symphysis pubis as to avoid injury to the peritoneum or the bladder posteriorly. The dissector is passed along the anterior surface of the posterior rectus sheath and advanced to the pubis, inferiorly past the arcuate line (line of Douglas), where the posterior sheath ceases to exist (Fig. 16.2). Once the pubic bone is reached, the balloon dissector is inflated under direct visualization through the laparoscope to create a working space. Usually 30 to 40 puffs are adequate to insufflate the preperitoneal space bilaterally to the iliac crest. The correct plane of balloon dissection allows for visualization of the peritoneal layer, the pubis, and Cooper's ligaments as well as inferior epigastric vessels anteriorly. If bowel loops or omental fat come into view a peritoneal tear has occurred.

The dissecting balloon is desufflated, removed and a 10 mm Hasson type trocar is placed at the infraumbilical location, alternatively a structural balloon may be used. The preperitoneal space is then insufflated to low $CO_2$ pressure (10 to 12 mm Hg). Additional trocars are then inserted into the preperitoneal space under direct

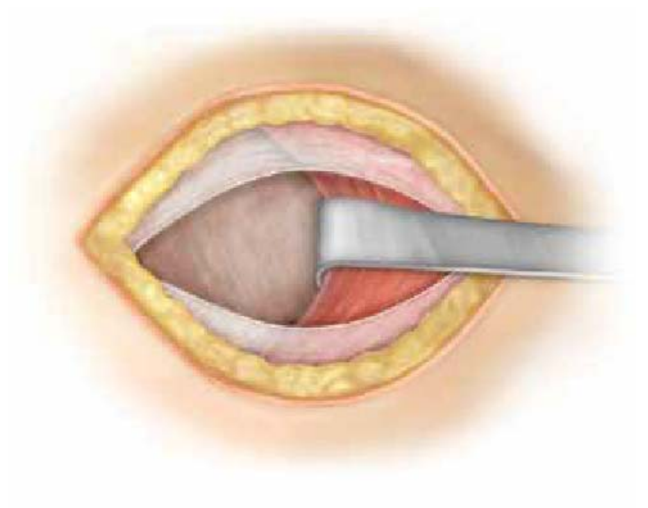

**Figure 16.1** Access to the preperitoneal space via infraumbilical anterior rectus sheath incision just lateral to the midline.



visualization. Midline placement of the additional trocars minimizes injury to the peritoneum and inferior epigastric vessels laterally. If inferior epigastric vessels are injured during the dissection, they can be clipped with a 5 mm clip applier and/or divided with cautery or a sealing device. For the midline positioning of the two 5 mm trocars, the lowest trocar is placed at least three fingerbreadths above the pubis. The second 5 mm port is midway between the lowest and the Hasson port.

Blunt laparoscopic graspers are introduced into the working space and the groin anatomy is inspected first. Location of landmarks such as the inferior epigastric vessels, iliofemoral vessels, pubic bone, and Cooper's ligament are identified. Iliac vein is lateral and inferior to Cooper's ligament. Exposing the iliac and femoral vessels from their fatty envelope may be dangerous and is not indicated. Any bleeding from the external iliac vessels at any time during the TEP procedure needs to be controlled via an immediate conversion to an open approach and suture repair of the vessel. During initial inspection, the general location of the internal inguinal ring and the spermatic cord and its structures are also ascertained.

The dissection begins by clearing off the pubis and Cooper's ligament and exposing any direct hernia component which should come into view medial to the inferior epigastric vessels. Care must be taken not to injure the small vessels, tributaries of the obturator vein, inevitably present on Cooper's ligament; electrocautery can be used sparingly to control any bleeding from injuring such vessels. A direct sac will appear as continuous with the peritoneal layer. Pseudosac or invagination of the transversalis fascia may be present and difficult to differentiate from a peritoneal sac *per se*. The direct hernia sac should be fully reduced and is not to be ligated in order to avoid bladder injury. Femoral space should be examined carefully for femoral hernias which would be lying superior and lateral to the femoral vein. Reduction of a femoral hernia can be aided by a small incision on the superior medial edge of the femoral ring.

Lateral dissection starts by identifying and preserving the inferior epigastric vessels and then gently and bluntly sweeping all loose connective tissue from the posterior abdominal wall laterally towards the anterior superior iliac spine (ASIS). Palpation of the abdominal wall at the ASIS may help to visualize the lateral boundary of the dissection. Anteriorly, a thin layer of connective tissue should be left undisturbed over the quadratus lumborum muscle to avoid sensory nerve injury. In addition, electocautery use should be avoided lateral to the spermatic cord to avoid nerve injury. Inferiorly, the psoas muscle may come into view and indicate sufficient inferior exposure. Indirect hernia if present will become apparent lateral to the inferior epigastric vessels. The indirect sac will be continuous with the peritoneum invaginating into the internal inguinal ring, adherent laterally and anteriorly to the spermatic cord. The indirect sac can be reduced by gentle traction. Blunt, gentle dissection of the cord and its structures is important as the indirect hernia component in the TEP approach may not always be readily apparent without this step. The sac is gently peeled off with a blunt instrument from the testicular vessels and vas deferens in the cephalad direction far enough to allow for a flat mesh placement. Usually dissection below the bifurcation of the vas deferens and gonadal vessels is sufficient. Lipomas of the cord are often found laterally

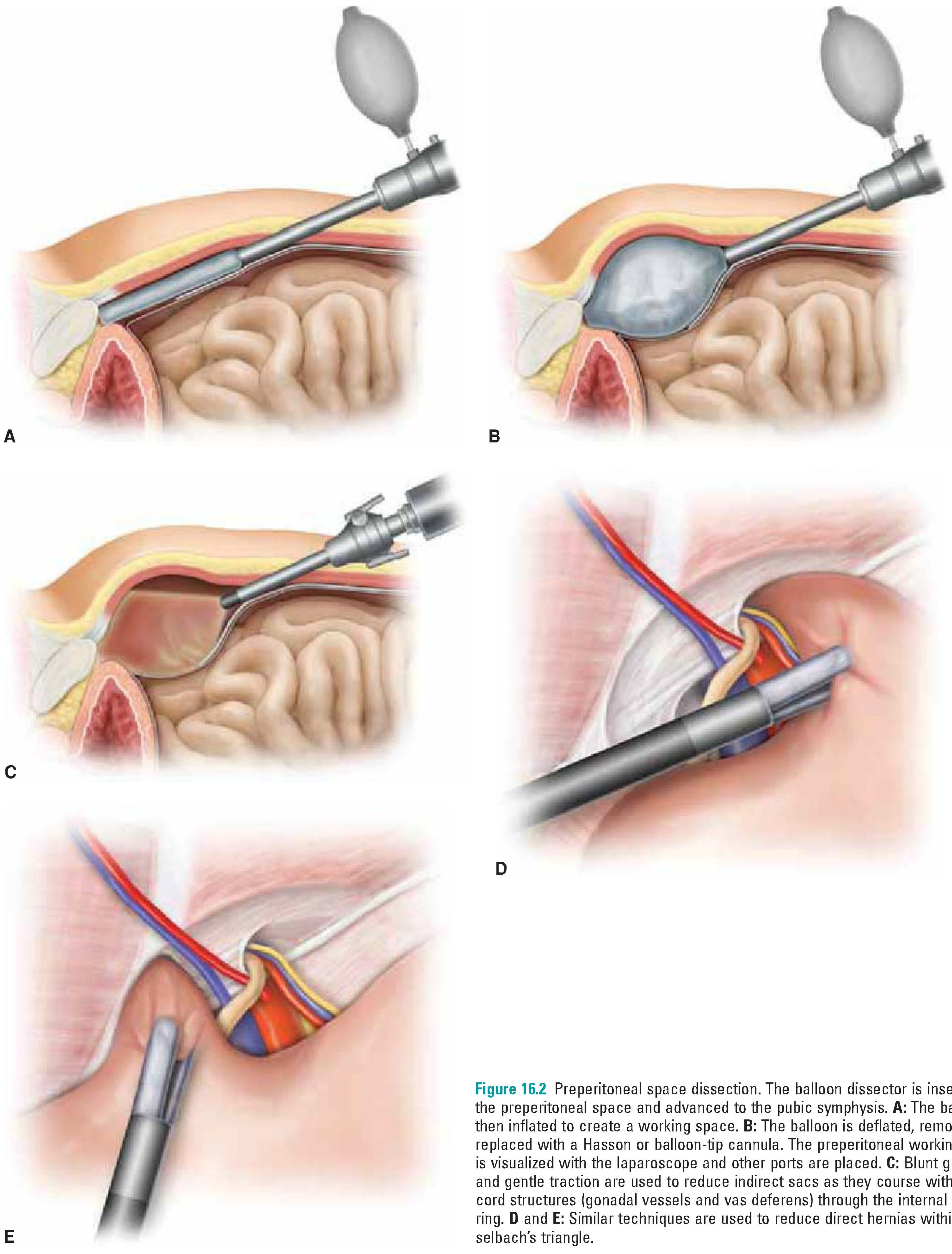


**Figure 16.2** Preperitoneal space dissection. The balloon dissector is inserted into the preperitoneal space and advanced to the pubic symphysis. **A:** The balloon is then inflated to create a working space. **B:** The balloon is deflated, removed, and replaced with a Hasson or balloon-tip cannula. The preperitoneal working space is visualized with the laparoscope and other ports are placed. **C:** Blunt graspers and gentle traction are used to reduce indirect sacs as they course with the cord structures (gonadal vessels and vas deferens) through the internal inguinal ring. **D** and **E:** Similar techniques are used to reduce direct hernias within Hesselbach's triangle.

along the spermatic cord vessels pulled out of the indirect space and left in the peritoneum or removed. During the sac and lipoma dissection electrocautery use is avoided and care is taken not to injure the lateral cutaneous nerve and the femoral branch of the genitofemoral nerve which can lie directly under the lipoma lateral to the internal ring.

When a large indirect sac is encountered the sac can be opened and ligated after it is dissected off of cord structures and after ensuring that there are no intraabdominal contents inside the sac. The anatomical relationships to remember when dividing the sac are the following: The vas deferens will lie medially on the sac and testicular vessels will be positioned laterally. The distal end of the sac is usually left open to avoid formation of an endocele. The proximal end of the sac or any tears in the peritoneum should be closed with an endoloop, intracorporeal suturing or surgical clips. This helps to prevent contact between mesh and intraabdominal contents and may prevent herniation of intraabdominal contents through the peritoneal defect.

If $CO_2$ enters the abdominal cavity through a peritoneal opening, it may impair preperitoneal visualization by decreasing the working space. A good way of managing any peritoneal tears during the TEP procedure is to use a Veress needle decompression. A Veress needle can be placed intraabdominally at the umbilicus or in the upper quadrants. Peritoneal tears and intraabdominal gas leakage occur in 40% to 47% of TEP cases and can lead to conversion to an open or TAPP approach. Peritoneal tears, if left unrecognized, can lead to intestinal complications. Although sometimes difficult to accomplish, peritoneal tears must be repaired to avoid potential consequences.

## Mesh Choice and Placement

In the TEP hernia repair the use of synthetic mesh is a standard part of the procedure, where the mesh is placed in the preperitoneal space. Folded mesh is placed through the Hasson port, the laparoscope replaced and the mesh oriented and positioned with blunt graspers. It is important that all three potential hernia sites are covered with the mesh. The mesh should overlap the pubic bone and it must lie flat on the abdominal wall after desufflation. Rolling of the mesh onto itself must be avoided to circumvent the hernia sac finding its way under the mesh to form a recurrence.

A number of different nonabsorbable and biologic meshes are available. Although long-term efficacy studies with biologic and polyester meshes are lacking, nonabsorbable polyethylene polymer or polypropylene (PP) meshes have been used successfully for laparoscopic and open repairs since the development of PP in the 1950s. The polyethylene polymer is used in the heavyweight meshes (Prolene, Ethicon GmbH, Hamburg, Germany) and in lightweight composite meshes with an absorbable and a nonabsorbable component (Vypro II Ethicon GmbH, Hamburg, Germany). Proponents of lightweight composite mesh claim that it may cause less of an inflammatory response and hence less postoperative pain, yet the two types of PP meshes have been shown to be equivalent in terms of postoperative outcomes. The Bard® 3DMax® Mesh, contoured mesh, has also been advocated for its ease to maneuver in the preperitoneal space, at a premium cost. The search for the ideal mesh for inguinal hernia repair remains in progress.

A $12 \times 15$ cm$^2$ flat polypropylene mesh can be fashioned to cover all hernia defect sites. The authors do not make a slit in the mesh as this step is unnecessary and may increase hernia recurrence. Although various cut-out shapes of the mesh have been previously described, the underlying principle of mesh placement remains the same : At least 3 cm overlap of all three potential inguinal hernia sites, to avoid recurrence from mesh shrinkage or migration and rolling. In an experimental animal study, Klinge et al. showed that polypropylene meshes can shrink 30% to 50% of their original size after 4 weeks.

The authors fix the mesh to Cooper's ligament with three or four spiral tacks (Fig. 16.3). Excessive use of tacks may contribute to postoperative chronic pain and increase the cost of the operation. It is important to remember that mesh fixation does not add strength to the repair and its purpose is chiefly to prevent mesh migration. Knowledge of the anatomical locations of inguinal nerves is important during mesh fixation as cadaver studies demonstrate that in 15% of patients, posterior nerves of the groin are

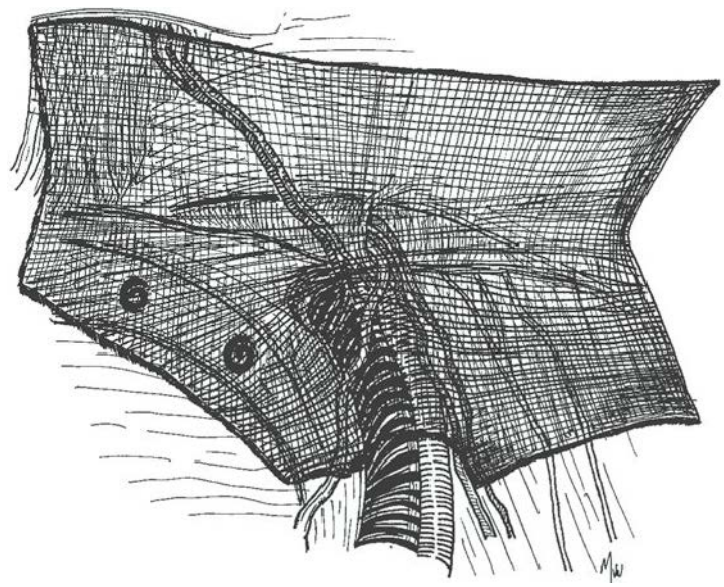

Figure 16.3 Mesh overlaps the direct, indirect and femoral spaces. Mesh is secured with two spiral tacks to Cooper's ligament.

injured secondary to mesh fixation. Fibrin glue fixation, absorbable tacks and nonfixation of the mesh have been advocated, but long-term efficacy studies are not yet available.

Mesh can be fixed medially to Cooper's ligament with a tacking instrument carefully avoiding the aberrant obturator vessels and the periosteum over the pubic bone (to avoid osteitis pubis). Two to three tacks in Cooper's ligament are sufficient. The mesh is then positioned with graspers to smoothly cover the undersurface of the abdominal wall. For large hernias, the mesh can then be fixed laterally, ensuring that the lateral edge is fastened to anterior abdominal wall above the ilioinguinal tract. Note is made of the position of the inferior epigastric vessels. The pressure of the tip of the tacker is palpated through the abdominal wall to avoid tacking below the iliopubic tract and thus avoid potential nerve injury (injury to genitofemoral, lateral femoral cutaneous, ilioinguinal, and femoral nerves can be injured with tacks). Lateral tacks should be avoided in thinner patients who may be more likely to palpate the tacks.

At the end of the procedure, pneumopreperitoneum is relieved and the mesh is held in position inferiorly and laterally with blunt graspers, making sure that peritoneum stays posterior to the mesh and does not roll underneath it to cause an immediate recurrence. Graspers and the 5 mm trocars are removed only once the correct mesh placement is ascertained with complete $CO_2$ evacuation. The 10 mm infraumbilical fascial opening is closed using absorbable 0 sutures for the anterior fascia. Local anesthetic is infiltrated into the wounds and the incisions closed with absorbable subcuticular closure, steristrips, and sterile dressings.

## POSTOPERATIVE MANAGEMENT

Patients are usually discharged on the same day of their TEP surgery with a prescription for narcotics and stool softeners. Urinary retention is common and older men we ask to void prior to discharge. Return to normal activities postoperatively is encouraged. Patients may return to work according to their comfort level, usually within 1 to 2 weeks.

## COMPLICATIONS

In general, complication rates have been shown to be comparable between open and laparoscopic repairs (Tables 16.1 and 16.2). The methods, outcomes, and how complications are reported vary from study to study; however, several advantages of laparoscopic techniques have been identified compared to open mesh repairs in terms of local

**TABLE 16.1 Select Prospective Randomized Trials Comparing Totally Extraperitoneal Repair and Open Inguinal Hernia Repairs with Mesh (Level I Evidence)**

| Reference | Study Design | Average Follow-up | No. of Repairs | Complications (Not Including Recurrences) | Recurrences | Operative Time (Minutes) | Postoperative Pain | Return to Work (Days) | Conclusions/Details |
|---|---|---|---|---|---|---|---|---|---|
| **Multicenter Prospective Randomized Trials** | | | | | | | | | |
| Neumayer et al. (2004) The United States (VA trial) | Laparoscopic (10% TAPP, 90% TEP) vs. Licht. | 24 mos | Laparoscopic 862 | 386 (39%) total complications 3 deaths (1 PE, 1 intestinal injury, 1 MI) 5% conversion to open | 10.1%[a] | –[b] | ↓ pain score on POD 1 to 14[a] | 4[a] | Intention to treat analysis. SF-36 outcomes similar to 2 y. Fewer perioperative and life-threatening complications for open repairs, but similar long-term complications. For recurrent hernias, recurrence rates were 10.0% for laparoscopic and 14.1% for open. |
| | | | Licht: 834 | 332 (33.4%) total complications 1 death (bowel obstruction in missed femoral hernia) | 4.9%[a] | –[b] | No difference at 3 mos | 5[a] | For "highly experienced" surgeons (>250 cases), there was no difference in recurrence for primary hernias (5.1% laparoscopic vs. 4.1% open) but significantly fewer for recurrent hernias (3.6% laparoscopic vs. 17.4% open). "Open technique is superior" |
| MRC Hernia Group (1999) The United Kingdom | Laparoscopic (23% TAPP, 77% TEP) vs. open (89% tension-free mesh) | 12 mos (711 patients) | Laparoscopic: 468 | 25 (5.6%) surgical complications (1 bladder, 1 lateral femoral cutaneous nerve/nerve, 1 common iliac art)[a] 108 (29.9%) complications at 1 wk[a] 6.6% conversion to open | 1.9%[a] | 58.4[a] | ↓ groin pain at 1 y[a] | 28[a] | SF-36 outcomes similar at 3 m. 16/25 surgical complications were injury to inferior epigastric vessels. All serious complications and two trocar hernias happened in the TAPP group. |

(*continued*)

**TABLE 16.1 Select Prospective Randomized Trials Comparing Totally Extraperitoneal Repair and Open Inguinal Hernia Repairs with Mesh (Level I Evidence) (*Continued*)**

| Reference | Study Design | Average Follow-up | No. of Repairs | Complications (Not Including Recurrences) | | Recurrences | Operative Time (Minutes) | Postoperative Pain | Return to Work (Days) | Conclusions/Details |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | Laparoscopic repairs offer advantages but potential for rare serious complications and recurrence support repairs being performed by specialist surgeons. |
| | | | Open: 460 | 6 (1.4%) surgical complications (1 enterotomy)[a]<br>155 (43.5%) complications at 1 wk[a] | | 0[a] | 43.4[a] | | 42[a] | "Open repair is the more appropriate option for the general surgeon." |
| Liem et al. (2003, 1997)<br>The Netherlands | TEP vs. open (Marcy, Licht, Bassini, Shouldice, McVay) | 44 mos (87% f/u) | TEP: 487 | 24 (5%) Conversion to TAPP or open<br>54 (11%) total postoperative complications | 0 deep wound infection[a]<br>10 (2%) chronic pain[a]<br>7 (1%) seroma[a]<br>3 (1%) pneumo-scrotum >1 d | 4.9%[a] | 45[a] | ↓ pain score[a] | 14[a] | 71% of laparoscopic recurrences and 4% of open recurrences occur in the first postoperative year.<br>10 of 21 laparoscopic recurrences were by a single surgeon.<br>Open repair associated with higher incidence of chronic pain.<br>Bassini repair results in unacceptably high recurrence rates. |
| | | | Open: 507 | 99 (19.5%) total postoperative complications<br>6 (1%) deep wound infection[a]<br>70 (14%) chronic pain[a]<br>0 seroma[a] | | 10.0%[a] | 40[a] | | 21[a] | TEP has more rapid recovery, fewer recurrences, and less chronic pain than open repairs, but takes slightly longer to perform. |

**TABLE 16.1 Select Prospective Randomized Trials Comparing Totally Extraperitoneal Repair and Open Inguinal Hernia Repairs with Mesh (Level I Evidence) (*Continued*)**

| Reference | Study Design | Average Follow-up | No. of Repairs | Complications (Not Including Recurrences) | | Recurrences | Operative Time (Minutes) | Postoperative Pain | Return to Work (Days) | Conclusions/Details |
|---|---|---|---|---|---|---|---|---|---|---|
| Eklund et al. (2006/2009) Sweden (SMIL study) | TEP vs. Licht | 3 mos and 60 mos (recurrence) | TEP: 665 | *Intraoperative 4.8%*[a]<br>Minor | *At 1 wk 17.3%*<br>Hematoma 10.5%<br>Seroma 0.9% | 3.5%[a] (2.4% excluding 1 surgeon) | 55 median 12 to 180 range | Pain at 1 wk 1.6%<br>Pain at 3 mos 7.6% | 7[a]<br>0 to 77<br>Full recovery | Higher cumulative recurrence rate in the TEP group; however, attributed to incorrect surgical technique. In the TEP group braising at 1 wk was shown a risk factor for recurrence.<br>In the open repair group, smoking and a medial hernia were risk factors for recurrence. |
| | | | | Bleeding 0.9%<br>Technical problem 1.8%[a]<br>Nerve injury 0%[a]<br>Conversion 1.8%[a]<br>Major<br>Hemorrhage 0%<br>Anesthetic related 0.2%<br>Reoperation in 24 h 0.2%<br>*At discharge 7.4%*<br>Urinary retention 4.2%<br>Hematoma 1.5%<br>Anesthesia related 1.5%<br>Other 0.2% | Superficial infection 1.4%<br>Urinary discomfort 0.9%<br>Testicular discomfort 1.2%<br>Reoperation 0.2%<br>Other 0.7%<br>*Complaints at 3 mos 14.1%*<br>Seroma 0.7%<br>Orchitis 0%<br>Sex related 0.2%<br>Infection 0.2%<br>Reoperation 0.3%<br>Other 1.4% | | | Numbness 0.5%[a]<br>Neuralgia 0.5%<br>Scrotal discomfort 2.7% | 20[a]<br>0 to 179 | |

(*continued*)

**TABLE 16.1 Select Prospective Randomized Trials Comparing Totally Extraperitoneal Repair and Open Inguinal Hernia Repairs with Mesh (Level I Evidence) (*Continued*)**

| Reference | Study Design | Average Follow-up | No. of Repairs | Complications (Not Including Recurrences) | | Recurrences | Operative Time (Minutes) | Postoperative Pain | Return to Work (Days) | Conclusions/Details |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Licht: 705 | *Intraoperative 2.1%*[a]<br>Minor<br>Bleeding 0.6%<br>Technical problem 0%[a]<br>Nerve injury 1.3%[a]<br>Conversion 0%[a]<br>Major<br>Hemorrhage 0.1%<br>Anesthetic related 0.1%<br>Reoperation within 24 h 0%<br>*At discharge 10.2%*<br>Urinary retention 7.5%<br>Hematoma 1.4%<br>Anesthesia related 1.3%<br>Other 0% | *At 1 wk 17.5%*<br>Hematoma 12.9%<br>Seroma 0.8%<br>Superficial infection 0.7%<br>Urinary discomfort 1.0%<br>Testicular discomfort 0.7%<br>Reoperation 0.2%<br>Other 0%<br>*Complaints at 3 mos 16.3%*<br>Seroma 0.2%<br>Orchitis 0.3%<br>Sex related 0.3%<br>Infection 0.6%<br>Reoperation 0%<br>Other 0.8% | 1.2%[a] | 55 median<br>20 to 145 range | Pain at 1 wk 1.3%<br>Pain at 3 mos 8.3%<br>Numbness 3.6%[a]<br>Neuralgia 1.3%<br>Scrotal discomfort 1.0% | 12<br>0 to 55 Full recovery<br>31[a]<br>0 to 163 | |

TAPP, transabdominal preperitoneal approach; TEP, totally extraperitoneal approach; Licht., Lichtenstein.
[a]Statistical significance (all unmarked values are not statistically significant).
[b]—indicates value was not measured.

**TABLE 16.2** Select Meta-analyses Comparing Laparoscopic (TEP and TAPP) and Open Inguinal Hernia Repair With and Without Mesh

| Reference | Study Design | Average Follow-up (Months) | No. of Repairs | Complications (Not Including Recurrences) | Recurrence | Operative Time (Mean Difference in Minutes) | Postoperative Pain | Return to Work (Days) | Conclusions/Details |
|---|---|---|---|---|---|---|---|---|---|
| Schmedt et al. (2004) Germany | 34 RCT TAPP and TEP vs. various open (Licht. group analyzed separately) | 27.9 (1 to 70) | TAPP and TEPP vs. Licht<br>23 trials 4,550 patients | Total 28.4% vs. 28.3%<br>Bowel injury 0.1% vs. 0.06%<br>Wound Infection 1% vs. 2.7%[a]<br>Hematoma 13.1% vs. 16%[a]<br>Seroma 12.2% vs. 8.9%[a]<br>Urinary retention 3.5% vs. 2.7% | 5.5% vs. 2.7%[a] | 65.7 (40 to 10) vs. 55.5[a]<br>(34 to 99) | Chronic 7.6% vs. 12.7%[a]<br>Inguinal paresthesia 3.9% vs. 8%[a] | 14.8 (5 to 46) vs. 21.4[a]<br>(7 to 43) | Laparoscopic repairs had a lower incidence of wound infection, a reduction in hematoma formation and nerve injury, an earlier return to normal activities or work, and fewer incidences of chronic pain syndrome. No difference was found in total morbidity or in the incidence of injury to intestine, bladder, major vascular structures, urinary retention, or testicular problems. |
| | | | TAPP and TEP vs. other open non-Licht.<br>11 trials 2,673 patients | Total 24.6% vs. 29.9%[a]<br>Bladder injury 0.1% vs. 0<br>Superficial inferior 1.2% vs. 2.4%[a]<br>Hematoma 8.6% vs. 14.3%[a]<br>Seroma 6.4% vs. 7.3%<br>Urinary retention 2.3% vs. 1.1%<br>Bleeding 0.09% vs. 0%<br>Testicular injury 0.6% vs. 0.8% | 3.2% vs. 2.7% | 13.8 (5 to 28) vs. 22.2[a]<br>(7 to 42) | Chronic 4.5% vs. 5.2%<br>Inguinal paresthesia 11.2% vs. 24.3%[a] | 13.8 (5 to 28) vs. 22.2[a]<br>(7 to 42) | Advantages for the Lichtenstein repair included a shorter operating time, a lower incidence of seroma formation, and fewer hernia recurrences. This result was strongly influenced by the VA Trial; if these data are excluded, a significantly higher total morbidity was found for the Lichtenstein repair and no difference in recurrence rates. |
| McCormack et al. | 41 RCT | 6 to 36 | TEP vs. open mesh<br>6 trials, 690 patients | Conversion 1.7% vs. 0% | 2% vs. 2.1% | 5.29[a] shorter for open | Persisting pain | 7 days shorter for TEP and | Convalescence was faster for TEP repair, and there was less persisting pain and numbness than with open approaches. Operation times were ~15 min longer with TEP. In the TEP, unlike the TAPP, group a higher number of serious complications was not noted. |

(*continued*)

**TABLE 16.2** Select Meta-analyses Comparing Laparoscopic (TEP and TAPP) and Open Inguinal Hernia Repair With and Without Mesh (*Continued*)

| Reference | Study Design | Average Follow-up (Months) | No. of Repairs | Complications (Not Including Recurrences) | Recurrence | Operative Time (Mean Difference in Minutes) | Postoperative Pain | Return to Work (Days) | Conclusions/Details |
|---|---|---|---|---|---|---|---|---|---|
| Cochrane review (2008) | 7,161 patients multiple comparisons TAPP and TEP vs. open mesh and nonmesh repairs (selected summarized) | | | Hematoma 5.2% vs. 18.8%[a]<br>Seroma 1.7% vs. 1.5%<br>Superficial infection 0.9% vs. 0.5%<br>Mesh/deep infection 0% vs. 0%<br>Port site hernia 0% vs. 0%<br>Vascular injury 0% vs. 0%<br>Visceral injury 0% vs. 0% | | | 1% vs. 10.8%[a]<br>Persisting numbness 0.6% vs. 4.2%[a] | TAPP[a] (Peto odds ratio 0.56, 95% CI 0.51 to 0.61[a]) | Using a mesh rather than choice of technique reduced the risk of a recurring hernia. Recurrence rates were similar in TEP compared to open groups. |
| | | | TEP vs. nonmesh 5 trials, 1,522 patients | Conversion 4.6% vs. 0%[a]<br>Hematoma 3.7% vs. 2.9% [a]<br>Seroma 1.8% vs. 0%[a]<br>Superficial infection 0% vs. 1.1%<br>Mesh/deep infection 0% vs. 0%<br>Port site hernia 0% vs. 0%<br>Vascular injury 0.2% vs. 0.3%<br>Visceral injury 0% vs. 0% | 2.3% vs. 4% | 10.30[a] shorter for open | Persisting pain 2.6% vs. 14.1%[a]<br>Persisting numbness<br>0% vs. 0% | | There were higher rates of conversion observed in TEP rather the TAPP.<br>There were fewer hematomas but more seromas in the TEP groups. However, when the MRC multicenter 1999 trial is included the differential effect in seroma is limited to TAPP repair only. |
| | | | Total for all TEP vs. all open 12 trials<br>2,384 patients | Conversion 4.6% vs. 0.07%[a]<br>Hematoma 5.9% vs. 9.7%[a]<br>Seroma 3% vs. 3.2%<br>Superficial infection 0.9% vs. 1.6%<br>Mesh/deep infection 0% vs. 0%<br>Port site hernia 0% vs. 0%<br>Vascular injury 0.09% vs. 0.2%<br>Visceral injury 0% vs. 0.1% | 2.3% vs. 2.8% | 9.94[a] shorter for open | Persisting pain 13.8% vs. 23.4%[a]<br>Persisting numbness<br>16.2% vs. 25.1% | | |

RCT, randomized controlled trial; TAPP, transabdominal preperitoneal approach; TEP, totally extraperitoneal approach; Licht., Lichtenstein: VA, Veterans affairs.
[a]Statistical significance (all unmarked values are not statistically significant).

complications, postoperative and chronic pain and speed of convalescence. Summaries of some multi-institution prospective randomized trials comparing specifically the TEP repair to the open techniques are outlined in Table 16.1. In addition, Table 16.2 provides a comprehensive overview of evidence from two meta-analyses comparing TEP and TAPP laparoscopic techniques to various open techniques of inguinal hernia repair. Both Schmedt et al. and the Mc Cormack study found that laparoscopic techniques offer a decreased hematoma formation, less superficial and deep wound infections, shorter convalescence and lower incidence of persisting pain and numbness after the repair, when compared to open mesh repairs. No difference was found in total morbidity or in the incidence of injury to intestine, bladder, major vascular structures, urinary retention, or testicular problems between the TEP and open techniques. In contrast, advantages for the open repairs included a shorter operating time and possibly a lower incidence recurrence, although this result was strongly influenced by the VA Trial, which had many biases. If the VA trial data are excluded, a significantly higher total morbidity was found for the Lichtenstein repair and no difference in recurrence rates compared to TEP.

The TEP repair is technically more difficult than the TAPP or the open repairs and therefore requires a potentially steeper learning curve for the surgeon. Of note are findings that surgeon's experience with the TAPP or TEP correlates directly with hernia recurrence rates and the learning curve for these techniques, and especially for TEP, is steep. The number of cases needed to reach proficiency levels and to decrease operative time has been commonly estimated at 30 to 50 cases. In the Veterans Affairs (VA) cooperative study comparing open to laparoscopic inguinal hernia repair, surgeons were required to have performed 25 laparoscopic procedures to participate. However, "highly experienced" surgeons were defined as those who reported having performed more than 250 laparoscopic inguinal hernia repairs. The recurrence rate after 2 years was improved by 50% (reported as less than 5%) when surgeons performed over 250 cases, especially for recurrent hernias. In contrast, the recurrence rate for the laparoscopic repair was greater than 10% for surgeons who reported having performed 250 or fewer laparoscopic repairs. Some may argue that 250 laparoscopic hernia cases are in excess of what is necessary for proficiency in performing these types of inguinal hernia repairs. Nevertheless, the point not surprisingly remains, that surgeon experience is instrumental for good outcomes. Fortunately, recent advances in surgical education welcomed the emergence of surgical simulators as important tools in shortening the learning curve for many laparoscopic procedures including the TEP repair. While traditional dogma has reserved laparoscopic hernia repairs for bilateral and recurrent herniorrhaphies, the authors also offer TEP for unilateral hernia repairs.

In summary, the two main observations from the vast number of studies analyzed are (1) that the rates of complications for both conventional and laparoscopic repairs are thought to be comparable and (2) that the complication or recurrence rates may decrease with increased surgeon experience.

## Wound Complications

Seroma formation is reported in 1% to 12% of patients and may be mistaken for a recurrence (Table 16.1). Seromas are usually self-limited and can be confirmed with a groin ultrasound. Wound or scrotal hematomas are common, reported in 1% to 8% of patients and are treated conservatively with ice elevation and pain control (Table 16.1).

In addition to infections common to all surgical procedures (wound infections, urinary infections, and pneumonia), mesh prosthesis infections and osteitis may result specifically after the TEP repair and are treated conservatively usually with antibiotics or NSAIDS, respectively. The mesh prosthesis may need to be removed and open non-mesh repair performed for severe groin mesh infections.

## Urologic Complications

Postoperatively, patients often experience pneumoscrotum, which resolves spontaneously. Urinary retention is a common self-limited complication after TEP, due to urinary catheterization, preperitoneal dissection, general anesthesia, and fluid overload as well as patient factors such as an underlying prostatism. Usually this is self-limited and resolves within 24 hours, occasionally requiring intermittent patient catheterization. Bladder injury may occur, especially if the patients had prior midline scars or prior prostate operations. A missed bladder injury requires a high index of suspicion in patients with increasing abdominal pain, lower abdominal swelling, dysuria, hematuria, inability to void, or elevated serum creatinine. Injuries to the vas deferens are best avoided by not grasping the vas and not cutting it. If injury occurs, urologic consultation is obtained for possible immediate or delayed open repair.

One of the potentially devastating but rare complications of inguinal hernia repair is ischemic orchitis, caused by surgical trauma with cautery or instrumentation of the pampiniform venous plexus. It was once thought that the cause was insufficient arterial supply to the testicle, secondary to overzealous tightening of the reconstructed internal inguinal ring, which may still occur in some instances. However, there is significant collateral arterial flow to the testis from the inferior epigastric, vesical, prostatic, and scrotal arteries and even in cases where the spermatic cord is purposely ligated, one-third of the testes have shown to not become ischemic. Testicular atrophy in primary open inguinal herniorrhaphy is reported at 0.5%, while in open recurrent herniorrhaphies it increases to 5%. Although the incidence of ischemic orchitis following the TEP repair is not well documented it is thought to be lower than in open procedures, since cord handling and dissection are reduced.

Postoperative symptoms of increasing testicular pain or swelling plus or minus fever need prompt physical examination and ultrasound/duplex scanning of the postoperative acute scrotum to rule out compromised vascular flow to the testicle. These symptoms may not become apparent until 2 to 5 days after the intraoperative injury occurs. To rule out testicular torsion scrotal exploration may become necessary. While, ischemic orchitis may resolve without sequelae, it is likely to progress to testicular atrophy or rarely to testicular necrosis requiring orchidectomy. Although testicular complications are uncommon following the TEP repair, the authors advocate disclosure of these potential complications to patients.

## Nerve Injury and Chronic Pain

Symptoms of burning, pain, or numbness postoperatively may be indicative of nerve injury to the five major nerves (ilioinguinal, iliohypogastric, genitofemoral, lateral femoral cutaneous, and the femoral nerves) or their branches that can be encountered in the groin during hernia repair. Immediate postoperative neuralgia secondary to genital or femoral branches of the genitofemoral nerve being injured can be treated by immediate re-exploration and removal of the offending tack or piece of mesh. Symptoms of nerve injury usually appear immediately postoperatively, intensify over the first 2 weeks, and most resolve within 8 weeks. Chronic pain, defined as pain that persists after 3 months, may require prolonged injections with local anesthetic and corticosteroids and rehabilitation and in most severe cases exploration and removal of tacks or a neurectomy. Nerve entrapment can occur with any of the laparoscopic approaches, but may be lowest with the TEP repair. Tetik et al. reported nerve injury in less than 2% of 1,514 repairs, with only 2 patients requiring re-exploration and staple removal. In agreement with this and other reports, a recent evaluation of chronic pain after TEP and Lichtenstein repairs by a multicenter randomized prospective trial, concluded that, after five years, the TEP inguinal hernia repair resulted in less chronic pain than the open Lichtenstein technique repair.

Knowledge of the groin anatomy is essential in avoiding nerve injury; however, one must keep in mind that the nerve distribution varies and may not be symmetrical. Table 16.3 outlines the course and sensory distribution of the three nerves at risk of being damaged during a TEP inguinal hernia repair: The lateral femoral cutaneous nerve, femoral branch of the genitofemoral nerve, and the femoral nerve. These nerves lie superficial to the internal oblique muscle and cannot be visualized. Entrapment of the

**TABLE 16.3 Inguinal Region Nerves at Risk of Injury During the TEP Procedure**

| Nerve | Origin | Branches | Course | Sensory Function | Motor Function |
|---|---|---|---|---|---|
| Genitofemoral | L1 and L2 nerve roots | Femoral branch Genital branch | Genitofemoral nerve emerges from the anteromedial border of the psoas muscle and divides into a genital and a femoral branch: The femoral branch passes onto the external iliac artery and beneath the inguinal ligament, lateral to the femoral artery, extending through the fascia lata to supply the skin of the anterior surface of the upper thigh. The genital branch travels along the psoas and pierces the transversalis fascia or passes through the internal inguinal ring where it travels with the spermatic cord to the scrotum; in the female, it accompanies the round ligament of the uterus | The femoral branch supplies innervation to the anterior–lateral thigh | Cremasteric muscle |
| | | | | The genital branch in females supplies sensation to the mons pubis and labium majora<br>In males, it supplies sensation to the scrotum | |
| Lateral femoral | L2 and L3 nerve cutaneous roots | Anterior and posterior branches in the thigh | It emerges from the lateral border of the psoas major muscle and journeys toward the ASIS and passes under the inguinal ligament over the sartorius muscle where it branches into anterior and posterior | Supplies sensation to anterior–lateral thigh. | — |
| | | | | Injury can result in a burning sensation along the lateral aspect of the thigh | |
| Femoral | L2 to L4 nerve roots | Anterior and posterior branches in the thigh | Emerges at the inferiolateral border of the psoas major muscle and passes behind the iliac fascia and beneath the inguinal ligament into the thigh | Supplies sensation to the entire anterior and posterior legs | Supplies motor function to pectineus and sartorius muscles anteriorly and quadriceps femoris posteriorly injury may result in muscle atrophy |

lateral femoral cutaneous nerve is the most common nerve injury in TEP resulting in pain and numbness in the upper lateral thigh, and is called meralgia paresthetica. Broin et al., carefully detailed its course in cadavers, and found that it was a mean distance of 6.6 cm from the inferior epigastric vessels and 5.6 cm from the internal inguinal ring, as it passes below the iliopubic tract. They recommend avoiding entrapment of this nerve by staying above the iliopubic tract and not staying too far lateral to the internal inguinal ring when staples are placed.

Limited dissection and lack of handling of the ilioinguinal and iliohypogastric nerves has been speculated as one of the benefits of the TEP repair over the open repair. Although nerve injury can occur during the TEP repair, the evidence is strong that the TEP repair results in a decreased persistent postoperative pain and shorter convalescence than the open approaches.

## Recurrence

Hernia recurrence is one of the most important outcome measures of the inguinal hernia repair. As discussed above, technical factors that contribute to recurrence are: surgeon inexperience, inadequate dissection of the myopectineal orifice, insufficient mesh size to overlap the hernia defects, mesh folding that allows for peritoneal slippage, missed hernias or lipomas, and mesh dislodgment secondary to hematoma formation. Further, recurrence is related to surgeon's experience, with failures occurring much more frequently early in the surgeon's learning curve.

The results of several prospective randomized trials (level I evidence) comparing recurrence rates between TEP and open mesh repair are summarized in Table 16.1. The data presented supports TEP as comparable to open (Lichtenstein) repair, with several studies showing recurrence rates of less than 6% even with long follow-up periods. The one large multicenter study that presents contrasting results to most others is the VA cooperative study from 2004. The VA study concluded that the rate of complications was higher in the laparoscopic group 39% compared with the open group 33%. In addition, the recurrence rates at 2-year follow-up in the VA trial were 10.1% and 4.9% after laparoscopic and open mesh repairs, respectively. These results must be interpreted with caution for several reasons. Firstly, the study does not differentiate TAPP from TEP repairs, secondly, the recurrence and complication rates were four-fold higher in both groups than reported in any other trial, and thirdly the study quotes very high, 9.8% conversion rates to open procedures.

A recent multicenter randomized trial by Eklund et al. compared a TEP and an open Lichtenstein repair specifically comparing recurrence rates. They have demonstrated that at a 5-year follow-up the cumulative recurrence rate was 3.5% in the TEP group and 1.2% in the Lichtenstein group. Interestingly, the recurrence rate in the TEP group was further reduced to 2.4% by the exclusion of a surgeon, who was responsible for 33% of all recurrences in the TEP group. In addition, after testing the study results for heterogeneity 57% of recurrences were attributed to 3 out of 22 surgeons participating in the study.

The importance of the correct surgical technique in preventing recurrences in the TEP repair cannot be underemphasized.

# CONCLUSIONS

Defining the optimal type of approach to inguinal hernia repair remains difficult. This is largely because this is a common operation of little morbidity and disability and the choice of approach depends on the individual priorities of both the surgeon and his or her patients. Over the last fifteen years, the TEP repair has evolved resulting in improved understanding of the procedure and its complications. In the author's hands TEP is better for most patients and an open repair is reserved for large scrotal and incarcerated inguinal hernias and/or patients who cannot tolerate a general anesthetic. There is currently a consensus that the laparoscopic TEP and TAPP approaches are indicated in bilateral and recurrent hernias and in individuals requiring a more rapid convalescence. Although the technique of the TEP repair remains challenging to master, the recurrence and complication rate in the literature is equivalent to other techniques and this approach offers advantages to a well-selected group of patients. In authors' experience, patients recover quickly after TEP, experience little pain, and return to full activities sooner than after open repairs.

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# 17 Totally Extraperitoneal Inguinal Hernia Repair Using Fibrin Glue

**Benjamin S. Powell and Guy R. Voeller**

## INDICATIONS/CONTRAINDICATIONS

Inguinal hernia repair is one of the most common surgical procedures performed not only in the United States, but also around the world. It is estimated that between 15% and 30% of inguinal hernias are now fixed laparoscopically depending on geographic location. With the advent of new technology there are a variety of ways a surgeon can fix a reducible inguinal hernia. Most methods have literature supporting a very low recurrence rate when using a mesh in either an open or laparoscopic approach. We advocate fixing all symptomatic inguinal hernias if the patient can tolerate surgery. When we are referred a patient with an asymptomatic inguinal hernia we advise them of watchful waiting but often if the hernia is protruding the patient will elect to have surgery even if it is not causing symptoms. Most of the choices for which approach to perform are up to the judgment of the surgeon. We perform both laparoscopic and open repairs for inguinal hernia (about 200 per year) but believe that the laparoscopic approach requires a different skill set and expertise for excellent long-term results and should not be done by the surgeon that repairs 20 to 30 inguinal hernias per year unless most of these are done laparoscopically.

The only absolute contraindication for TEP inguinal hernia repair is the inability to tolerate general anesthesia. For these patients we recommend open repair under local anesthesia with a mesh. We also believe that in patients who have had previous preperitoneal surgery such as prostate removal, the TEP approach is too difficult and even though studies show that it is possible and has higher risks than an open operation in virgin tissues. In addition, if the hernia cannot be completely reduced such as large scrotal hernias we will opt for the easier to do open approach. We will perform the TEP repair in large, older teenagers if the hernia is significant in size and requires mesh.

Lastly, in men in whom there is concern about elevated PSA levels and prostate cancer, they should be told that the TEP may make preperitoneal prostate removal more difficult in some cases depending on the mesh used and the experience of the urologist. Even though studies show that in expert hands preperitoneal prostate removal is readily done after a previous TEP repair, this should be discussed at length with this patient population.

This chapter will discuss the technique of totally extraperitoneal (TEP) inguinal hernia repair with polyester mesh and fibrin glue. Some authors contend that TEP inguinal hernia repair is best used only for bilateral and recurrent inguinal hernias, but we believe that it is an excellent repair for unilateral hernias when the surgeon is an expert at the operation. In recurrent hernia there often is scarring in the preperitoneal space from the previous open repair that can make the TEP somewhat more difficult and the occasional TEP surgeon may struggle. In addition, until one is over the learning curve, doing bilateral repairs will take far too long and the surgeon will become frustrated and cease learning how to do the operation. For one to become a very good TEP surgeon, it is critical to do many unilateral repairs. The senior author has performed approximately 3,000 TEP repairs and new challenges are still frequently encountered to this day.

## INDICATIONS FOR TEP WITH FIBRIN GLUE

- Unilateral, bilateral, and recurrent inguinal hernias

Contraindications:

- Inability to tolerate general anesthesia
- Previous preperitoneal surgery
- Large scrotal hernias that cannot be reduced
- Elevated PSA (relative)
- Small, young children

## PREOPERATIVE PLANNING

Preoperative planning for TEP inguinal hernia repair typically revolves around the choice of whether the patient is a candidate for the repair. The decision should be dictated by the surgeon's expertise and the indications and contraindications discussed in the previous section. Most all studies show that the laparoscopic approach has less intense immediate pain leading to quicker return to regular activity. In addition, recent studies show that in expert hands the TEP repair has less chronic long-term pain risk. However, the surgeon should do the repair that they do most often and if this is not TEP then it should not be offered. We stop any and all anticoagulation and if a heparin bridge is required until the day of surgery we make sure that it is not given the night before the surgery. Aspirin is stopped, but the operation can usually safely be done if the patient requires this drug.

We do not believe that each patient should have both groins addressed unless there is a good reason. If the patient is complaining of problems in a groin where no bulge can be palpated and is undergoing repair of the contralateral groin, we will evaluate the "non-impulse" side at the time of surgery. If the patient is undergoing a unilateral repair that turns out to be a direct defect at the time of surgery, we always look at the contralateral direct space. Direct hernia disease is a collagen problem and we almost always will repair the contralateral side unless it is absolutely perfect in appearance. We have found that if you do not do so in these patients, they will soon return for repair of this side. It is thus critical that a good inguinal exam of both groins be done preoperatively and documented well. We will obtain herniograms in patients if there is some question about a true hernia being present.

## SURGERY

### Pertinent Anatomy

A thorough knowledge of preperitoneal anatomy is required to perform an excellent TEP. Adequate dissection in this space allows for complete visualization of the myopectineal orifice and any defects therein (Fig. 17.1). Initial dissection of a TEP

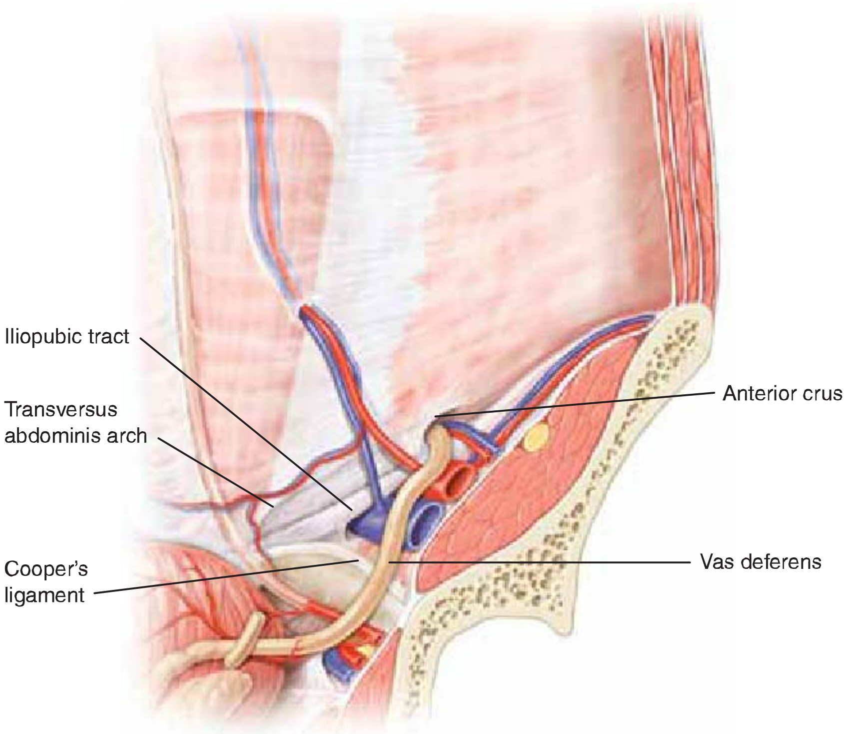


Figure 17.1 The right myo-pectineal space.



hernia begins in the posterior rectus space. Below the arcuate line, the posterior rectus sheath is attenuated and the preperitoneal space is then entered. This space is continuous with the space of Retzius of the pelvis. In the lower portion of the abdomen, dissection is fairly easy in regards to dissecting the cord structures free from the preperitoneal fascia surrounding them as well as the peritoneum. The phrases such as "triangle of pain" and "triangle of doom" we believe should be done away with since while the overall make-up of the myopectineal region is constant, there is quite a bit of variability of the location of the iliac artery in relation to the peritoneum and cord structures and the various nerves also have significant variability in location (Fig. 17.2). We believe that a thorough understanding of the entire myopectineal area and its variabilities is critical to avoiding serious disasters. In some 3,000 TEP repairs we have not had an injury to bladder, colon or iliac artery or vein showing that this operation can be done safely if the surgeon learns the anatomy. Understanding the anatomy depicted in Fig. 17.1 is the key to a successful TEP repair. Landmarks such as the pubic bone, Cooper's Ligament, inferior epigastric vessels, and cord structures are the key in assisting the surgeon to stay oriented in this small and anatomically "busy" space.

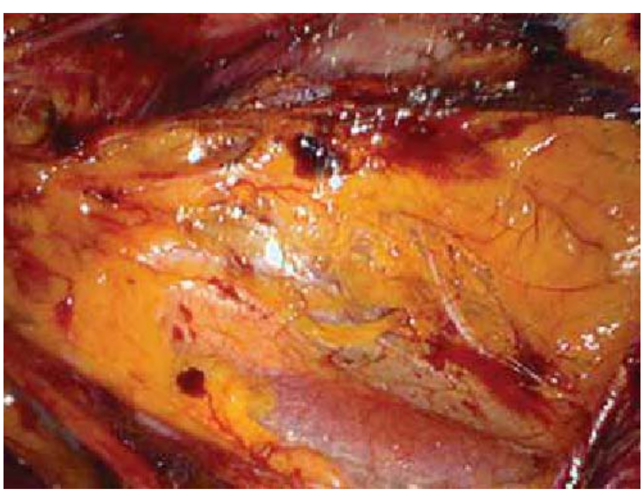

Figure 17.2 Nerves on the right psoas muscle.

# Positioning

Proper patient positioning is key for laparoscopic inguinal hernia repairs as with other laparoscopic techniques. The patient is placed supine on the operating room table with arms tucked at the side. We typically have a laparoscopic monitor placed at the foot of the table. We remove a stripe of hair, the width of the hair trimmer, in the midline from above the umbilicus to just below the pubic bone. We always place a Foley catheter since a fully decompressed bladder is key in direct hernias in allowing the mesh to be safely placed far down over the pubic bone as it must be in these defects. We only use 5cc of fluid in the Foley balloon since 10cc is very prominent during the repair. Some surgeons will have the patient empty their bladder prior to the operation, but we have found that the intravenous fluid given by anesthesia quickly fills the bladder and can limit the ability to place the mesh down over the pubic bone as far as possible. An alcohol-based prep is used and an Ioban™ is placed to prevent mesh contact with skin flora. The risk of mesh infection in TEP is almost non-existent. We have never had a mesh infection in our some 3,000 TEP repairs using the Ioban™ and thus prophylactic antibiotics are not indicated.

# Operative Technique

After proper patient positioning, an infraumbilical incision is made in the midline. Dissection is carried down to the fascia with s-shaped retractors. Depending on which side the inguinal hernia is on will dictate where you incise the rectus sheath. We make a longitudinal incision in the rectus sheath just off midline on the side of the hernia. The incision is widened with a hemostat to allow placement of an s-shaped retractor. The rectus muscle is then retracted laterally to expose the posterior rectus sheath (Fig. 17.3). While some do manual dissection to gain access to the preperitoneal space (this is what initially did), we changed to using the balloon dissector when it became available since it is quicker than manual dissection, usually bloodless and overall "neater." We prefer the original round unilateral balloon since it will not tear the epigastric vessels or damage tissue layers as can the bilateral balloon. The balloon dissector is then passed along the posterior sheath until it contacts the pubic bone. Once the pubis is felt with the balloon dissector, the balloon is insufflated under direct vision while viewing it through the zero-degree laparoscope. It is key while placing the dissector that the surgeon never force the issue and never rub the pubic bone vigorously. This is especially true if a Foley has not been placed since there have been reports of bladder injury from the trocar of the dissecting balloon. Often if the patient has a direct hernia, the balloon dissector will completely or partially reduce the preperitoneal fat or bladder in the defect. The balloon dissector is removed and a balloon-tipped Hasson

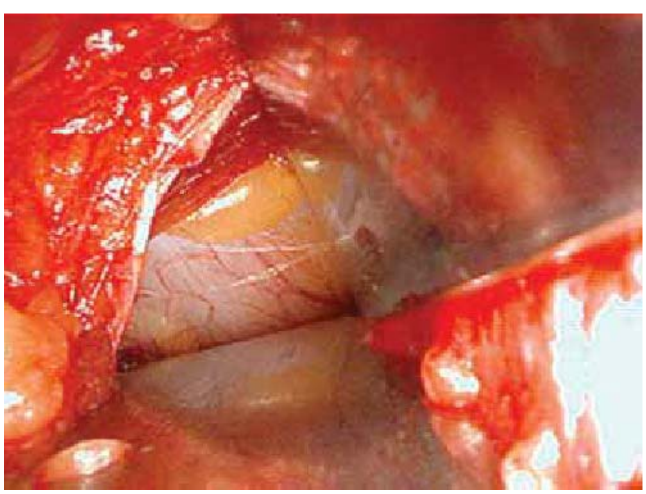

**Figure 17.3** View of posterior rectus sheath.

trocar is placed into the retrorectus space. Carbon dioxide is then used to insufflate the preperitoneal space. It is important to keep the pressure at 12 mm Hg or less since anything higher can force $CO_2$ into the fat and decrease the working space for the repair. At this point a 45-degree 10 mm laparoscope is used and two more 5 mm trocars are placed. One trocar is placed suprapubically and the second is placed halfway between the umbilicus and the pubis. The 45-degree laparoscope allows the surgeon to see up on the abdominal wall as is necessary to properly do the repair. The patient is then placed in Trendelenburg position to aid in dissection.

Initial dissection takes place to clear off tissue around the pubic bone to clearly identify Cooper's ligament. In direct hernias this means reducing the fat from the defect and pushing the transversalis sac back down into the defect. If the patient has a low insertion of the arcuate line, then it must be released by cutting it at its insertion onto the abdominal wall and sweeping it cephalad to the level of the umbilicus. Attention is then turned to making an adequate lateral and cephalad space to aid in later mesh placement. The basis for the TEP is the original open operation as described by Rives in the 1970s. The peritoneum must be dissected off the cord, anterior abdominal wall, and the retroperitoneum to the level of the umbilicus. The peritoneum is gently dissected off the psoas so that the mesh will sit on the muscle. During this dissection often the nerves are seen. There is a fat layer present in the lateral space that should be left on the abdominal wall and not the peritoneum. If this fat is disturbed, it can lead to annoying hemorrhage. Once the lateral space has been dissected, attention is then turned to parietalization of the cord structures. Typically, we pull the peritoneum medially and sweep the cord structures off the peritoneum laterally (Fig. 17.4). This allows the surgeon to readily see the proper plane to separate the indirect sac or peritoneum from the cord, i.e., between the small blood vessels of the vas and the peritoneum. Any hole in the peritoneum can be dealt with by decreasing the insufflation pressure to 10 mm Hg and if necessary, a Verress needle can be placed into the peritoneal cavity above the umbilicus for decompression. Holes in the peritoneum do not need to be closed as long as the $CO_2$ is evacuated completely from the peritoneal cavity. Once this is done the edges of the defect come together and heal quickly. Figure 17.5 shows what a pantaloon hernia looks like from a laparoscopic viewpoint. We typically use a polyester mesh as described by Rives–Stoppa for the repair since Rives pointed out that polyester is soft and pliable and can conform well to all the crevices and valleys of the preperitoneal space. He believed that polypropylene was too stiff to conform well and was critical of its use when Wantz brought the repair to America after learning it from Rives and Stoppa. Our mesh is anatomically shaped (there are right and left meshes) and specifically designed for laparoscopic placement in the preperitoneal space. Figure 17.6 shows mesh insertion through the infraumbilical trocar. The mesh is positioned so that there is wide coverage of both the direct and indirect spaces. Direct hernias must have the mesh extending at least 2 cm beyond the defect in all directions. We do not keyhole our mesh since this is

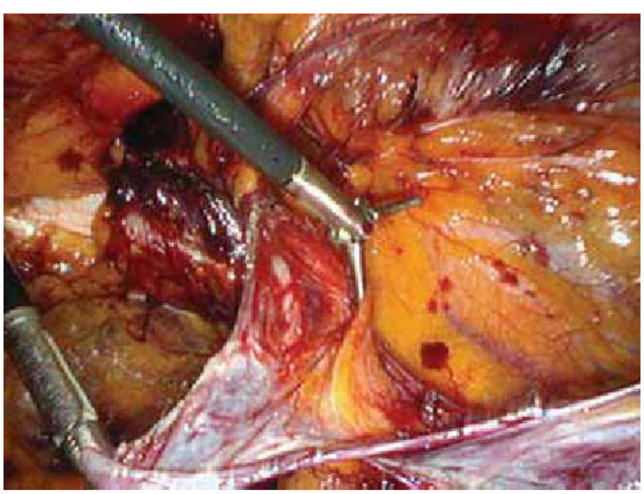

**Figure 17.4** Dissection of peritoneum off cord structures from medial to lateral.

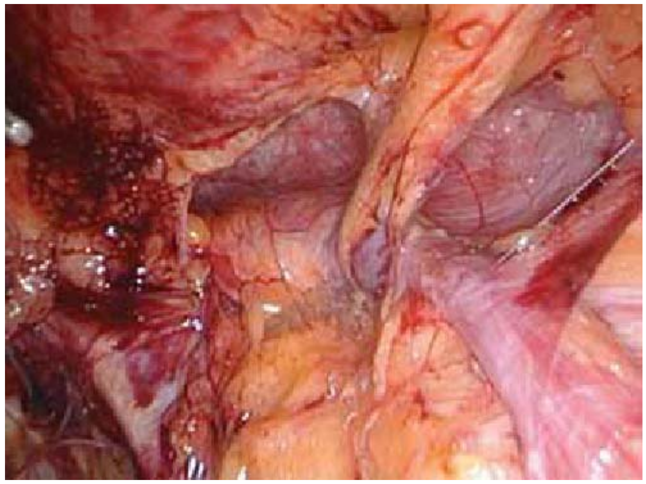

Figure 17.5 Laparoscopic view of pantaloon hernia.

not how the operation was described by Rives. A keyhole in the mesh creates a weakness for a recurrence and also the keyhole may constrict the cord as scarring occurs. The mesh is positioned over the psoas and the peritoneum should be visible cephalad to the edge of the mesh to prevent recurrences up under the mesh. A laparoscopic applicator of fibrin glue is then used to "spot-weld" the mesh to the tissues to keep it in place for the first 24 to 48 hours during which time mesh displacement can occur (see "Results"). The polyester mesh is the ideal mesh for use with fibrin glue. The mesh has the correct porosity and make-up so that the fibrin glue is able to penetrate these pores and allows for good adhesion to surrounding tissues (Fig. 17.7). The use of the fibrin glue is an off-label use of the product, but it has been used for years in Europe for hernia repair and we have used it since 2003 for our TEP repairs. Our nurses are so adept at preparation that there are no delays or problems with the glue preparation. We only use Tisseel® brand of fibrin glue since it is the only one that is a true adhesive due to the correct concentration of the aprotinin component (Fig. 17.8). We have tried other glues and they do not work as well at all and in addition only certain meshes glue well. We apply the glue to the edge of the mesh circumferentially and in direct hernias down over the pubic bone. The fibrin glue dries within seconds and is gone by about 2 weeks postoperatively. The advantage of the glue is that we can fix the mesh over the psoas, the cord, and other areas where mechanical fixation is not safe. Once the fibrin glue has dried, the pneumo-preperitoneum is slowly evacuated and we watch the peritoneum and abdominal contents fall onto the mesh. The fascial defect is closed with a 0 vicryl suture. The skin is then closed with sutures, and sterile dressing is applied (Fig. 17.9).

Figure 17.6 Placement of mesh through infraumbilical trocar.

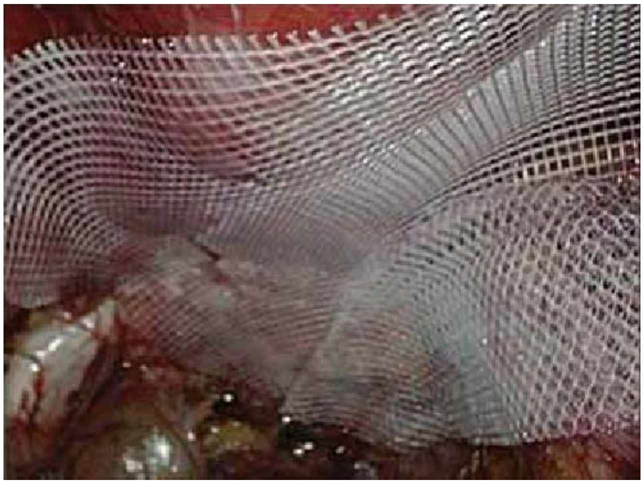

Figure 17.7 Final view of mesh with fibrin glue over defect.


Figure 17.8 Tisseel™ fibrin glue with assorted applicators including laparoscopic applicators. Tip appliers 1–4 are for open application. Numbers 5 and 6 are used in laparoscopic glue application.

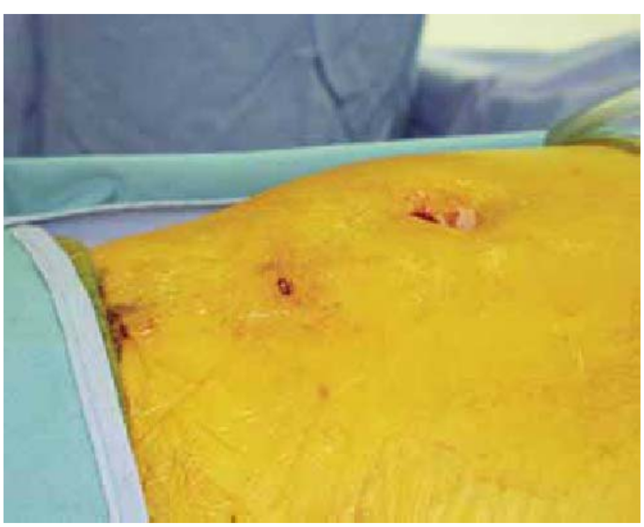

Figure 17.9 Incisions after trocar removal.

## POSTOPERATIVE MANAGEMENT

Postoperative management after TEP repair is fairly straightforward. Most patients are same day surgery patients and go home after surgery with oral pain medication as needed. Usually NSAID type medication is all that is required. Most patients report in clinic that they discontinued use of the oral pain medicine within a few days of surgery. We do not place any restrictions on patient's activity and they are allowed to do what they want and when they want. Typically, we have one; maybe two postoperative visits; then yearly follow-up.

## COMPLICATIONS

Complications from TEP repair with fibrin glue should be relatively rare. Very morbid complications such as major vascular, visceral, or cord injuries should be extremely rare and we have yet to experience these complications. Mesh infections should occur rarely, if at all with TEP repair. In our experience, recurrent hernias are rare and we have seen only one in over 900 patients where glue was used for fixation. Randomized trials show less acute and chronic pain with the use of fibrin glue and we have seen the same thing. We used very limited mechanical fixation (tacks per hernia) prior to the use of glue and never had a patient where we had to remove a tack due to pain. Even so, with the change to glue we have noticed that patients simply do better during recovery when glue is used. While anaphylaxis has been seen with the systemic use of aprotinin, this is a very rare occurrence with topical use and we have had no instances in approximately 900 TEP repairs using Tisseel™.

## RESULTS

The topic of mesh fixation for TEP repair is commonly discussed in the hernia literature. It is a common misconception that Rives and Stoppa did not believe in mesh fixation when they developed the open unilateral preperitoneal repair that is the basis for the TEP laparoscopic repair. This is not true (no fixation was only used by Stoppa when he repaired bilateral recurrent hernias with a giant piece of mesh). Figure 17.10 is an illustration from Rives' original article and it can be seen that there are multiple suture fixation points, many along the retroperitoneum to keep the mesh fixed posteriorly. This is the fixation that we mimic with the use of the fibrin glue and this cannot be done with mechanical fixation. We feel that mesh fixation with fibrin glue is a very good alternative to either tacks or no fixation. Several groups have done basic science research looking at the fixation question. Kathkhouda was the first to look at laparoscopic extraperitoneal inguinal hernia repair with regard to fixation. In their original study, they evaluated 49 laparoscopic hernia repairs in female pigs, 18 fixed with fibrin sealant, 16 with staples, and 15 with no fixation. They found that there was no difference in graft motion between staples or fibrin sealant, but the non-fixation group had significantly more graft motion. The tensile strength in the fixation groups was much higher than the non-fixation group. Kes et al. did a study in 2003 looking at the incidence of mesh collapse and protrusion in an animal model. The importance of this animal study showed that the protrusion of the mesh was directly proportional to size of the defect; with the larger the defect the more protrusion was seen. One of the most recent studies from Schwab in 2008 looked at mesh fixation in a lab model of TEP hernia repair. The group looked at six different meshes using suture fixation, fixation with fibrin sealant, and no fixation. The no fixation group showed more mesh migration, which was prevented with the glue and suture groups. The most important finding in the study was a statistically significant improvement in fixation stability of the fibrin glue group.

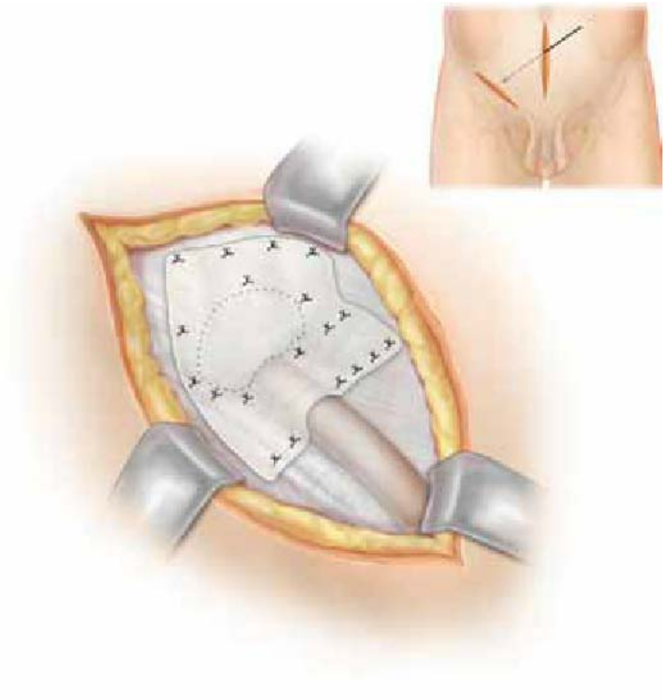

Figure 17.10 Rives' original diagram showing suture fixation of the mesh.



There have been several clinical studies in the last 5 years looking at TEP hernia repair with fibrin glue. Novik first started his work with fibrin glue in laparoscopic inguinal hernia repair in 2000, with long-term results published in 2006. He found in nine hernia repairs that at 40 months there were no recurrences or problems. Topart then performed a study of 66 patients who had TEP hernia repairs using fibrin glue. These patients were compared with an earlier cohort of patients where tacks were used for fixation. The only difference in the two groups was significantly less postoperative chronic pain in the fibrin glue group. The next study was in July 2007 by Olmi with a randomization of 600 patients to glue, tacks, anchors, and staples. In this study, there was reduced pain and complications and quicker return to activity in the fibrin glue group. Ceccareli et al. looked at fibrin glue in TAPP inguinal hernias versus repairs with mechanical fixation. In their study, they felt there was less postoperative pain and complications in the glue cohort. There are several studies looking at no fixation versus fixation in the TEP hernia repair. While we believe no fixation may be all right for smaller indirect and direct hernias, we are not comfortable in doing this with larger hernias. The best study looking at no fixation is Taylor's work, but he says in the discussion that no fixation should only be done in hernias less than 2 cm in diameter and he admits the follow-up was short.

The cost of the glue is similar to the tacking devices. The most expensive hernia is the recurrent hernia. We believe proper fixation with glue mimics the Rives description of preperitoneal hernia repair that the TEP is based upon. Its use is also supported by basic science and clinical studies which show that its use decreases morbidity, mesh displacement, and thus recurrence.

## CONCLUSIONS

- TEP inguninal hernia repair with fibrin glue is an excellent option for inguinal hernia repair. The fibrin glue allows the surgeon to mimic the open preperitoneal repair as described by Rives which is the basis for the TEP repair.

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# 18 Single Incision Laparoscopic Surgery: Total Extraperitoneal Inguinal Hernia Repair

**Brian P. Jacob**

## Introduction

Since the introduction of minimally invasive surgery as an alternative to traditional open surgery, numerous randomized studies have proven several advantages including better visualization, reduced postoperative pain, reduced wound and pulmonary complications, less immune suppression, speedier recovery time, and improved cosmesis. Subsequently, both physicians and industry have continued to investigate novel ways to advance minimally invasive surgery to augment patient satisfaction and outcomes. Several techniques have recently been introduced, including a resurgence of 2 mm and 3 mm instruments, natural orifice transluminal endoscopic surgery (NOTES), magnetic and robotic surgery, and single incision laparoscopic surgery (SILS), also known as laparoendoscopic single site surgery (LESS) or single port access (SPA) surgery. Of these options, SILS has seen the most rapid growth over recent years.

Despite two decades worth of laparoscopic advancements, currently only 18% of the 800,000 inguinal hernia repairs performed annually in the United States are performed laparoscopically. That being said, the slow adoption of novel techniques like NOTES and SILS into the specialty of inguinal hernia repair is not surprising. In fact, over the past 10 years, most of the advancements made for hernia repair have been focused on mesh products and fixation devices, and less so on access techniques. The reasons for this are multifactorial, but in part include overall costs and technical challenges involved in performing a laparoscopic inguinal hernia compared to that of an open repair.

SILS for inguinal hernia repair, first published in 2009 by Filipovic-Cugura's group from Croatia, has since been supported by a handful of single center experiences. Also in early 2009, we showed the ability to perform a SILS Total Extraperitoneal Inguinal Hernia Repair (TEP) using a SPA device with routine laparoscopic instruments. In 2010, SILS TEP has continued to grow in popularity and more than 16 feasibility abstracts have been presented at international hernia conferences by groups from over 11 different

**TABLE 18.1 Sample Available Single Port Access Devices**

| Company | Single Port Access (SPA) Device |
|---|---|
| Applied Medical™ | GelPoint™ Advanced Access Platform |
| Covidien™ | SILS™ Port |
| Ethicon™ | Ethicon Endo-surgery SSL™ Access System |
| Karl Storz™ | S-Portal |
| Olympus™ | TriPort™ or QuadPort™ Access System |
| Pnavel Systems™ | Uni-X™ Single Port Laparoscopic Access System |

countries. Some of these studies have yet to be published. For instance, at the 2010 Asia Pacific Hernia Society meeting, Dr. Davide Lomanto's group from Singapore presented their success following their initial experience with SILS inguinal hernia repair, while Dr. H Tran and colleagues recently presented over 100 cases from Australia at the European Hernia Society held in Istanbul, Turkey. A group from Spain, led by Dr. Salvador Morales-Conde, has also reported success with the technique at the same meeting. To date, however, there has likely been less than 500 cases performed worldwide, and within each of the presented case reports there are a number of significant variables that make it difficult to compare each of the cohorts. Therefore long-term outcomes need to continue to be assessed in institutional review board (IRB)-approved studies before the procedure can be more widely promoted.

The major technical variables that exist when performing a SILS TEP hernia repair include:

- The access mechanism
  - SPA device (Table 18.1)
  - Traditional trocars inserted within a single skin incision (Figs. 18.1 and 18.2)
- The instruments (standard, articulating, pre-shaped)
- The camera type (flexible or standard)
- Mesh and fixation device choices (surgeon specific)

When selecting a preferred technique from these variables, most surgeons adopt methods that most closely resemble their current practice with variations on the access

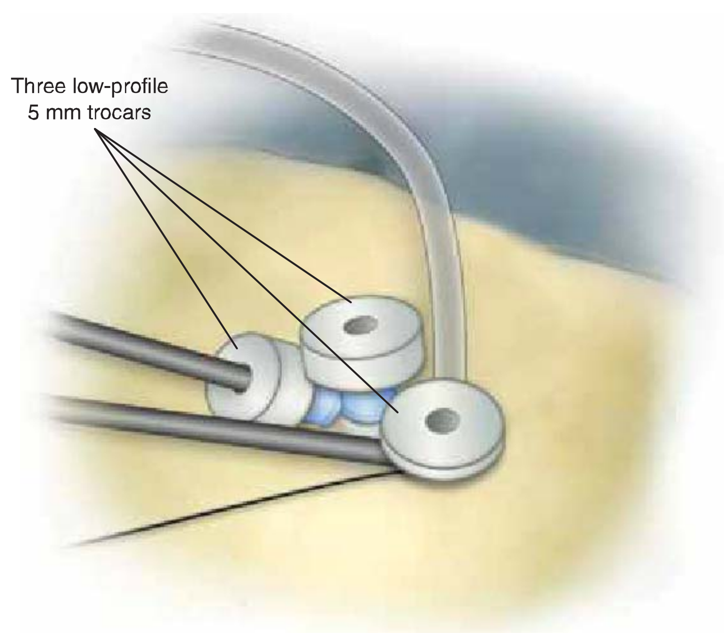


**Figure 18.1** Multiple trocars in one skin incision.

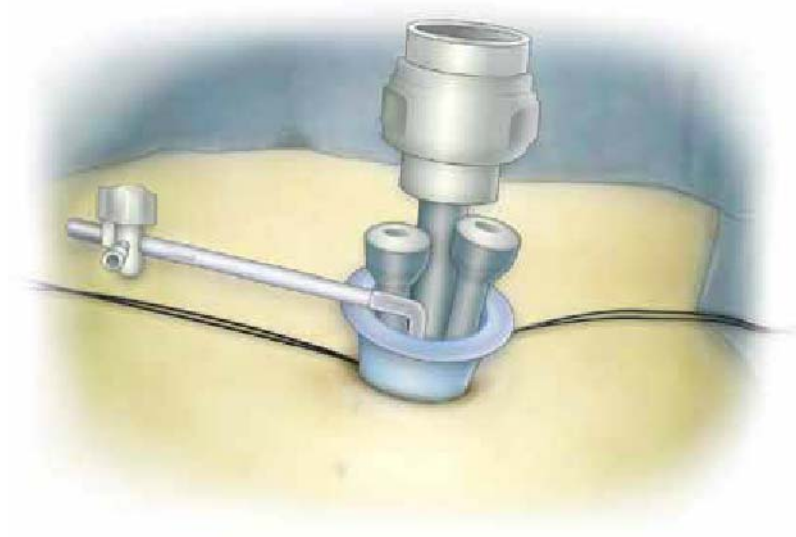

Figure 18.2 Single port access device.



mechanism. The one common dominator mandatory for anyone adopting SILS TEP into their practice is that extensive experience with traditional laparoscopic inguinal hernia surgery is required. This chapter will review the common technical steps required to perform a single incision laparoscopic TEP inguinal hernia.

## SURGERY

SILS TEP inguinal hernia repair is performed under general anesthesia, with the patient in the supine position with both arms adducted and pneumatic compression stockings for deep vein thrombosis prophylaxis placed. In all cases, a urinary (Foley) catheter is placed to decompress the bladder and a single dose of intravenous antibiotics is administered. The technical steps of entering and creating the preperitoneal working space with a balloon are the same as those described by Dr. Guy Voeller in 1995 for any routine TEP hernia repair. The single skin incision is made, and can be performed transversely within or about 1 to 2 cm below the umbilicus as well as vertically within the umbilical stalk depending on the anatomy of the umbilicus. The decision of where to put the incision is up to the surgeon and can be tailored to the desired shape of the patient's umbilicus. The subcutaneous dissection is extended to over the anterior fascia of the rectus muscle. We prefer to place two stay sutures, one on the midline and one as lateral as possible, and use the stay sutures to elevate the fascia in order to facilitate making the fascial incision. Next, the anterior fascia is divided longitudinally for approximately 2.0 to 2.5 cm, but can be made smaller if using a SPA device that permits a smaller fascia incision. Finger dissection is then used to free the plane circumferentially beneath the fascia. A plane deep to the rectus muscle is then created down to the level of the pubic bone with a dilating balloon dissector under direct laparoscopic vision.

The set-up continues by removing the balloon dissector, and inserting a single port access device (Fig. 18.2). The depicted SPA device can be substituted with any of the other devices available, although most groups report success with the devices made by Covidien™ and Olympus™. Through this SPA device, a 12 mm and two 5 mm trocars are placed. In all cases, we used a routine 45° 10 mm laparoscope and standard reusable laparoscopic instruments, just as we use in our routine laparoscopic TEP repairs.

The TEP dissection and mesh insertion process proceed in a traditional laparoscopic TEP manner, and that description is beyond the scope of this chapter. Still, the peritoneum in all cases is reduced down to a level below the iliac vessels. The motions of the surgeon's hands during the dissection may tend to be more in an upward and

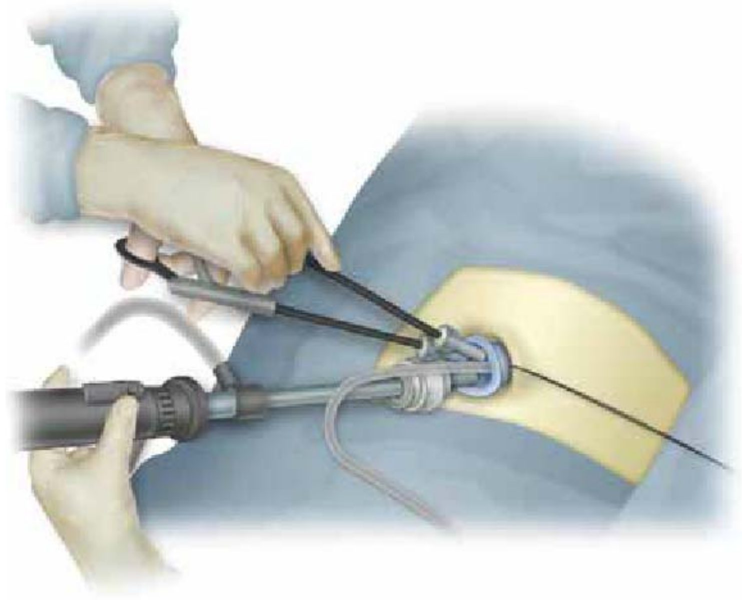

**Figure 18.3** SILS TEP: Instruments, hand movements, and triangulation.

downward motion from time to time (Fig. 18.3); however, the dissection should proceed without the feeling of restricted movements or instrument clashing and with complete ability to triangulate the instruments to perform a delicate and precise dissection. The use of a SPA device will prevent any air leak sometimes experienced with the insertion of multiple trocars.

In all cases of unilateral hernia, the contralateral side is also evaluated. If found, a contralateral hernia is also repaired. Once the repairs are completed and hemostasis is assured, the single port access device is removed, the fascia closed with a running 0-Vicryl suture, and the skin closed with 4-0 Monocryl sutures. 1% lidocaine is injected and a bandage applied. The Foley catheter is then removed at the end of the case.

## RESULTS

We performed an IRB-approved retrospective review following our initial pilot study that included 10 patients with 17 hernias that underwent a single incision laparoscopic TEP inguinal hernia repair using a single port access (SPA) device and standard laparoscopic instruments and laparoscope between February 2009 and March 2010. Two additional patients had an attempted SILS TEP, but were not included in the pilot study. These included one patient who, in October 2008 underwent our first SILS TEP, but without the aid of a SPA device. In another case, we immediately converted to a traditional 3-trocar TEP after inadvertently creating a large rent in the peritoneum while inserting the SPA device. The loss of TEP domain made visualization less than optimal and since it was very early in our experience, we simply elected to continue the operation in a standard TEP fashion.

Patient demographics (Table 18.2), incision size, hernia location, operative time, and postoperative physical examination in the recovery room, at 2 to 3 weeks, at 3 to 6 months, and at 1 year were recorded where appropriate. Operative time recorded by the operating room nursing staff was from incision start time to the application of the dressing. Our visual analog scale (VAS) for this study was a simple subjective choice of pain intensity on a 0–10 scale, 10 being the most severe. In our routine survey, chronic significant pain is defined as pain greater than 3/10 that has also bothered the patient more than rarely and beyond 3 months. The presence of urinary retention in the immediate recovery period was also recorded. Data collected at each follow-up visit

**TABLE 18.2 Patient Information**

| Age | BMI (KG/M2) | Comorbidities | OR Time (Min) | Incision Length (mm) | Findings | Unilateral (U) or Bilateral (B) | Mesh |
|---|---|---|---|---|---|---|---|
| 53 | 31.2 | 0 | 100 | 25 | Indirect | U | Polypropylene |
| 79 | 24.6 | CAD | 73 | 30 | Indirect | U | Polyester |
| 51 | 33.5 | DM, HTN | 62 | 23 | Indirect | B | Polypropylene |
| 61 | 23.5 | DM, HTN, Colon Ca | 105 | 25 | Indirect | B | Polypropylene |
| 35 | 31 | 0 | 91 | 35 | Indirect | B | Polypropylene |
| 59 | 20.4 | Cholest | 100 | 25 | Indirect and Lipomas | B | Polypropylene |
| 26 | 20 | 0 | 115 | 20 | Indirect | B | Polypropylene |
| 26 | 21.6 | 0 | 78 | 25 | Indirect | U | Polypropylene |
| 63 | 25 | 0 | 83 | 20 | Indirect Bilateral | B | Polypropylene |
| 48 | 20.4 | 0 | 85 | 25 | Direct | B | Polyester |

BMI = body mass index; OR = operating room; CAD = coronary artery disease; DM = Diabetes; HTN = hypertension; Colon Ca = colon cancer; Cholest = hypercholesterolemia.



included documenting pain using the same subjective pain scale (0–10), recurrence, seroma or hematoma occurrence, as well as overall satisfaction (0–10) with 10 being the best and 0 being "never again." Patients were asked if they considered their incision as "cosmetic." At the end of a mean 1-year follow-up period, all data were compiled and analyzed. During the study period, the operating room times of unmatched traditional bilateral TEP hernia patients by the same surgeon were also recorded and used only as a reference. Statistical analysis was not performed.

At the time the data was analyzed, mean follow-up was 12.7 months (range from 6 to 19 months) and 100% of the patients had followed up to date. Seventeen hernias were repaired in nine males and one female with a mean age of 50.1 (range 26 to 79 years). Six patients had bilateral indirect hernias while three patients had unilateral indirect hernias. One patient had bilateral direct hernias. Of the 17 hernias repaired, one was a recurrence and the rest were primary. Incision size was a mean of 25.3 mm (20 to 35 mm). The 35 mm incision was made in the patient in whom we also simultaneously repaired an incarcerated umbilical hernia. Fourteen of the repairs were done with "heavyweight" polypropylene (3D Max™, Davol, RI, USA) and tacks (Protack™, Covidien, Norwalk, CT), two hernias were repaired with lightweight polyester with polylactic acid microhooks (Progrip™, Covidien, Norwalk, CT), and one was repaired with a flat piece of polyester (Covidien, Norwalk, CT).

There were no minor or major intraoperative complications. The mean operating time was 89.6 minutes. For reference, our traditional laparoscopic TEP hernia repairs during the same time period had a recorded mean operating time of 84 minutes. Despite occasional arm-crossing and very infrequent instrument "sword fighting," we truly found no restriction of movements and maintained the ability to triangulate and precisely dissect with our instruments as needed (Fig. 18.3).

Overall, recovery was completely uneventful. In this cohort, there was no urinary retention. Patients reported using narcotic pain medicine for a mean of 1.5 days (range 0 to 4 days). In the recovery room on the day of the operation, at 2 to 3 weeks, at 3 to 6 months, and at 1-year follow-up time periods, the mean groin pain scores were 3.6, 2.5, 0.4, and 0.2/10, respectively. Overall satisfaction was 9.7/10. There have been no chronic seromas, no testicular pain, and no inguinal hernia recurrences. There are no incisional hernias. No patients reported any chronic groin or incisional pain beyond the 3 months' time point.

Ninety percent of the patients found their incisions to be cosmetic. There was one early postoperative seroma that formed under the SILS incision that was also used to simultaneously primarily repair an umbilical hernia repair. This incision had been extended to 35 mm and the seroma drained spontaneously. This incision represented the patient (10%) who did not consider the incision as cosmetic.

**Figure 18.4** Postoperative photo 6 months after SILS TEP bilateral inguinal hernia repair.

## Discussion

Despite a growing number of case series being published, our data represent the first 1-year follow-up results following a cohort of patients who underwent a single incision TEP inguinal hernia repair. Immediate and long-term postoperative pain was truly minimal and there were no patients with chronic groin pain. There were no inguinal hernia recurrences and no incisional hernias occurred. Overall patient satisfaction including cosmesis was excellent (Fig. 18.4). As more publications show the technique's feasibility and durability, SILS TEP may very well be worth advancing.

With regard to incision size, we have observed that the incision size mandated by certain SPA devices, while partially hidden within the umbilical stalk, does remain longer than an incision traditionally made for a 12 mm trocar used during a routine TEP. Smaller SPA devices could easily overcome this observation. Despite the incision size used, no incisional hernias developed in our cohort, and at 1-year follow-up the cosmetic appearance is excellent (Fig. 18.5).

**Figure 18.5** One year after SILS bilateral TEP inguinal hernia repair.

Our study has several limitations including a small and carefully selected sample size with a low mean BMI of 25.1 kg/m$^2$. The results of the study do not suggest that single incision laparoscopic hernia repair should now be performed on every hernia patient. Rather, the results should simply encourage surgeons to continue studying and advancing SILS TEP inguinal hernia repair so that the technique is as safe and durable as the current laparoscopic TEP being performed today.

## Trocar Options for Single Incision TEP Inguinal Hernia Repair

When performing a SILS TEP, we have found that the use of a SPA device readily permits triangulation of the routine laparoscopic instruments with very little restriction of movement, enabling us to perform safe and precise dissection maneuvers with standard instruments. Many SPA devices are available but each has its own unique properties (Table 18.1). Randomized comparative studies have not been done to permit the recommendation of one over another, and only anecdotal opinion exists to make a recommendation. Likely each of the devices has unique qualities that are useful for varying different procedures. That being said, for the SILS TEP, we initially found that the use of the Covidien™ SILS™ Port device readily permits unrestricted movements with no air leak. A variety of mesh products were able to be deployed without difficulty, and fixing the mesh was not inhibited. Its current disadvantage is that it mandates a 2.0 to 2.5 cm incision. On the other hand, the use of the Olympus™ TriPort™ which comes with an introducer, permits a smaller skin incision and can be deployed with only a 1.6 to 1.8 cm skin and fascia incision and also affords great maneuverability with no air leak. In addition, it comes with a built-in wound protector, which would negate the need for a laparoscopic bag, should a specimen need to be retrieved. To date, we have not yet used the devices by Storz™, Applied Medical™, or Ethicon™ to perform a SILS TEP.

The insertion of any of the SPA devices correctly involves a quick learning curve, and errors can be made at this step that could make a SILS TEP difficult (Fig. 18.6). We recommend for those early in the learning curve to make the fascial incision a little larger in order to minimize the risk of violating the posterior fascia/peritoneum during insertion. Smaller SPA devices will make insertion easier and less risky through smaller skin and fascial incisions.

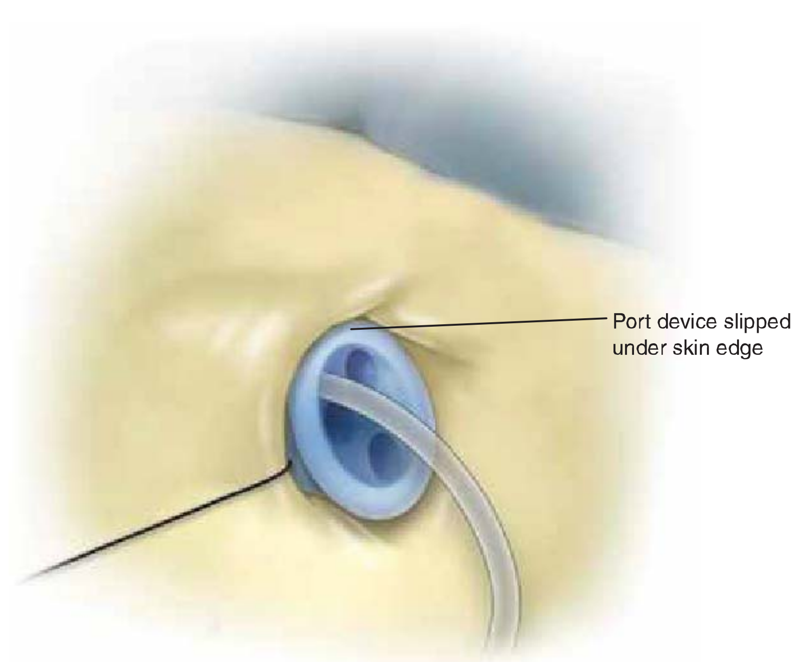


**Figure 18.6** SILS™ Port that has slipped under the skin edge.

### Instrument Options for Single Incision TEP Inguinal Hernia Repair

In addition to standard laparoscopic instruments, a number of other instruments have become available to successfully perform a SILS TEP. Articulating instruments for SILS TEP, such as those made by Covidien™ or CambridgeEndo™ have been supported. In addition, rigid, pre-shaped instruments such as the Hi Q LS curved 5 mm hand instruments by Olympus™ or the Dapri instruments by Karl Storz™ are being trialed.

Unlike Dr. O Surgit and his colleagues who successfully performed the SILS TEP with articulating instruments, we prefer routine laparoscopic instruments, especially when reducing an adherent indirect hernia sac. When using an articulating instrument to reduce an adherent hernia sac, there can be too much "give" at the bend in the instrument and thus not enough torque generated to efficiently reduce the peritoneum off the cord structures. In addition, when adopting a new technique, it is helpful to avoid deviating from routine maneuvers as much as possible. Thus for surgeons already familiar with the TEP procedure, the SILS TEP using standard laparoscopic instruments is an ideal technique to learn, as the expense and learning curve of an articulating instrument can be avoided.

## CONCLUSIONS

Patient selection for SILS TEP hernia repair should remain up to the patient's and surgeon's discretion as, to date, there is no proven clinical *benefit* to the technique other than that it eliminates two small 5 mm incisions from the abdomen. There are some studies attempting to show a pain advantage or a cosmetic advantage for single incision techniques. Although our experience with SILS TEP suggests very low pain scores followed by rapid recovery with no long-term morbidity, we personally have not yet observed any obvious reduction in pain complaints compared to surgery with a standard TEP approach. Of course, we are aware that pain is very subjective. Regarding cosmesis, although our cohort of patients studied was very satisfied and SILS TEP permits a cosmetic incision, at this time it remains debatable if a SILS TEP affords any true cosmetic *advantage* compared to existing techniques for repairing an inguinal hernia. What is true is that a SILS TEP affords the ability to repair bilateral inguinal hernias through one small skin incision that can be made within the umbilicus.

For sure, it seems that the patient demand for SILS TEP and other novel techniques has the potential to rise. It behooves the surgical community to embrace and to improve novel techniques in order to make each procedure just as safe as the current standards. As Dr. P Bucher et al. has shown in a recent retrospective survey study, a potential patient may likely choose single incision surgery over its traditional laparoscopic surgery counterpart, provided that both techniques had a similar risk-to-benefit profile. The burden is on the surgeon to improve these novel techniques and to work with industry to optimize the hardware needed to make these operations as safe as laparoscopy is today.

In our pilot study with mean follow-up greater than 1 year, we have shown that the single incision laparoscopic TEP inguinal hernia repair with the aid of a SPA device, routine laparoscopic camera, and routine laparoscopic instruments is feasible without significant morbidity. Other groups have also shown SILS TEP to be feasible with other types of access devices, other types of cameras, and with articulating surgical instruments. For SILS TEP, smaller diameter SPA devices would be preferential and randomized prospective studies are still warranted to be able to make statements regarding advantages or disadvantages. Through a small infraumbilical skin incision, SILS TEP can provide a durable unilateral or bilateral inguinal hernia repair when performed by experienced laparoscopic hernia surgeons.

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# 19 Onlay Mesh Repair

**Morris E. Franklin, Jr. and Karla Russek**

## INDICATIONS/CONTRAINDICATIONS

Incisional hernias develop in 2% to 20% of laparotomy incisions, necessitating approximately 90,000 ventral hernia repairs per year in the United States. About a third of these patients experience serious discomfort, aesthetic complaints, intestinal obstruction, or acute strangulation warranting hernia repair. In general, primary hernia repair has been abandoned owing to unacceptably high recurrence rates, and mesh placement is now considered the standard technique. Mesh placement in the posterior position (onlay technique), rather than anterior placement or within the abdominal musculature, is associated with the lowest recurrence and infection rates.

The onlay mesh technique can be used for basically any type of intraabdominal hernias (incisional, spigelian, inguinal, etc.). The laparoscopic approach to hernia repair seeks to apply the sound principles associated with the Rives–Stoppa, but with modifications in the technique for mesh placement. Once implanted, inflammatory tissue grows from the underlying peritoneum between the mesh interstices, creating a solid tissue-prosthesis aponeurosis that is the basis for the IPOM repair.

Using the laparoscopic approach, a large prosthetic mesh can still be placed on the anterior abdominal wall (internal rather than external to the posterior fascia or peritoneum), overlapping the defect by several centimeters in all directions. However, with this technique, there is no need for the extensive soft tissue dissection seen in the open approach and its attendant complications. Furthermore, the patient can expect to receive all the other benefits of a minimally invasive procedure, such as decreased hospital stay, lower round complication rates, and decreased pain.

## PREOPERATIVE PLANNING

There is an ongoing controversy regarding patients' selection criteria for laparoscopic onlay mesh technique with respect to number of prior hernia repairs, hernia size and location, number of previous operations, body mass index (BMI), and history of intraabdominal sepsis. Technical difficulty as well as postoperative morbidity and mortality may be related to definable preoperative risk factors.

# SURGERY

The technique demands general anesthesia as well as placement of a nasogastric tube and a Foley catheter.

## Positioning

The patient must be firmly attached to the table to allow for alterations in position to Trendelenburg, reverse Trendelenburg, or extreme side-to-side "airplaning" to allow adhesions to be dissected. We prefer to secure the patient to the table with tape at the shoulder level. Sequential compression devices are applied to the legs, and the video monitors are positioned at the foot of the table or at a place convenient for viewing by all involved.

## Technique

Insufflation, usually from a non-midline location, is begun with a Veress needle. The initial ports are most commonly placed lateral to the rectus muscles. The adhesions opposite the initial ports are carefully taken down, and additional ports are placed as adhesions are cleared. Each of these additional trocars should be considered as a port through which a stapler (or laparoscope) or mesh (Fig. 19.1) can be placed. Therefore, 10 to 12 mm trocars are desirable at all ports, although 5 mm ports may be used with corkscrew fixation devices. Bleeding must be meticulously controlled and bowel injury avoided as the anterior abdominal wall is being cleared. We practice closure of large defects with nonabsorbable suture (Fig. 19.2), even if only a limited closure is possible. In our practice, this is usually accomplished percutaneously, using the Carter-Thomason (Inlet Medical, Inc, Eden Prairie, MN, USA) suture passer with placement of #2 Tycron (Ethicon, Somerville, NJ, USA) as individual sutures (Fig. 19.3).

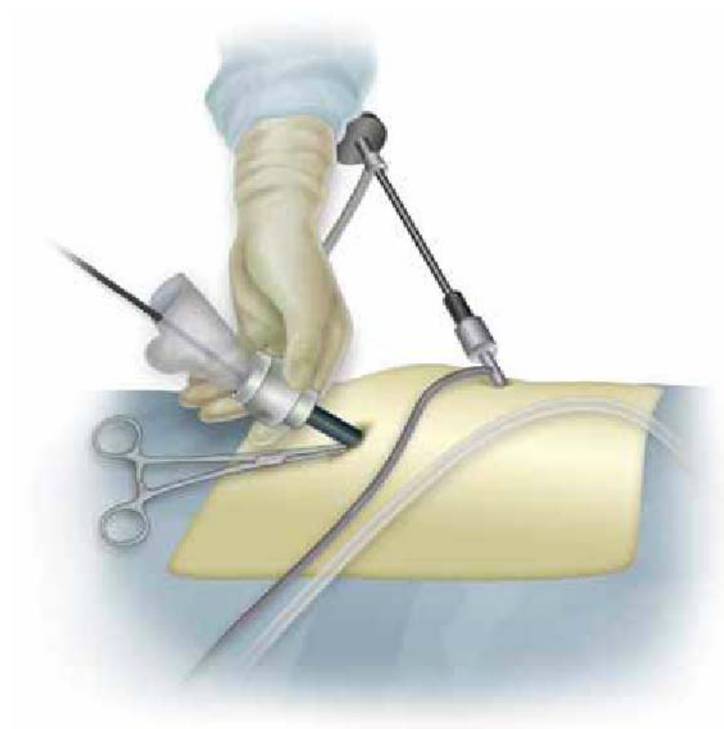

**Figure 19.1** Mesh introduction: Rolled-up mesh introduction through trocar.

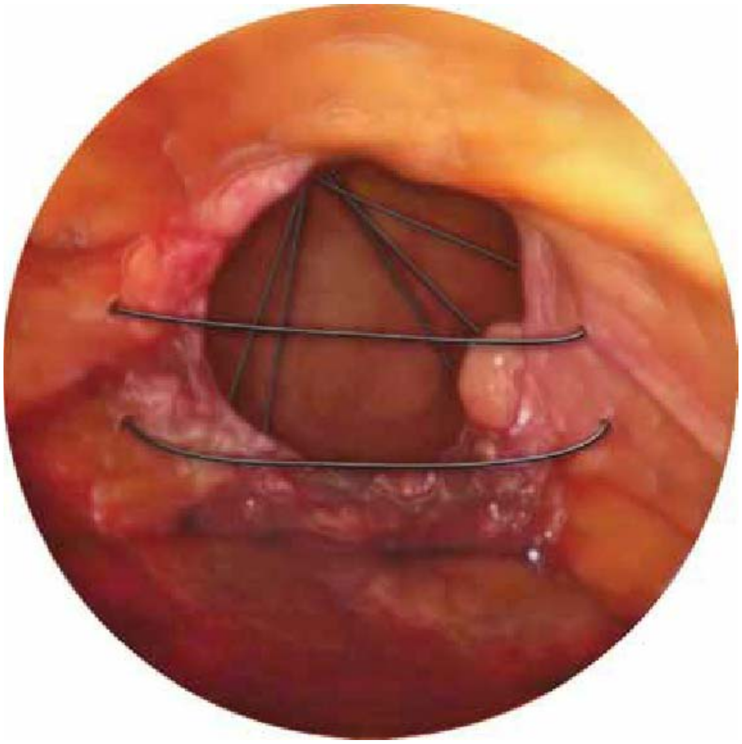

**Figure 19.2** Defect closure: Hernia defect closure with suture passer.

Taking into consideration the thickness of the abdominal wall, polypropylene mesh is tailored to the area judged adequate for coverage of the defect, as estimated by laying the mesh out on the abdominal wall. As many defects as possible should be covered with each piece of mesh while, at the same time, maintaining a minimum margin of 3 to 5 cm circumferentially around each defect (Fig. 19.4). Although one piece of mesh is ideal, it may not be possible in all instances, especially those abdomens where

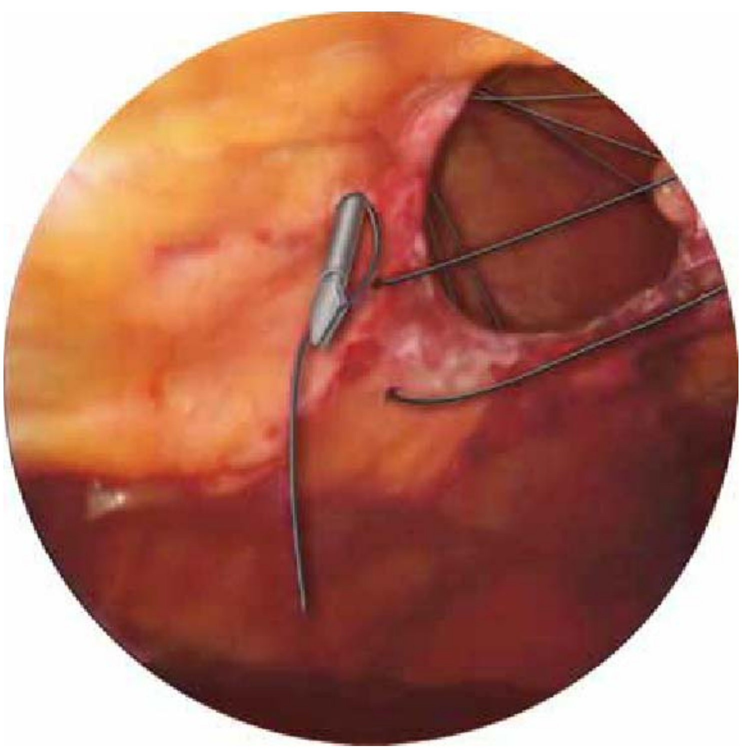

**Figure 19.3** Suture passer: Detailed view of suture passer.

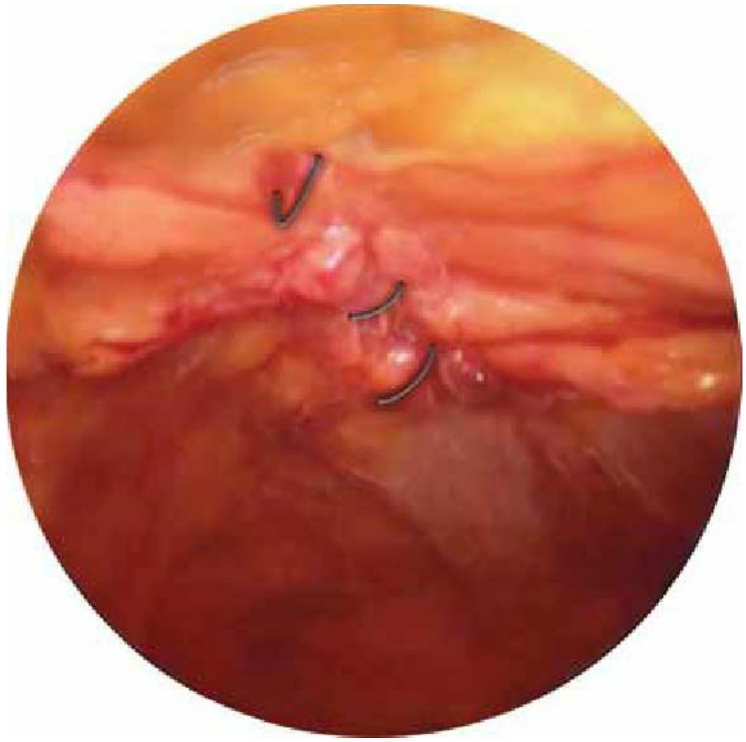

Figure 19.4 Mesh fixation: Transfascial sutures placed 1 cm apart.

extensive or multiple, widely spaced defects are present. The mesh must be placed over the defect and held in place with staples and, in most circumstances, transfascial (2-0 Prolene) sutures (Fig. 19.5).

Until recently, the presence of frank pus or necrotic bowel was considered a contraindication to mesh placement. With the advent of biologic meshes, grossly contaminated hernias can be repaired with the clinically significant strength of a nonabsorbable mesh and the decreased infectious complications of an absorbable prosthetic.

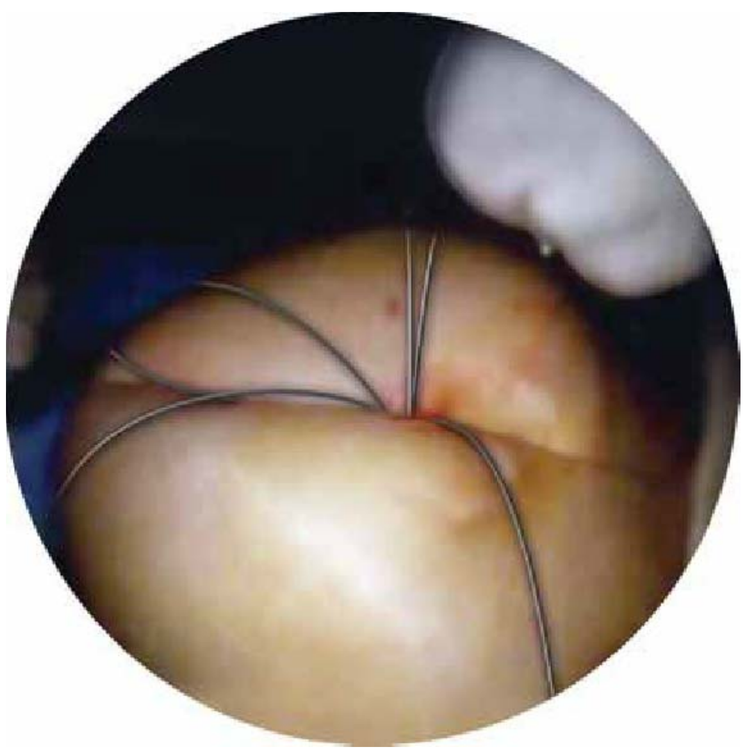

Figure 19.5 Transfascial sutures placed on hernia defect.

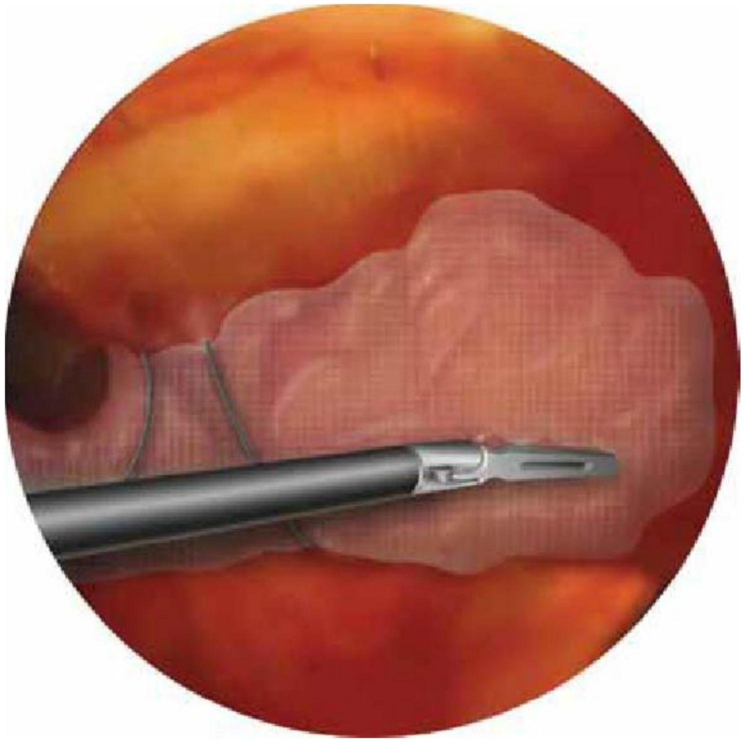

**Figure 19.6** Intraabdominal look after defect closure.



All trocar ports greater than 5 mm should be carefully and completely closed (Fig. 19.6) and the abdomen desufflated after covering the repaired are with omentum. In this fashion, the omentum is tacked (stapled) in place to serve as a barrier to separate the mesh from the bowel. Operation times vary with severity of adhesions, number of defects, bowel involvement, and need for concurrent procedures.

## POSTOPERATIVE MANAGEMENT

The postoperative course is relatively benign with the nasogastric tube and Foley catheter being removed in the recovery room in most instances. Hemoglobin, hematocrit, and electrolyte levels are checked the next day. We expect to see subcutaneous fluid in many hernia sites in the immediate postoperative period and explain this possibility to the patients prior to surgery. The patient is given a diet when bowel sounds are present, which can vary from immediately to several days postoperatively, depending on the amount of dissection, handling of bowel, and small bowel bleeding. Patients are allowed to go home when they are afebrile, their wounds are clean, a regular diet is tolerated, and only minimal pain is present.

Patients are routinely seen back in the clinic by the operating surgeon at 2 weeks, 1 month, 3 months, and 6 months postoperatively and then yearly thereafter.

## COMPLICATIONS

The most common complication encountered is the seroma formation, most patients develop a small, sterile fluid collection that does not require further treatment and eventually reabsorbs. A commonly described complication is the conversion to an open procedure, which most of the times is secondary to poor visualization from dense adhesions and in some cases from profound bowel distension preventing adequate visualization and mobilization.

Hernia repair is associated with a significant risk of enterotomy, reported to be as high as 20.3% by Gray et al. Intraoperative complications related to a missed enterotomy can have devastating effects. Multiple adhesions or prior abdominal surgery increases the risk of bowel injury, and when extensive adhesiolysis is required, patients are at increased risk for enterotomy. We consider that if the abdominal contamination was minimal, and the enterotomy can be repaired laparoscopically, there is no reason not to continue with the same planned procedure. Complications often described are trocar-site infection, prolonged ileus, urinary tract infection, pseudo-obstruction, and pulmonary problems. Other postoperative complications described, but less commonly encountered, are recurrent pain and suture-site neuralgia. In cases of suture-site neuralgia, the first line of treatment is anti-inflammatory drugs, if the pain persists, the patient should be referred to a pain specialist, and after a set of xylocaine and hydrocortisone injections, the pain resides.

The most feared complication over all is hernia recurrence and/or mesh infection.

## CONCLUSIONS

On the basis of the Rives–Stoppa technique, posterior patching of the defect with a large piece of prosthetic mesh allows extensive tissue in-growth for permanent mesh fixation and utilization of intraabdominal pressure to actually hold the mesh in place.

In open mesh repair, the mesh is placed in between the different layers of the abdominal wall, predominantly in the retromuscular position. In this position, the mesh is additionally stabilized by the intraabdominal pressure that presses the mesh against the closed anterior rectus sheath, which functions as a thrust bearing. The porous meshes used are well integrated within days. In laparoscopic hernia repair, however, where the mesh is placed onto the peritoneum with a central fascial defect that remains open, a sufficient fibrocollagenous in-growth is needed to withstand the intraabdominal pressure. This is the reason why we consider transfascial sutures of uttermost importance.

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# 20 Sports Hernia

**L. Michael Brunt**

## Introduction

The topic of sports hernia has gained increasing attention in recent years due to a number of high profile athletes who have undergone surgery for this problem. Although athletic groin injuries are very common in sport, it is important to understand that the condition referred to as a "sports hernia" (which is more appropriately described by the term athletic pubalgia) represents a small percentage of groin injuries that occur in athletes. Moreover, groin injuries in athletes represent a challenging problem both from a diagnostic and therapeutic standpoint because of the broad differential diagnosis, subtle physical examination findings, anatomic complexity of the pelvic and groin region, and the multiplicity of causes. These injuries may result in a significant loss of playing time and, therefore, can be a source of frustration for the athlete, athletic trainers, and treating physicians. In this chapter, the clinical presentation and diagnostic approach to the athletic groin will be reviewed and an overview of repair techniques and surgical outcomes will be presented.

## Background

Sports that have repetitive twisting, turning and kicking motions at high speed such as soccer, ice hockey, and football are associated with a significant incidence of groin injury. In one study from Scandinavia, groin injuries occurred in 5% to 28% of soccer players and accounted for 8% of all injuries over one season. Similarly in a study of Swedish hockey players, groin injuries accounted for approximately 10% of all injuries. Unlike many other injuries in sport, most of these are soft tissue injuries and do not typically result from direct physical contact.

A number of risk factors have been identified that may increase an athlete's risk of groin injury. In one study of National Hockey League players, Emery and colleagues found that fewer than 18 sport-specific training sessions in the off-season, a history of previous groin or abdominal strain, and veteran player status were all associated with an increased risk of groin injury. Another study from the NHL by Tyler et al. showed that hockey players with an adductor to abductor strength ratio of less than 80% were 17 times more likely to sustain an adductor strain. Moreover, adductor strengthening reduced the incidence of injury from 3.2/1,000 to 0.71/1,000 player game exposures.

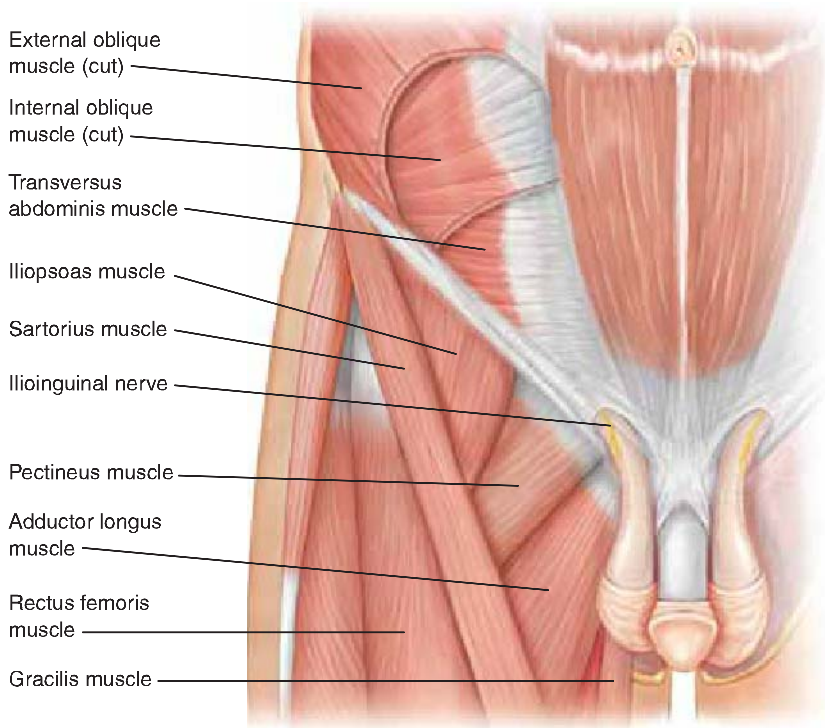



**Figure 20.1** Schematic of the anatomy in the pubic region. Shown are the rectus abdominis, obliques, adductor group, and hip flexors.

# Differential Diagnosis

In order to differentiate the various causes of athletic groin pain, an understanding of the complex anatomy of the musculoskeletal relationships around the pelvis as illustrated in Figure 20.1 is essential. The pelvis acts like a fulcrum or joint around which the powerful abdominal and thigh muscles act. The rectus abdominis inserts on the anterior pubis and its aponeurosis is continuous with that of the adductor longus as shown in Figure 20.2 on both the schematic illustration and sagittal MRI sequences.

The differential diagnosis of groin pain in the athlete is broad and includes injuries to the bony pelvis, muscular strains, hip injuries, and even non-athletic causes. An outline of the principal conditions to be considered in a differential diagnosis is listed below.

Differential diagnosis of groin pain in athletes:

- Pelvis: Stress fracture, traumatic fractures or contusions, osteitis pubis
- Hip: Labral tear, femoral acetabular impingement, osteoarthritis
- Thigh: Muscular strains—adductor group, hip flexors
- Abdominal muscular strains: Rectus abdominis, obliques
- Sports hernia/athletic pubalgia
- Inguinal hernia
- Non-athletic causes (ovarian cyst, endometriosis, inflammatory bowel disease)

Stress fractures are most commonly seen in endurance runners and can affect the inferior pubic ramus or femoral neck region. Osteitis pubis is a condition in which there is midline pubic symphysis pain that is probably related to overuse and abnormal biomechanics around the pubis. Treatment consists of reduced activity, physical therapy, and corticosteroid injections for selected cases. Muscular strains can occur in any of the muscle groups around the hip and pelvis but most commonly involve the adductor muscle group. These may be acute or chronic and typically resolve with conservative management. In one study of sports groin injuries, adductor longus strains accounted for 62% of all sports injuries. Hip injuries should always be excluded in the athlete with groin pain, particularly labral tears and femoral acetabular impingement. Inguinal

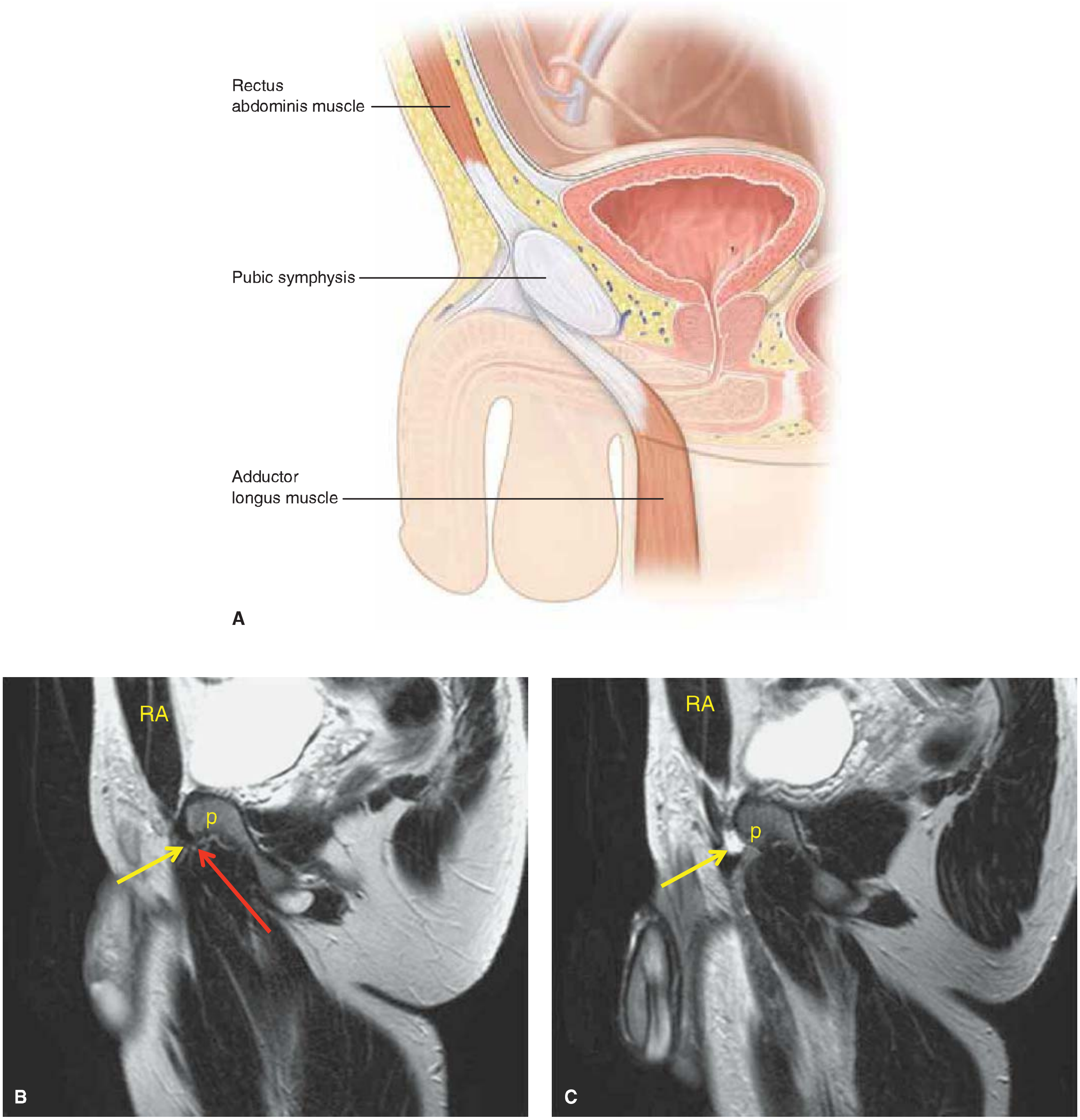



**Figure 20.2** **A:** Sagittal schematic view of rectus–adductor aponeurosis complex and attachment at the pubis. **B:** MRI sagittal view (T2-weighted fat suppressed sequence) that shows normal appearance of the rectus/adductor complex. *RA,* rectus abdominis; *p,* pubis; arrows point to normal rectus/adductor aponeurosis. **C:** MRI sagittal view that shows a tear in the distal rectus at the aponeurotic junction (arrow pointing to bright line).

hernias are included among the possible diagnoses but are rarely present. Finally, non-athletic causes of groin pain should be considered especially in female athletes.

## Diagnostic Evaluation

The evaluation of the athlete with groin pain begins with a detailed history and physical examination. The following points are important to elicit in the history:

- Onset of the pain (acute vs. chronic)
- Precise location of the pain
- Is the pain diffuse or radiating?
- Factors that aggravate or alleviate the pain
- Possible mechanism of injury involved
- History of prior injury or any change in training regimen

In a classic sports hernia type athletic pubalgia, athletes complain of chronic lower abdominal and inguinal pain that is most pronounced during the extremes of motion. Specifically, symptoms are aggravated by sudden turns or cutting movements, propulsive skating movements in hockey, and kicking in soccer or football. Importantly, the pain limits sudden accelerating movements which can be the difference in success and failure for high level athletic performance. Other symptoms that may be associated include pain with coughing or sneezing and adductor symptoms. The onset is often insidious with no clear precipitating event and fails to resolve with conservative management.

Physical examination findings are often subtle and include tenderness in the medial inguinal canal/distal lateral rectus at the right lateral pubis as shown in Figure 20.3. Other findings may include a dilated external ring, a palpable gap over the inguinal canal, and pain with resisted trunk rotation (Fig. 20.3B) or resisted sit-ups. Importantly, there is no evidence of a true inguinal hernia bulge.

Imaging is indicated for excluding other causes of groin pain. Plain pelvis x-rays may be useful for screening hip and bony pelvis abnormalities. The preferred imaging modality in North America is a pelvic MRI which provides details about the various muscular anatomy, tendons, and bony structures around the pelvis. Findings on MRI may include parasymphyseal edema on the side of the injury (Fig. 20.4), a tear in the distal rectus or proximal adductor longus aponeurosis adjacent to the pubis (Fig. 20.5), and evidence of chronic adductor tendinopathy (Fig. 20.6). Some groups have used dynamic ultrasound

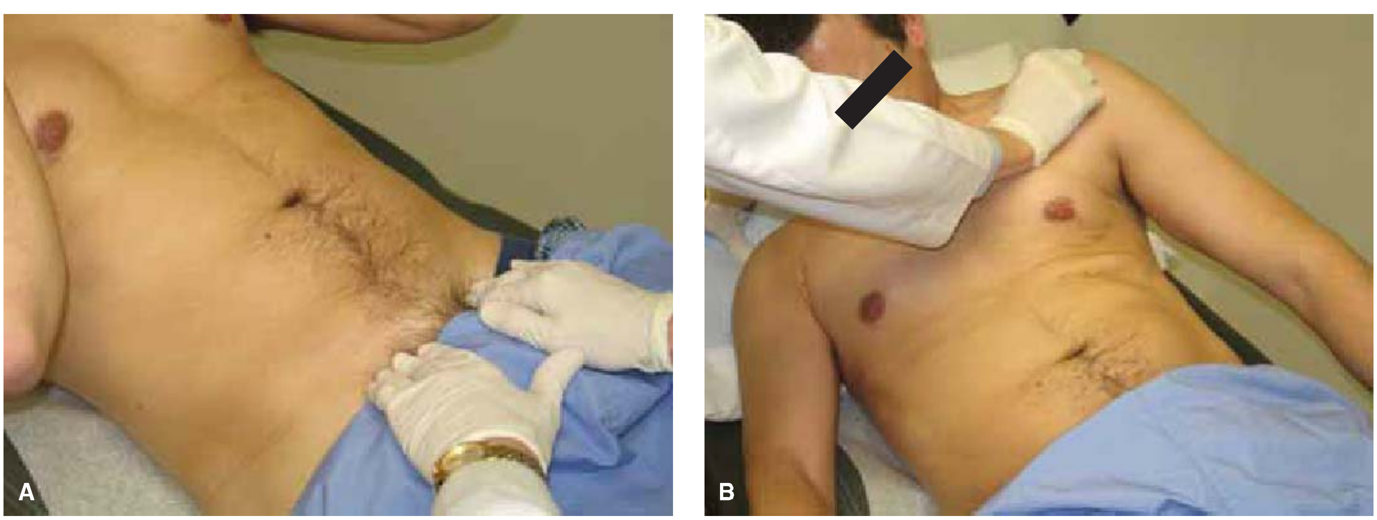



**Figure 20.3** Examination of inguinal floor for athletic pubalgia. **A:** The floor is examined supine and durign a sit-up for areas of weakness and tenderness. **B:** Testing of oblique muscles. The athlete is asked to rotate the shoulder toward the opposite hip against resistance.

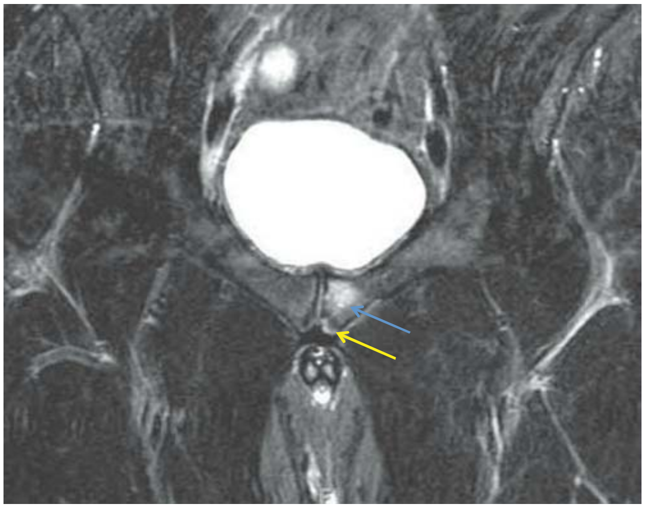


**Figure 20.4** MRI of pelvis in an ahtlete with athletic pubalgia. Shown is edema in the parasymphyseal region of the pubis and secondary cleft sign (*arrows*) indicating aponeurotic lesion associated with this condition.

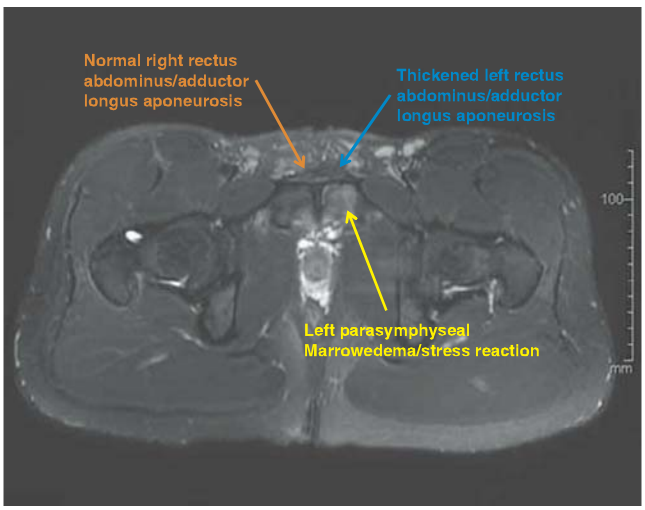



**Figure 20.5** MRI that shows thickening in the distal rectus at the pubis on the left side (*arrow*). The right side is normal.


**Figure 20.6** MRI that shows changes in the left adductor longus insertion (*arrows*) consistent with a chronic tendinopathy.

to assess the integrity of the posterior inguinal floor, but this modality requires considerable experience and is very operator dependent.

## INDICATIONS

The indications for surgery in the athlete with a sports hernia type pubalgia are symptoms that limit athletic performance after failure of a minimum of 6 to 8 weeks of conservative management. In addition, the examination findings should corroborate the location of maximum pain and tenderness as consistent with a sports hernia condition, and other diagnoses should be excluded by examination and imaging. One study by Ekstrand compared surgery versus various non-operative conservative treatment regimens in 66 soccer players with chronic groin pain. All athletes had groin pain for more than 3 months and only the surgical group showed substantial and statistically significant improvement.

# Pathophysiologic Mechanisms

The surgical approach to the treatment of sports hernia type pubalgia should be based on an understanding of the pathophysiology and mechanisms involved in this condition.

Three principal mechanisms have been described:

1. injury to the distal rectus abdominis/adductor tendon complex at the pubis
2. a weak or deficient posterior inguinal floor
3. ilioinguinal or genital nerve involvement

Meyers has developed the concept of "pubic joint" on either side of which are attached powerful abdominal and thigh muscles. An imbalance in muscle strength across the pelvis may lead to increased stress across the pubis and chronic pubalgia type pain. There may be a tear or weakening of the rectus muscle at its insertion site on the pubis (Fig. 20.2) and/or increased pressure within the adductor compartment. Similarly, a weak posterior floor can result from an imbalance in forces with the stronger hip and thigh musculature putting stress across the pubis onto the weaker lower abdominals that can then lead to weakening of the external oblique and posterior inguinal floor and widening of the groin canal with increased tension at the pubis (Fig. 20.7).

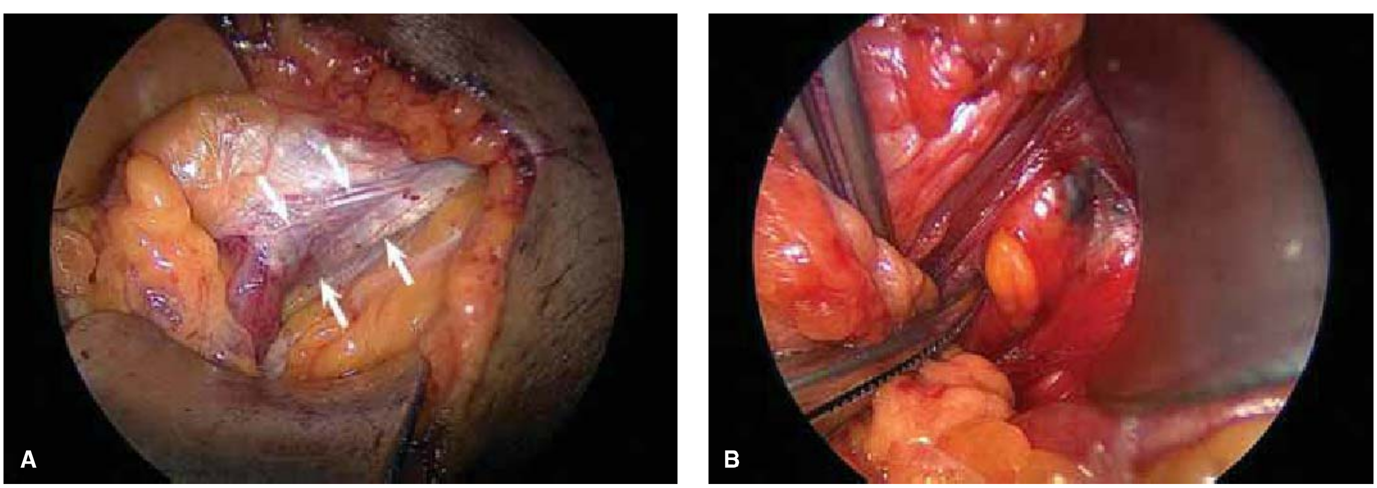



**Figure 20.7** Operative findings in an athlete with a sports hernia. **A:** Attenuated external oblique with translucency of the central portion of the aponeurosis distally (*arrows*). **B:** Disruption in the posterior inguinal floor.

**Figure 20.8** Ilioinguinal nerve exiting a separate slit in the external oblique aponeurosis separates from the external ring in an athlete undergoing sports hernia repair. The external oblique has already been opened through the external ring to expose the spermatic cord.



Finally, some groups have postulated either entrapment of branches of the ilioinguinal and/or iliohypogastric nerves through tears in the external oblique aponeurosis (Fig. 20.8) or pressure on the genital branch of the genitofemoral by a localized bulge in the posterior inguinal canal during Valsalva. These latter mechanisms have led some groups to recommend routine or liberal resection of one or more of these nerves during surgical repair. It should be noted that these mechanisms are not mutually exclusive of each other and may co-exist in a given athlete.

## SURGERY

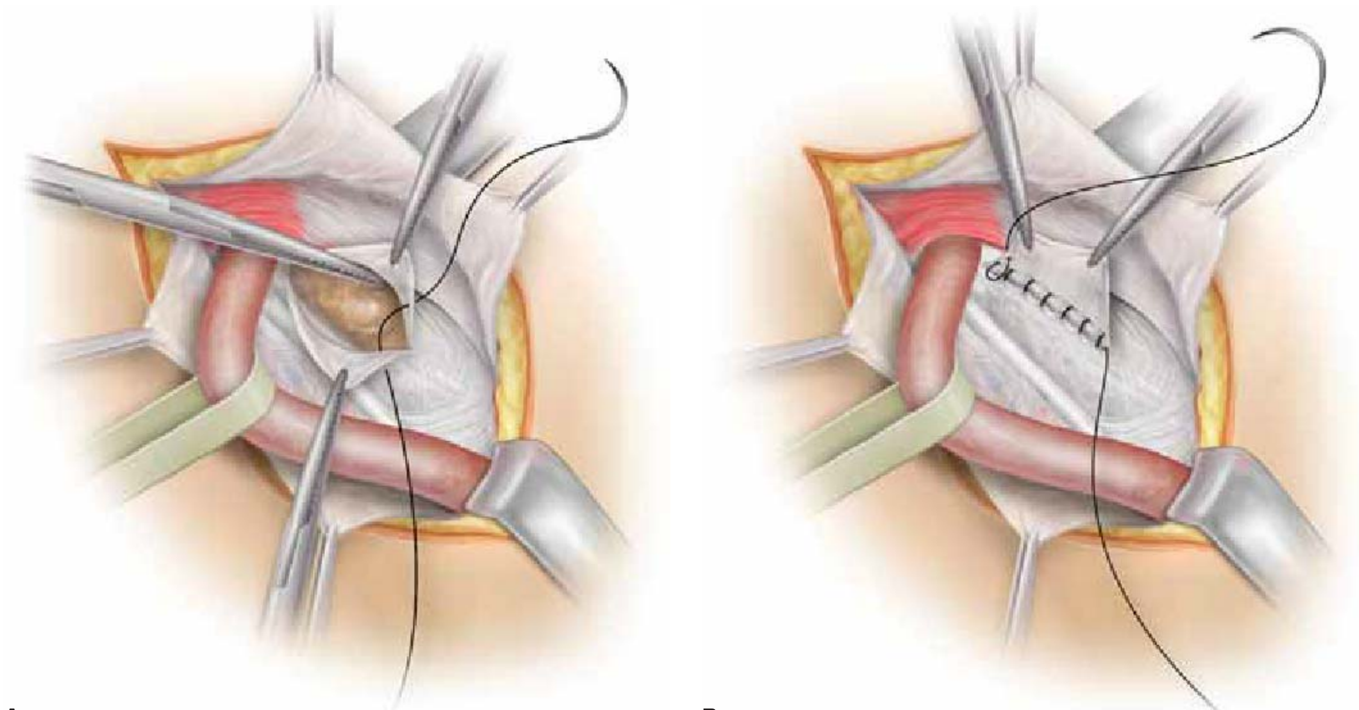
A variety of surgical approaches have been used for the treatment of sports hernia and athletic pubalgia. Broadly, these consist of three categories of repair.

1. Primary pelvic floor repair
   - Meyers approach (rectus to pubis realignment)
   - Muschawek minimal repair technique ± genital neurectomy
2. Open anterior tension-free mesh repair
3. Laparoscopic mesh repair

The primary pelvic floor repair that has been employed by Meyers is a sutured repair that is focused on attachment and realignment of the lower rectus with the pubis. Further details of this repair have not been published. Meyers often accompanies this repair with a partial adductor release in which multiple tiny incisions are made into the tendinous insertion site near the pubis to decompress the adductor compartment. The Muschawek minimal repair technique involves primary repair of the posterior inguinal floor. Only the defect is opened and the surrounding normal tissue is left undisturbed. Two overlapping rows of suture are used to imbricate the defect and in order to stabilize the posterior wall and reduce tension on the rectus abdominis (Fig. 20.9). In addition, a genital neurectomy is performed if there is tension on the nerve or bulging that compresses the genital nerve.

The open anterior tension-free mesh approach is illustrated in Figures 20.10–20.12. This is analogous to a Lichtenstein type repair and typically utilizes lightweight polypropylene mesh. In addition to the repair of the posterior floor, anchoring sutures are placed in the lateral rectus to further stabilize that side of the abdominal attachment. An ilioinguinal neurectomy is performed if the nerve is entrapped in a slit in the external oblique away from the external ring or if it would potentially be tethered by the mesh in order to eliminate it as a source of postoperative pain. The Montreal group uses a somewhat different tension-free mesh approach in which a polytetrafluoroethylene (PTFE) patch is placed just below the external oblique aponeurosis to reinforce that layer. In addition, ilioinguinal and/or iliohypogastric neurectomies are frequently performed in their athletes.

Some groups have advocated a laparoscopic posterior mesh repair. In one study of 55 athletes with chronic groin pain, occult hernias were identified laparoscopically in 20 (36%). This finding is somewhat at variance with the large experience with various



A B

**Figure 20.9** Minimal repair technique of sports hernia as performed by Muschawek. **A:** Only the defect in the posterior inguinal floor is opened. **B:** The defect is repaired primarily by two overlapping rows of suture.

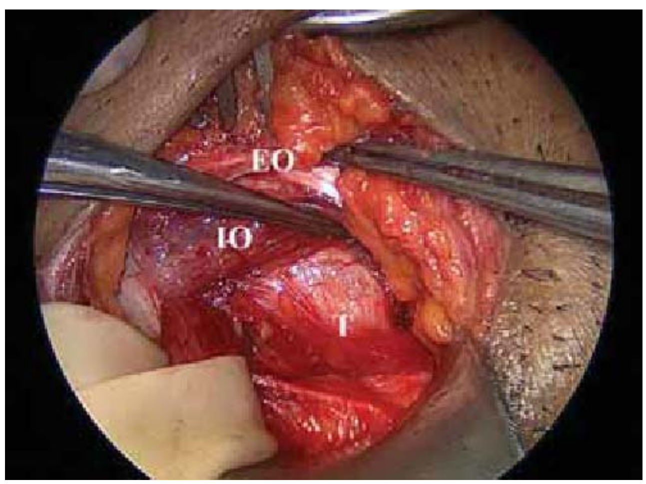



**Figure 20.10** Dissection of the inguinal floor that shows the external oblique, internal oblique, and transveralis layers. Note the stranding and defect in the posterior floor (*arrows*). *EO,* exsternal oblique; *IO,* internal oblique; *T,* transversalis.

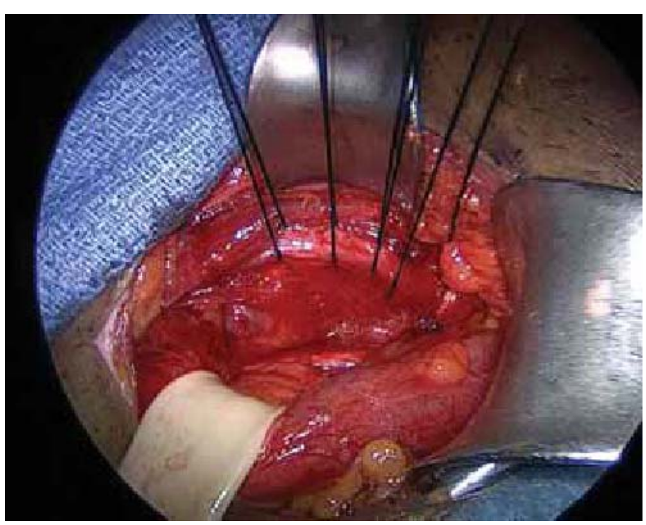


**Figure 20.11** Anchoring sutures in healthy transversalis aponeurosis in the right inguinal floor for mesh fixation.

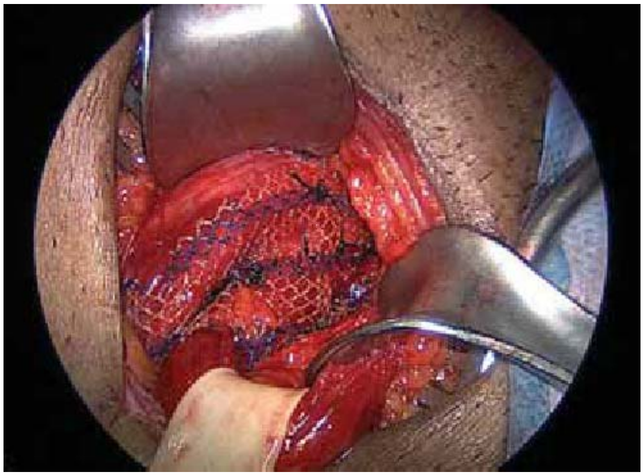


**Figure 20.12** Lightweight mesh is sutured in place to cover the entire posterior floor in a tension-free manner.



open repairs and maybe due in part to an artifice of the laparoscopic insufflation. This repair is the same technically as standard laparoscopic transabdominal preperitoneal or total extraperitoneal inguinal hernia repair with broad mesh coverage of the entire floor, particularly the area of the medial floor and distal rectus insertion (Fig. 20.13).

## POSTOPERATIVE MANAGEMENT

Regardless of the surgical approach to the repair of sports hernia–related pubalgia, a structured postoperative rehabilitation program is essential in facilitating a return to sport. Our group has utilized a stepwise program that is focused on both core abdominal strengthening and stabilization as well as attention to lower body strength, flexibility, and balance (Fig. 20.14). In particular, strengthening and stretching exercises involving the adductor muscle group are an important component to this. In general, the first 7 to 10 days after repair the athlete is limited to normal activities of daily living and walking. From that point on, activity is increased progressively and sequentially beginning with light jogging, stationary biking, and progression to core and lower body exercises. Finally, sport-specific activity is initiated until the athlete is ready for physical contact and return to play. Athletes are allowed to progress according to pain and the timetable should be flexible and individualized according to symptoms. Muschawek has advocated an accelerated path for return to sport in athletes undergoing

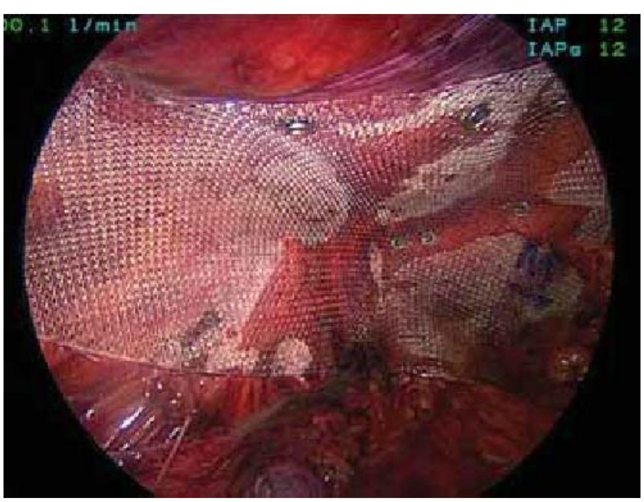



**Figure 20.13** Laparoscopic repair using total extraperitoneal approach. The mesh covers the entire inguinal floor including posterior rectus sheath and its insertion on the pubis.

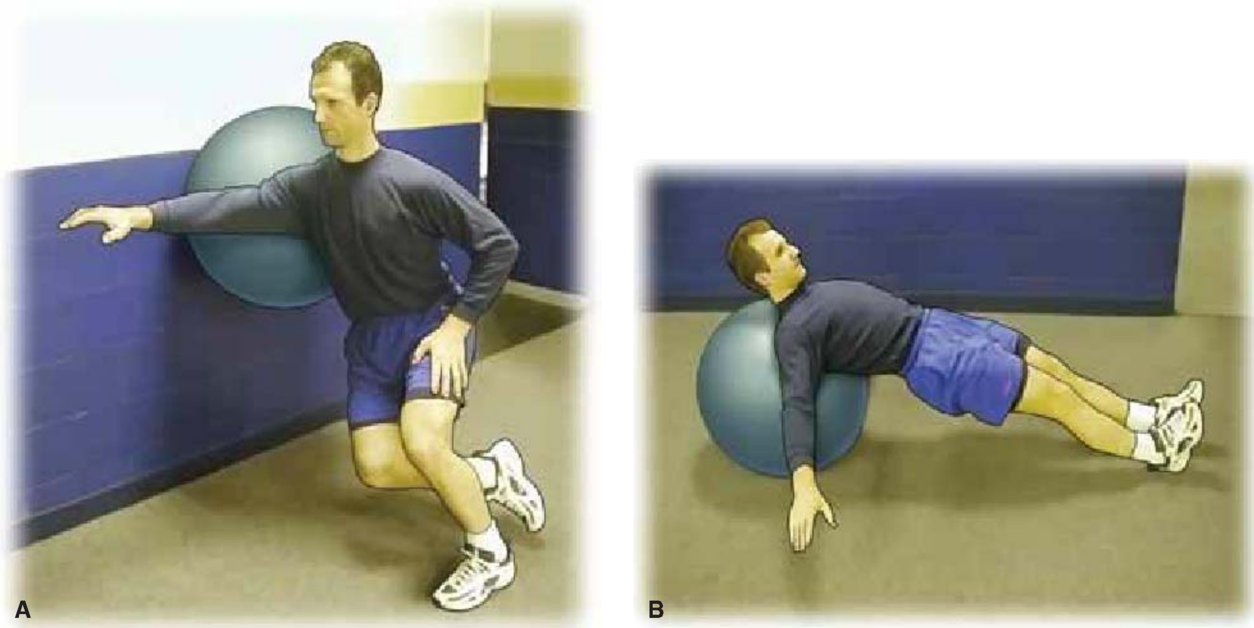


**Figure 20.14** Rehabiltitation program for abdominal core strengthening. Shown are (**A**) side wall ball squats and (**B**) core stabilization with Swiss ball. Photographs courtesy of Ray Barile, ATC, St. Louis Blues Hockey Club.

the minimal repair technique. Such an approach has allowed return to play as early as 3 to 4 weeks after the procedure. In the majority of cases, repairs are typically done in the off-season for sport and so a more conservative timetable for return to play is generally utilized. In our experience, return to play is feasible within 5 to 8 weeks after repair in most individuals but may take longer in selected athletes who have significant adductor or other associated injuries.

## RESULTS

The reported outcomes of the surgical treatment of sports hernia pubalgia describe return to sport rates of 90% or more for each of the three main types of repair. The largest series reported is from Meyers in Philadelphia. Operations were performed in 5,218 athletes out of a total of 8,490 individuals who were evaluated (61.4%). Twenty-six different variations of repairs and 121 different combinations of procedures were carried out. Most repairs involved a primary pelvic floor repair as described above in conjunction with different types of release procedures. Complications were reported in approximately 1% of athletes and included hematomas that required reoperation in 0.3%, wound infections in 0.4%, dysesthesia in 0.3% and penile thrombosis in 0.1%. Return to sport was reported for 95.3% of athletes at up to 3 months after operation, but further details have not been provided.

Muschawek reported results in a prospective evaluation of 129 athletes treated from 2008 to 2009. Ninety-six percent of athletes had resumed training by 4 weeks after repair and a full return to pre-injury sports activity had occurred in 75.8%. There were no recurrences reported over the follow-up period. Similar outcomes have been reported after tension-free mesh hernia repairs. In our experience over 90% of repairs have been done under local anesthesia as an outpatient procedure. Successful return to athletic competition was seen in 91% of athletes at a mean follow-up interval of 13.6 months after surgery. The most common reason for failure in our experience had been ongoing adductor symptoms that resulted in subsequent adductor release procedures in 5 individuals. As a result, we have begun to carry out a partial adductor release similar to that reported by Meyers in highly selected athletes with predominately adductor pathology.

Finally, laparoscopic repair has also been reported by several groups. The largest series is from Evans and colleagues in the United Kingdom in which 278 athletes were treated with 90% successful return to play at an interval of 4 weeks after surgery. Follow-up was variable but ranged from 3 months to 4 years. One small prospective randomized trial compared laparoscopic to open repair in rugby athletes. The open repairs varied between Bassini and Lichtenstein type. Return to training rate at 4 weeks was somewhat higher in the laparoscopic group compared to the open group and there was one failure due to recurrent pain in each group. Despite these results, there is controversy over the role of the laparoscopic repair for this condition and a need for operative re-intervention has been observed anecdotally by some groups.

# Summary

Groin injuries remain a common problem in high level athletes. It is essential that these individuals be evaluated by a multidisciplinary team that includes not only the athletic trainer, but also the sports orthopedist and a general surgeon who is knowledgeable in athletic groin injuries and sports hernia type pubalgia. Surgical treatment is indicated for highly selected athletes who have failed conservative treatment measures. A variety of surgical approaches can be used with success and a structured postoperative rehabilitation program is essential for successful return to athletic competition.



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# 21 Recurrent Laparoscopic Hernia Repair

**Edward L. Felix**

## INDICATIONS/CONTRAINDICATIONS

Although most surgeons agree that the laparoscopic approach is ideally suited for the repair of recurrent inguinal hernias, there still is not total agreement on what approach should be used when a laparoscopic repair fails. Whether an open or laparoscopic approach should be utilized must be dictated by the experience of the surgeon. This is because the repair of recurrent laparoscopic inguinal hernias (RLHs) is challenging and requires advanced laparoscopic skills as well as an in-depth understanding of the posterior anatomy (Figs. 21.1 and 21.2). Before undertaking the laparoscopic repair of an RLH, a surgeon must also be totally comfortable utilizing the laparoscopic transabdominal preperitoneal (TAPP) inguinal hernia repair since it is the safest laparoscopic approach for recurrent laparoscopic hernias. The indications for repair are the same as for any inguinal hernia and other than a lack of experience there is no absolute contraindication to the laparoscopic repair of RLH.

## PREOPERATIVE PLANNING

Before starting a laparoscopic repair of a recurrent laparoscopic hernia it is important to know the status of the peritoneal cavity. Since the laparoscopic repair will be transperitoneal, it is essential to know if there is likely to be extensive adhesions or adhesions at the umbilical level which might jeopardize the safety of the repair. The surgeon must have a game plan before beginning the repair. This means that the surgeon must know what is going to be done if confronted by the unexpected. There must be a plan that allows the procedure to be converted to an open anterior repair if needed. Finally, the surgeon must have a plan in place for closing the peritoneum or covering the mesh repair if re-peritonealization is impossible.

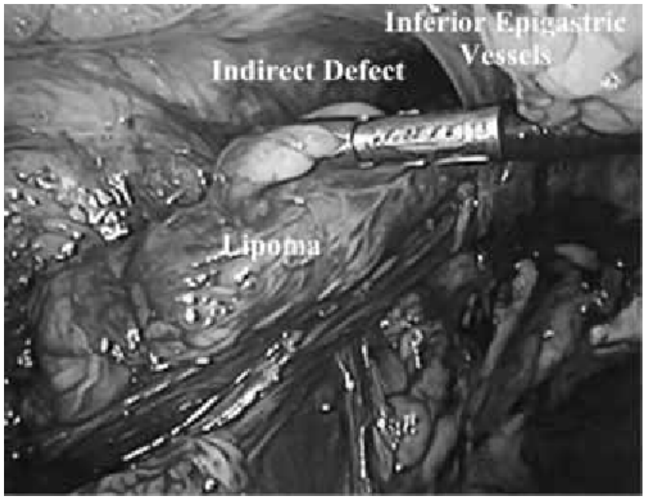


Figure 21.1 Anatomy before reduction of a lipoma in a left inguinal hernia.

# SURGERY

## Positioning

The patient's arms are placed at the side of the patient so that the surgeon is free to stand anywhere along the side of the table. The monitor is positioned at the foot of the table and is angled so that the screen is facing the surgeon. In the TAPP repair most surgeons stand on the side of the table of their dominant hand and reach across the patient with the other hand. The assistant surgeon or scrub nurse, if acting as the assistant, stands opposite the surgeon. The scrub table is placed across the legs so that both the surgeon and nurse can reach the instruments.

## Patient Prep

Although it has been shown that the routine use of a foley catheter increases the risk of retention, if the surgeon thinks that the procedure will be prolonged a catheter can be placed. Otherwise the patient must void before the induction of anesthesia. The entire abdomen should be prepped so that the position of the trocars can be varied if necessary. The groin on the side of the hernia is shaved and prepped in case the procedure must be converted to open.

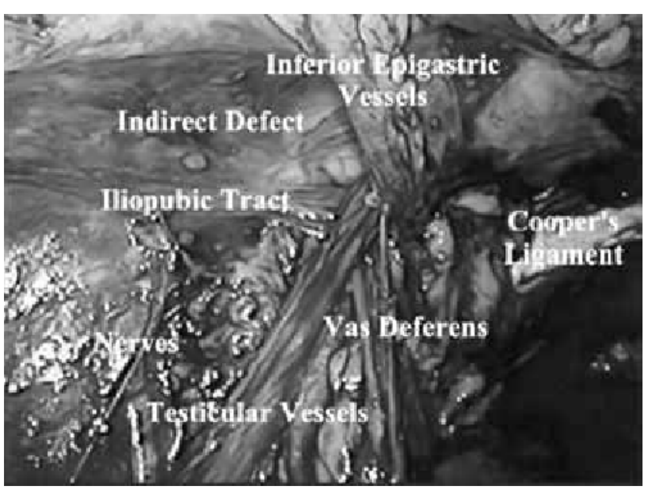


Figure 21.2 Anatomy of the dissected left inguinal hernia.

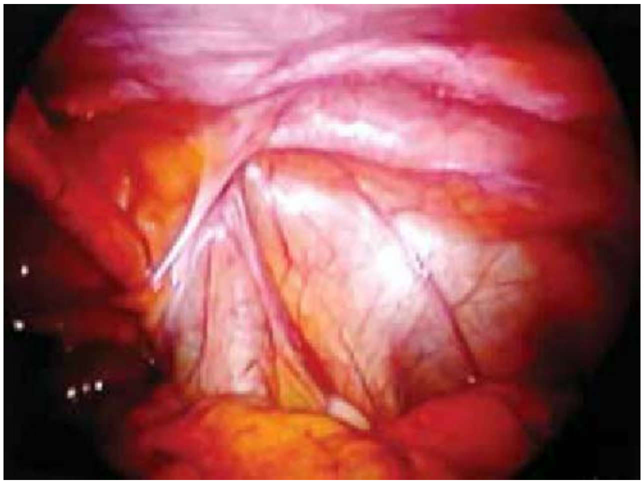

**Figure 21.3** TAPP view of a right recurrent indirect hernia with rolled up mesh.

## Instrumentation

A straight or angled 10 mm scope can be used according to the surgeon's preference. Instruments should be laparoscopic unipolar scissors, bipolar coagulator, atraumatic graspers, and a laparoscopic needle holder. A suction irrigator, 5 mm clip applier and tacker should be available, but do not need to be opened for every case. A 10 mm Hasson type trocar is used at the umbilicus and 5 mm trocars laterally.

## Procedure

The repair of an RLH is best begun as a TAPP repair (Fig. 21.3). This approach allows the surgeon to have an unobstructed view of the previous repair (Fig. 21.4). The mechanism of recurrence will then be apparent. The totally extraperitoneal (TEP) inguinal hernia repair approach runs the risk of tearing the peritoneum where it is fixed to the mesh, injuring any structure that is incarcerated and can be impossible if the extra peritoneal space is obliterated.

The procedure begins with insulation and placement of a Hasson trocar at the umbilicus. After the abdomen and recurrent hernia are examined to determine the safety of proceeding with a laparoscopic repair, a 5 mm trocar is placed laterally approximately at the level of the umbilicus on each side. Any incarceration is reduced (Figs. 21.5 and 21.6) and the peritoneum is incised above the hernia from lateral to medial to expose the extra peritoneal space. The previously placed mesh is usually fixed to the abdominal wall and should be left in place. If however, the mesh is folded on itself

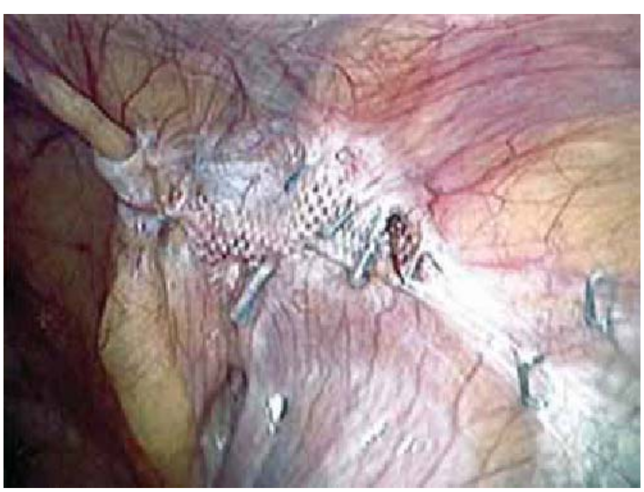

**Figure 21.4** TAPP view of a recurrent right femoral hernia with previously placed mesh visible through the peritoneum.

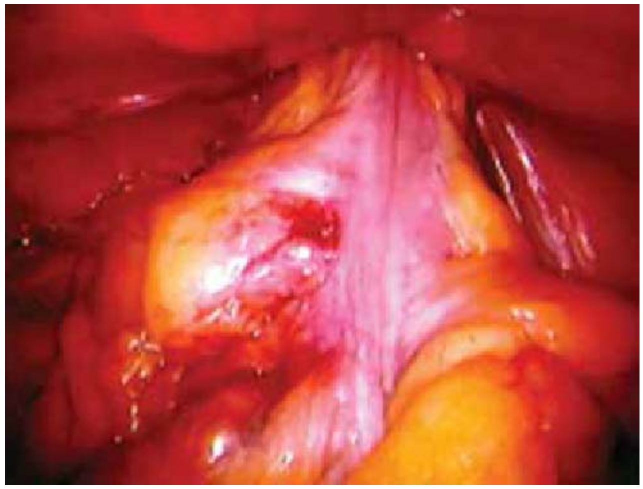

**Figure 21.5** Colon incarcerated in a large recurrent laparoscopic hernia.

causing pain, then it should be excised (Figs. 21.7 A and B). The entire floor must be exposed because it is not unusual for there to be more than one site of recurrence. The vas deferans and testicular vessels must be identified in order to avoid injuring these structures (Fig. 21.8).

After the floor dissection is complete a mesh is fashioned to cover the recurrence. The mesh may overlap the previously placed mesh and in some patients it needs to be slit for the cord. Although it is not necessary to fix the mesh to the wall in most laparoscopic repairs, fixation should be used to repair a recurrent laparoscopic hernia. Care must be taken to only place anchors into Cooper's ligament and above the iliopubic tract. The latter can be difficult, but its location can be determined by palpation of the abdominal wall and groin.

The final part of the procedure is to re-approximate the peritoneum so that it completely covers the mesh. The best method is to suture the peritoneum with a running technique (Fig. 21.9). Occasionally tacks can be used if the peritoneum has partially shredded, but routine closure of the peritoneum with tacks increases the chance of injuring the retroperitoneal nerves. If the mesh cannot be completely covered by peritoneum an alternative technique is to use a mesh with a protective coating like that used in laparoscopic ventral hernia repairs. The 10 mm umbilical trocar site should be carefully closed at the end of the procedure to avoid creating a new hernia at this site.

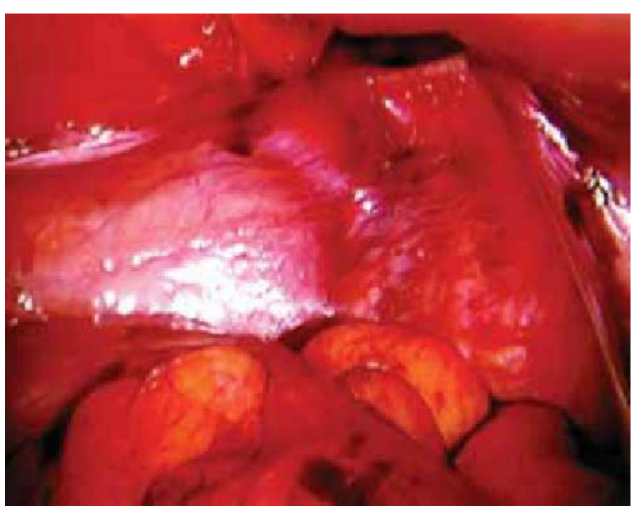

**Figure 21.6** The large recurrent hernia after the incarcerated colon has been reduced.

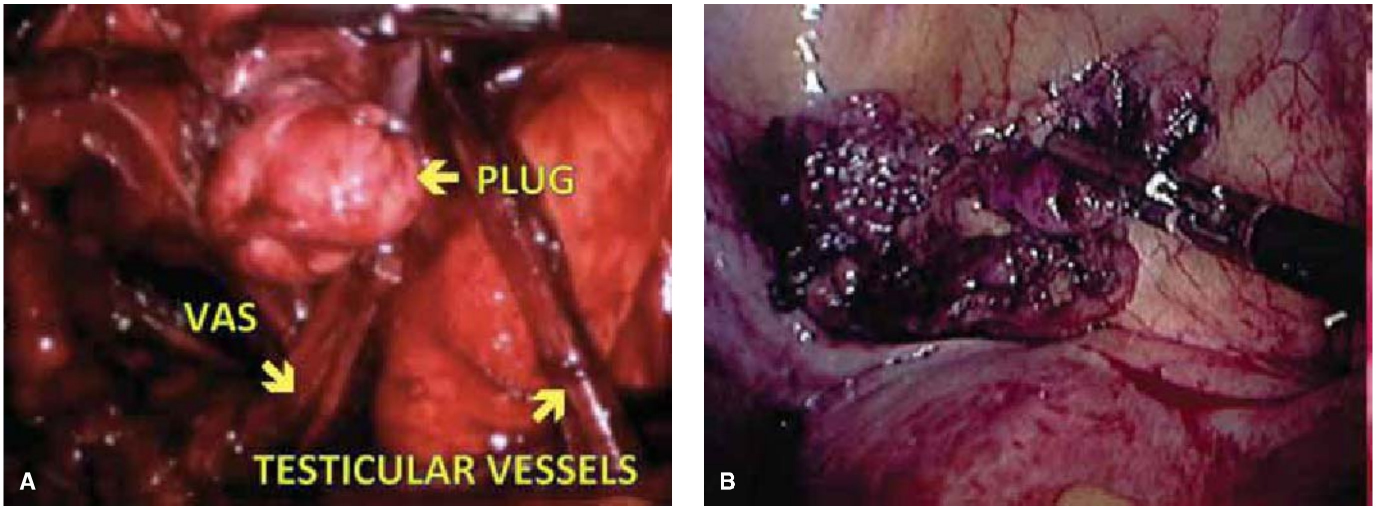


**Figure 21.7 A:**The view of a recurrent plug hernia in a patient with significant pain secondary to the plug. **B:** The mesh plug after it is excised with cautery and scissors.

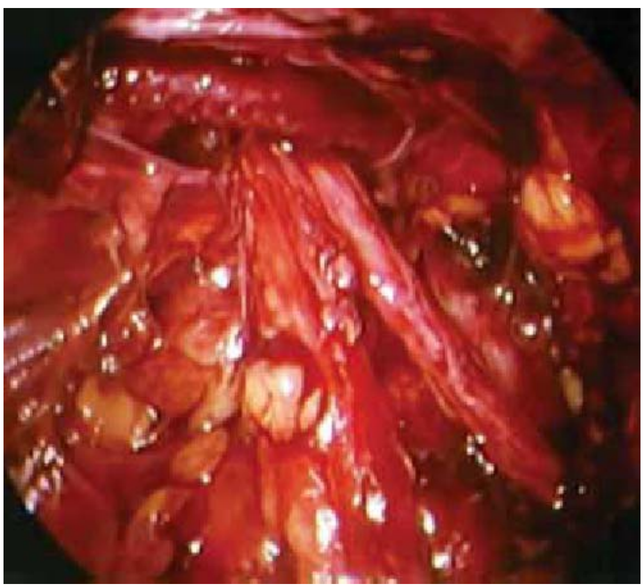

**Figure 21.8** A TAPP view of rolled up mesh exposing the cord structure.

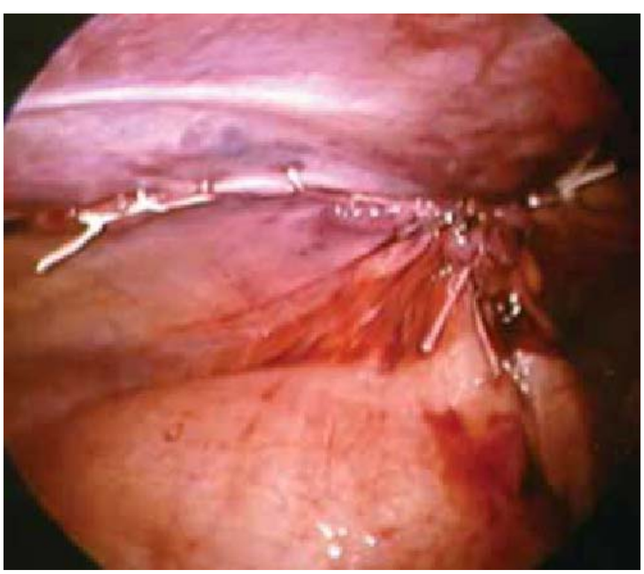

**Figure 21.9** Suture closure of the peritoneum with the colon suspended below the suture line.

## POSTOPERATIVE MANAGEMENT

Patients are discharged home the day of surgery after they have voided and should be warned that it is not unusual to have bruising developed in the groin and genitalia. In general activity is not restricted during the recovery period.

## COMPLICATIONS

Potential complications after a laparoscopic repair of a recurrent laparoscopic hernia are no different than after a primary repair, but the incidence is potentially higher because of the level of difficulty of the repair. Since the repair is performed trans-abdominally, there is a risk of injury to intraabdominal structures. Since there can be intense scar tissue around the cord from the first repair, de-vascularization of the vas deferans is a risk. Fixation of the mesh is usually required in this recurrent repair; therefore, nerve injury is more likely than after a primary repair without fixation. Finally closure of the peritoneum is more difficult than after a first time laparoscopic repair, so there is an increased chance of exposing the mesh. This in turn can lead to a bowel obstruction from adhesions (Fig. 21.10) or an internal hernia.

## RESULTS

There has been very little written about how one should handle a failed laparoscopic hernia repair. Our own study in 2001 showed that recurrent laparoscopic repairs can be handled safely and successfully laparoscopically. Five of seventeen needed to have an additional small anterior incision to remove a lipoma, but the actual repairs were completed with the laparoscopic posterior repair. Two of seventeen had to be converted to open because of peritoneal adhesions. The other significant study is by Kook and van Steensel who reported on 34 laparoscopic recurrences successfully re-repaired with a TAPP approach with no conversions. The lack of extensive literature discussing the treatment of failed laparoscopic inguinal repairs may be due to the low recurrence rate of primary laparoscopic repairs in experienced centers.

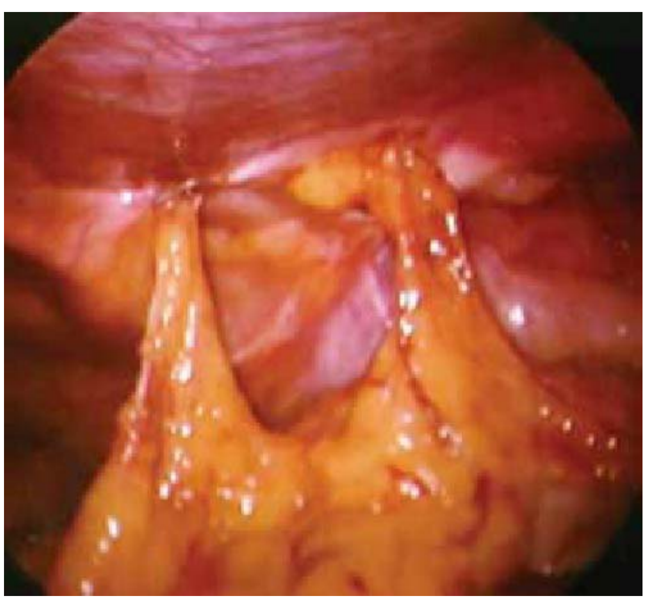

**Figure 21.10** An example of omentum adherent to inadequately closed peritoneum.

## CONCLUSIONS

When a laparoscopic inguinal hernia repair fails the surgeon has the choice to repair it with a conventional open anterior repair or look laparoscopically and proceed with a laparoscopic repair if feasible. The laparoscopic repair of a RLH should not be elected by the inexperienced laparoscopic surgeon. It can be a difficult operation with a lot of negative potential if performed poorly. The laparoscopic approach, however, should be the choice for the well-experienced laparoscopic surgeon. It has the advantage of revealing why the first repair failed and correcting the original error. In addition, it has all of the advantages of the laparoscopic repair; faster recovery, and less long-term pain.

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# 22 Umbilical Hernia Repair

**Thomas McIntyre and Alok Gupta**

## INDICATIONS

Umbilical hernias are classified as spontaneously reducible, manually reducible, incarcerated, or strangulated. They have the potential to cause great discomfort, bowel obstruction, and intestinal gangrene. Symptomatic umbilical hernias should be electively repaired if spontaneously or manually reducible. Urgent or emergent repair is indicated if there is clinical suspicion of incarceration or strangulation; timing is of the essence to limit the severity of bowel ischemia and reduce the likelihood of requiring bowel resection.

Women of childbearing age deserve separate mention. Reducible umbilical hernias may progress to incarceration or strangulation as the intraabdominal pressure rises due to a growing gravid uterus. As such, pre-emptive umbilical hernia repair should be performed in all women of childbearing age. If identified during pregnancy, reducible hernias should be repaired during the second trimester if possible, while incarcerated or strangulated hernias require urgent intervention at the time they are identified. Spinal anesthesia has been used in select cases during pregnancy, along with right side up positioning to displace the uterus off the inferior vena cava and ensure adequate venous return to the heart.

## CONTRAINDICATIONS

There are no absolute contraindications to umbilical hernia repair. The physiologic status of the patient, medical co-morbidities, history of surgical procedures on the abdomen, and sound clinical judgment should guide the surgeon's decision-making.

Repair of reducible umbilical hernias identified in the first trimester of pregnancy should be deferred until second trimester. Those identified during the third trimester should be deferred until the postpartum period. If not reducible, the umbilical hernia should be repaired when identified.

Liver cirrhosis and ascites are not considered contraindications. While patients with umbilical hernias in the setting of liver cirrhosis are at higher risk for complications following surgery, recent studies have shown that early elective repair is safe and should be performed. Surgical repair also decreases the risk of decompensated cirrhosis in the acute setting of a bowel obstruction or intestinal strangulation. Postoperative medical management of ascites is critical to minimizing complications and recurrence. In patients with massive ascites, a closed suction drain should be considered along with medical management to control ascites until the incision has healed.

## PREOPERATIVE PLANNING

A complete history and thorough physical examination is usually adequate to identify most umbilical hernias. With the rising incidence of obesity in the United States, accurate assessment by examination may be increasingly difficult. Even in these cases, it is rarely necessary to employ advanced medical imaging technologies for definitive diagnosis.

The patient should be physiologically optimized for the procedure to reduce the risk of cardiopulmonary and anesthesia-related complications. Smoking cessation should be encouraged to improve wound healing. Anticoagulants and antiplatelet therapy should be held when possible. If the patient presents with signs and symptoms of a small bowel obstruction, nasogastric decompression should be performed prior to induction of general anesthesia to reduce the risk of aspiration.

- Informed consent should specifically include a discussion about the possibility of bowel resection, the risk of recurrence, estimated to be 1% to 3%, and the potential need for future surgical intervention.
- Various options for anesthesia exist including general, regional, and local with IV sedation. Selection should be tailored for each patient.
- Administration of preoperative antibiotics is controversial. Routine coverage with a first generation cephalosporin is the most common practice, especially when prosthetic mesh will be used.

## SURGERY

### Position

The patient is placed supine in a comfortable position.

### Preparation

The umbilicus must be carefully cleaned which may require a cotton tipped swab to reach deep crevices. The usual skin prep using an alcohol-based solution should follow.

### Incision and Exposure

- A curvilinear incision is made sharply inferior or superior to the umbilicus. Occasionally, a vertical incision is made through the umbilicus for cosmesis or around the umbilicus to increase exposure for very large defects (Fig. 22.1).
- Dissection proceeds through the subcutaneous tissue toward the hernia sac and stalk of the umbilicus. The sac is circumferentially mobilized using a blunt curved instrument except for the point of attachment to the umbilical stalk. The sac is then separated from the umbilical stalk carefully so as not to lacerate the umbilical skin. The neck of the hernia sac is dissected free from the surrounding tissues in order to circumferentially define the edges of the fascial defect (Fig. 22.2).
- In some instances, it may be necessary to divide the umbilical stalk at its base off the midline fascia in order to identify and free the hernia sac and fascia. This should be done with cautery if necessary with care taken to avoid injury to the hernia sac.
- If there is suspicion of incarcerated intestines within the hernia sac, the sac should be opened and the intestinal contents reduced or resected as indicated. Frequently the sac contains omentum that can be easily reduced. If reduction is not possible the omentum should be resected with sequential clamping and ligature.

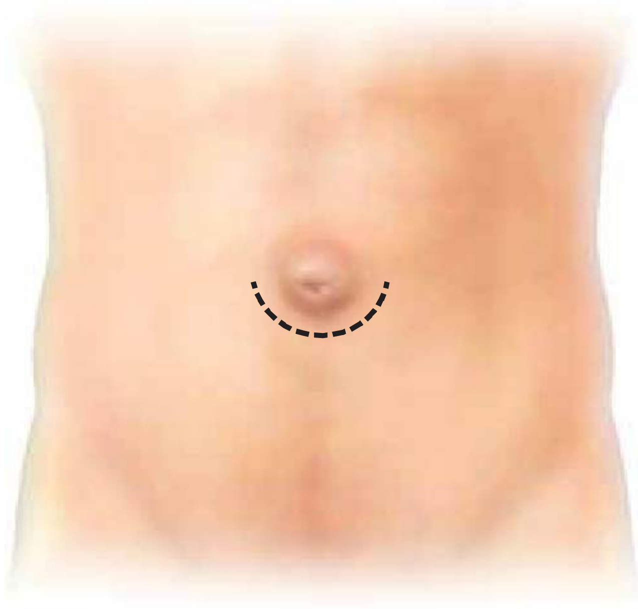

Figure 22.1 Infraumbilical incision.



- Once the contents are completely reduced the fascial edges should be freed of any additional intraabdominal adhesions using either blunt or sharp dissection with care taken to avoid bowel injury.

## Repair

The decision as to how to repair the fascial defect is based upon size:

- Defects less than 1 cm are repaired primarily with interrupted non-absorbable or delayed absorbable sutures (Fig. 22.3).
- Defects greater than 2 cm should be repaired with composite mesh to minimize tension. The mesh should underlay the fascial edges with extension beyond the edges of the defect for 2 cm circumferentially. Transfascial non-absorbable sutures should be placed to secure the mesh in four quadrants (Fig. 22.4). It is not necessary to close the overlying fascial edges after placement of the mesh, however it is occasionally done when there is no tension on the fascial closure in order to cover the mesh.

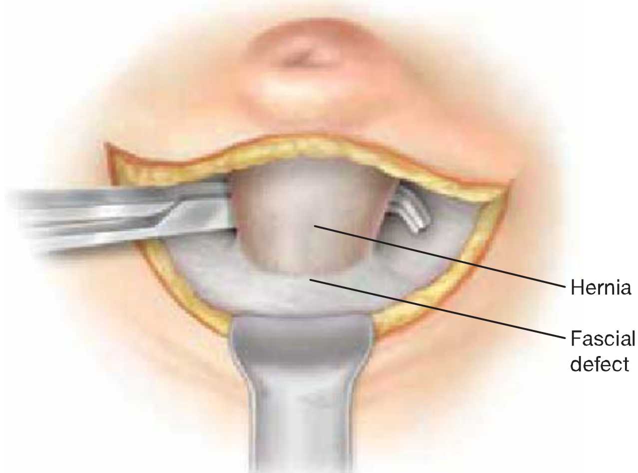


Figure 22.2 Circumferential definition of fascial defect.

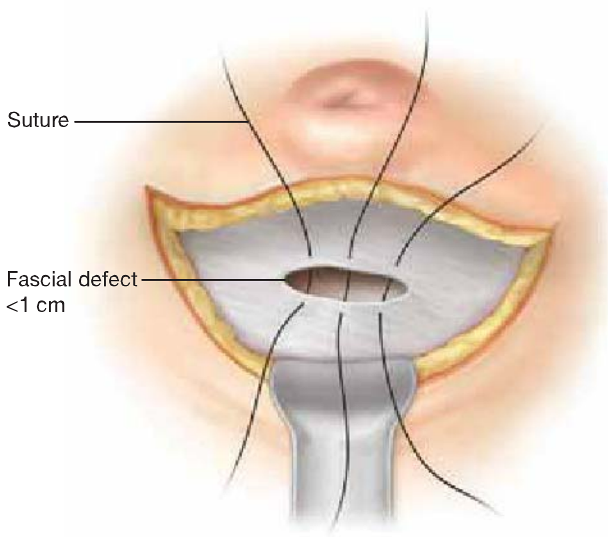


Figure 22.3 Repair of defects <1 cm.

- For defects between 1 and 2 cm in diameter the surgeon should use his/her judgment as to which method to use. Either technique should aim to achieve a repair with minimal tension.
- Prosthetic mesh should be avoided in the setting of a bowel resection.
- With the introduction of prosthetic mesh, the traditional 'Mayo' or 'vest-over-trousers' technique has been virtually abandoned. Rates of recurrence were higher (up to 30%) with this technique and have subsequently fallen with "tension-free" techniques (1% to 3%).
- When umbilical hernia defects are found to be large (>4 cm) on preoperative evaluation, laparoscopic repair should be considered. Technique should follow the principles of the standard laparoscopic ventral hernia repair.

## Closure

The apex of the umbilical stalk should be anchored to the midline fascia with an absorbable suture. Additional absorbable sutures can be used to obliterate the subcutaneous space. This reduces the risk of hematoma and seroma formation. The skin should be closed with absorbable subcuticular sutures. A dry pressure dressing using an umbilical bolster should be placed to decrease seroma formation; an abdominal binder should also be considered.

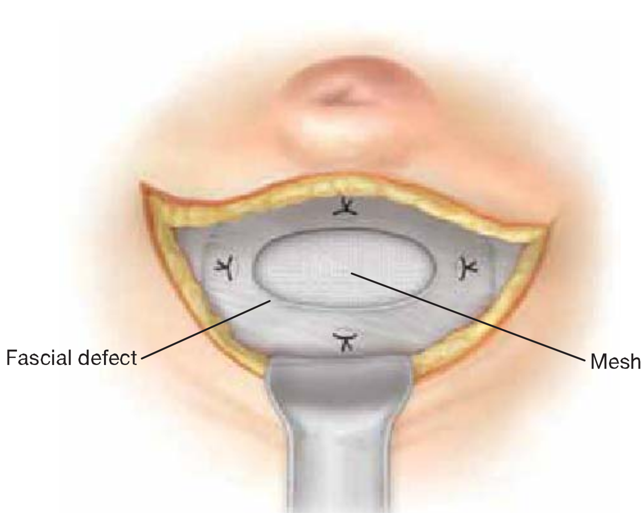


Figure 22.4 Repair of defects >1 cm with underlay mesh.

## POSTOPERATIVE MANAGEMENT

This procedure is most commonly performed electively in the outpatient setting. When performed as an emergency, postoperative care is dictated by the physiology of the patient.

- Patients can be started on liquids postoperatively and have their diet advanced as tolerated. If there is evidence of preoperative bowel obstruction or intraoperative incarcerated bowel, postoperative bowel rest and nasogastric decompression should be considered.
- Patients should refrain from heavy lifting and straining for at least 4 to 6 weeks postoperatively.

## COMPLICATIONS

Umbilical hernia repair is extremely safe with low rates of complications. In addition to complications common to a wide variety of general surgical procedures including bleeding, cardiopulmonary dysfunction, and anesthesia-related complications, a few others should be mentioned.

- The most serious potential complication is injury to visceral contents incarcerated within the hernia sac. This is extremely rare. If an injury to bowel is encountered at the time of surgery it should be repaired and prosthetic mesh should not be used. Signs or symptoms of postoperative ileus, bowel obstruction, or unexplained pain, fevers, or leukocytosis should prompt a workup for missed bowel injury.
- Seroma/hematoma (5% to 20%). This is more common with large hernias. The majority of these can be observed and they will resolve over time; however, they can occasionally cause pain and discomfort, if pain persists aspiration can be performed under sterile conditions. This is not recommended after repairs with mesh due to the potential for infection.
- Wound infection (1% to 3%)

## RESULTS

- Traditionally, adult umbilical hernia repair without the use of mesh has been associated with recurrence rates between 10% and 30%. With the advent of mesh prosthetics, the importance of creating a "tension-free repair" has become paramount and rates have dropped dramatically. The only randomized clinical trial comparing techniques reported that recurrence rate dropped from 11% to 1% with the use of mesh. Recurrence rates with repairs done with mesh range from 1% to 3%.
- Laparoscopy has been demonstrated to be a safe alternative way to perform a mesh repair based upon retrospective reviews and feasibility studies. There have been no randomized studies demonstrating improvement in recurrence rates or morbidity with application of laparoscopy for standard umbilical hernias. However, laparoscopy should be strongly considered with larger defects based upon our experience with laparoscopic ventral hernia repair.

## CONCLUSIONS

The clinical picture of the patient and classification of the hernia are imperative in determining whether and when repair should be performed. Some patient populations such as pregnancy or liver cirrhosis require special consideration.

Umbilical hernia repair with or without mesh is overall safe, effective, and should be offered to most patients. The most appropriate technique for closure is one which minimizes tension. Complication rates are exceedingly low and results are usually excellent with this procedure.

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# 23 Choice of Mesh

**Arthur Rawlings and Brent D. Matthews**

*If we could artificially produce tissue of the density and toughness of fascia and tendon, the secret of the radical cure of hernia repair would be discovered.*

Theodore Bilroth (1829–1894)

## Introduction

Edoardo Bassini ushered in the modern era of hernia repair in 1887 with his "radical cure" for an inguinal hernia on the basis of an anatomical repair. Despite improved understanding of abdominal wall anatomy, the advent of aseptic technique, the development of antibiotic therapy for prophylaxis, and refined surgical skills over the decades, recurrence from a tissue repair of an abdominal wall hernia occurs at an alarming rate. This is not the "radical cure" that Bassini envisioned for an inguinal hernia nor for any abdominal wall hernia. For example, one study showed that a primary repair of a large ventral hernia is reported to have a 63% recurrence rate at 10 years. This is reduced to 32% if a mesh is used to augment the primary closure. If the hernia is small, less than 10 cm$^2$, then the recurrence rate for a primary repair is 67%, whereas it drops to 17% if a mesh is used to augment the repair. Though there is much to learn about hernia anatomy and its usefulness in repair, studies have demonstrated that a mesh should be a primary tool for an abdominal wall hernia repair. A mesh should be used unless there is a compelling reason not to use one. With so many options available the question becomes, "Which one?"

## What is the Ideal Mesh?

Before discussing what is available, it would be a good exercise to consider what would be an ideal mesh. What is being asked from a piece of mesh in an abdominal wall hernia repair? There are several desired characteristics, some absolute while others only highly desirable. The ideal mesh would be (in no significant order):

1. Noncarcinogenic
2. Strong enough to prevent a recurrence
3. Easy to handle

4. Easy to manufacture
5. Economical
6. Biocompatible: Having a minimally adverse or no inflammatory host response, or being completely remodeled into the host tissue
7. Treatable if it becomes infected
8. Undetected by the patient or by physical examination
9. Compatible with future abdominal access
10. Nonallergenic or causing no hypersensitivity reaction

On looking over the list, it is easy to say that the ideal mesh has yet to be produced. This does give a good benchmark for the evaluation of what is on the market and a goal for future developments.

## What is Available?

Phelps used the first man-made prosthetic material for hernia repair in 1894. He placed silver wire coils in the floor of the inguinal canal and closed the layers of the abdominal wall over them. He relied on the host response to this foreign body to increase the fibrosis in the inguinal floor to reinforce the hernia repair. This was further developed by German surgeons who used hand-made silver filigrees, fine silver wire woven into a net, as the first "mesh" to be routinely used for hernia repairs. Though this has fallen out of favor, metal mesh for hernia repair was used longer than any other prosthetic material for hernia repair, including even the most popular materials used today.

Francis Usher initiated the current revolution in prosthetic materials for hernia repair when he published his use of polypropylene mesh for hernia repair in 1958. Since then many materials have come and gone; a few have stayed. Through all the experiments and trials, three nonbiologic mesh materials have stood the test of time: Polypropylene, polyester, and polytetrafluoroethylene (PTFE).

## Polypropylene

Polypropylene, the mesh used by Usher, is a polymer of a carbon backbone with hydrogen and methyl groups attached (Fig. 23.1). It looks as if it would be inert in the human host, but this structure initially undergoes oxidation at the tertiary carbons, which then can progress to oxidation of the carbon backbone. The impact of this clinically is that explanted meshes have shown oxidative damage with surface cracking, a decrease in

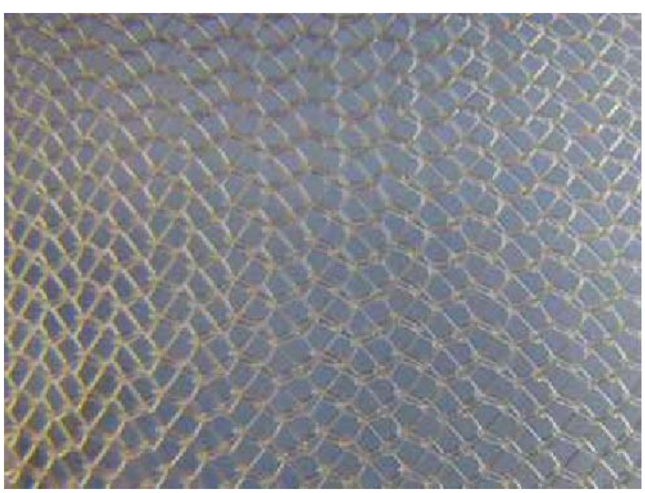

**Figure 23.1** Knitted monofilament polypropylene mesh. Photo courtesy of Corey Deeken, PhD.

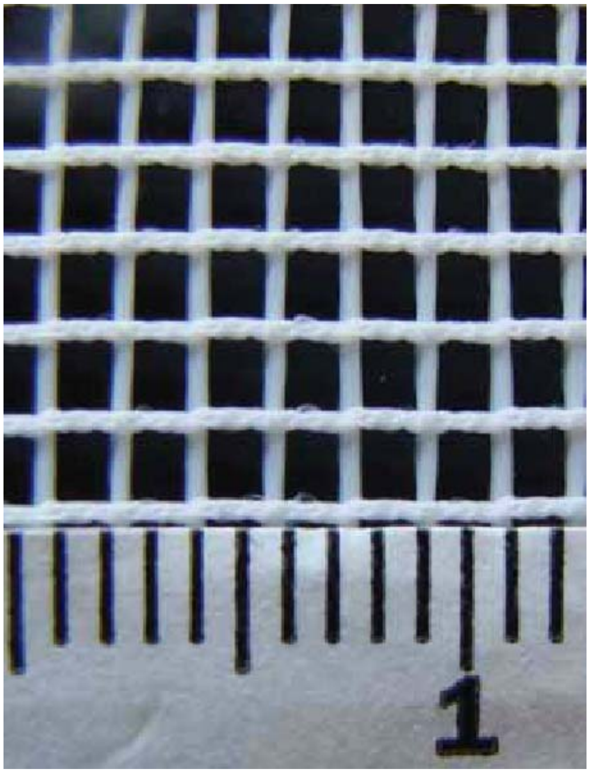

Figure 23.2 Woven polyester mesh. Photo courtesy of Corey Deeken, PhD.

mass, and reduced compliance. This polymer can be manufactured into weaves or knits of different patterns and densities. Absorbable strands can also be woven together with the polypropylene to give the mesh a stiffer feel and easier handling characteristics for implantation, which will then become more pliable in the patient as the body degrades the absorbable strands.

# Polyester

Polyester is a polymer of a carbon and oxygen backbone with hydrogen and oxygen attached (Fig. 23.2). This polymer comes in many different forms, polyethylene terephthalate (PET or Dacron) being one of the most common. Its versatility and strength to weight ratio make it a popular fabric for clothing. This material also looks as if it would be inert in the human host, but that is not the case. Polyester is hydrophilic and undergoes hydrolysis whereas polypropylene is hydrophobic and undergoes oxidation. The hydrolysis of polyester can break the backbone of the polymer in a slow process that eventually can turn the polymer into a monomer. For example, one study looked at 65 explanted polyester vascular grafts and showed by a linear regression model that the bursting strength is reduced by 31.4% at 10 years and 100% by 25 to 39 years. The clinical significance for this in abdominal hernia repair is not fully known, but it does highlight that these seemingly inert materials do undergo change in the human host. In general terms, polyester tends to have less scar contraction, less tissue adherence, and feels softer than polypropylene.

# Polytetrafluoroethylene (PTFE)

Polytetrafluoroethylene (PTFE) is a polymer of fluorine atoms attached to a carbon backbone (Figs. 23.3 and 23.4). Its most commonly known commercial applications are

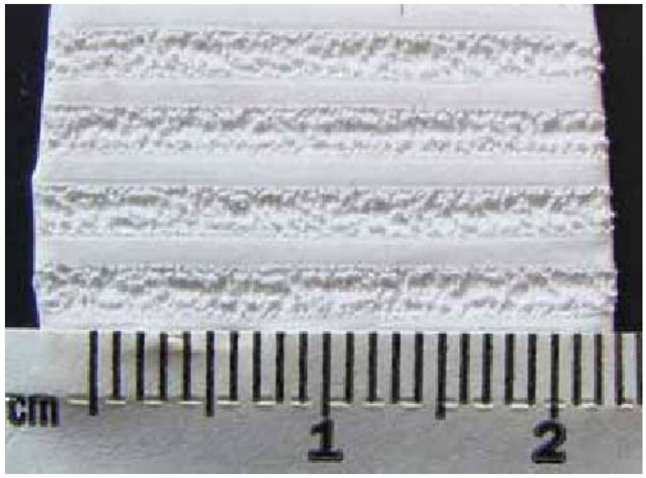


**Figure 23.3** ePTFE (expanded PTFE) mesh, large pore side. Photo courtesy of Corey Deeken, PhD.

Teflon and Gore-Tex. The carbon–fluorine bond is one of the strongest organic bonds known. This means that PTFE is more resistant to oxidation in the biochemical milieu of the human host than polyester or polypropylene. Tissue enzymes and microorganisms appear to not degrade this mesh. These properties led pediatric surgeons, who wanted a prosthetic that could be easily removed from the patient's body at a later date, to be the first to use PTFE as a prosthetic material. Since then, PTFE meshes have been engineered with different pore sizes on each side to take advantage of the host tissue's different interactions with pore size. These expanded PTFE (ePTFE) meshes have been designed with very small pores on one side, which significantly reduces adhesions, and large pores on the other side, where tissue can grow into the material. This extremely small pore size means that ePTFE performs poorly in the presence of infection. Unlike polypropylene and polyester, which performs reasonably well in a contaminated environment or when exposed to the outside by allowing granulating tissue to grow between the mesh strands, ePTFE usually has to be removed if there is an infection or if it becomes exposed. It is more prone to seroma formation and encapsulation than polypropylene and polyester. But, with its small pore composition, it does not develop adhesions like bare polypropylene or polyester.

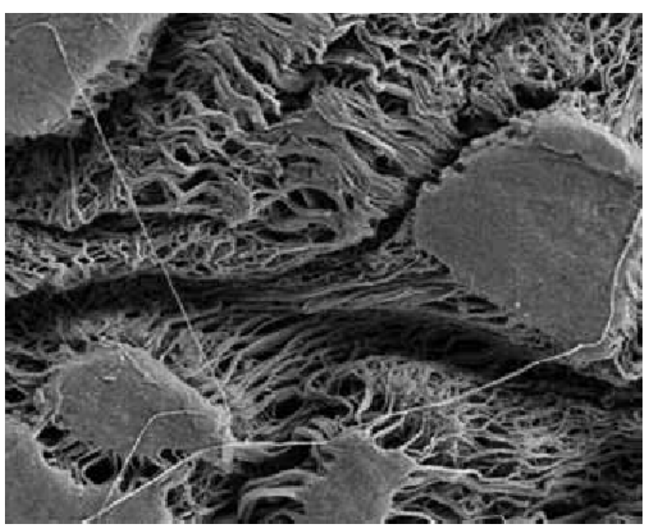

**Figure 23.4** ePTFE (expanded PTFE) mesh, large pore size magnified by 1500×. Microphotograph courtesy of Corey Deeken, PhD.

# Barrier-coated Meshes

The placement of an intraperitoneal sublay mesh for a ventral hernia repair is asking for a unique, two-sided task. On the one side, the mesh is to adhere to the abdominal wall. It is to incorporate within the abdominal wall without changing the mesh architecture, while maintaining its mechanical properties and protecting against recurrence. At the same time, the other side is to have no incorporation or attachments from the abdominal contents. It is to form a neoperitoneum without any adhesions. As mentioned earlier, ePTFE with its difference in pore size from one side to the other is engineered to give the mesh this two-sided function. Another example is a two-layer mesh with polypropylene on one side and ePTFE on the other side (e.g., Bard Composix). Other meshes have been developed to address this issue. These have some form of an absorbable barrier that is designed to protect the abdominal contents from the permanent mesh material until the neoperitoneum is formed, giving a more permanent protection of the abdominal contents from the mesh.

Proceed mesh is a polypropylene mesh with an oxidized, regenerated cellulose barrier. This is the Interceed technology, commonly used in gynecologic surgery to reduce adhesions after such procedures as a cesarean delivery, applied to mesh technology. The cellulose layer becomes a physical barrier between the mesh and the intraabdominal contents, while the polypropylene mesh integrates, the neoperitoneum forms, and the injured bowel heals.

Sepramesh is a polypropylene mesh with a hyaluronic acid and carboxymethylcellulose (Seprafilm technology) coating on one side (Fig. 23.5). This forms a hydrogel, which separates the mesh from the abdominal contents during that crucial initial phase as the mesh incorporates and the abdominal contents heal.

Parietex composite is a collagen-coated polyester mesh with a polyethylene glycol–glycerol coating. The polyester is hydrophilic, which encourages tissue in-growth compared to polypropylene, while the polyethylene glycol and glycerol coating discourage adhesions by becoming a hydrogel barrier with a hydrophobic property.

C-QUR mesh is a polypropylene mesh coated with a proprietary blend of Omega 3 fish oil (Fig. 23.6). The coating undergoes a metabolic hydrolysis in the human host. The bonds are broken and the constituent parts are absorbed through natural lipid metabolism mechanisms. Unlike the previous barriers, which break down in a matter of a few weeks, this process occurs over about a 6-month period, allowing for more time for the polypropylene to incorporate into the host tissue, the bowel to repair, and the neoperitoneum to form.

There are still other meshes on the market, each with their unique barrier designed to decrease adhesions.



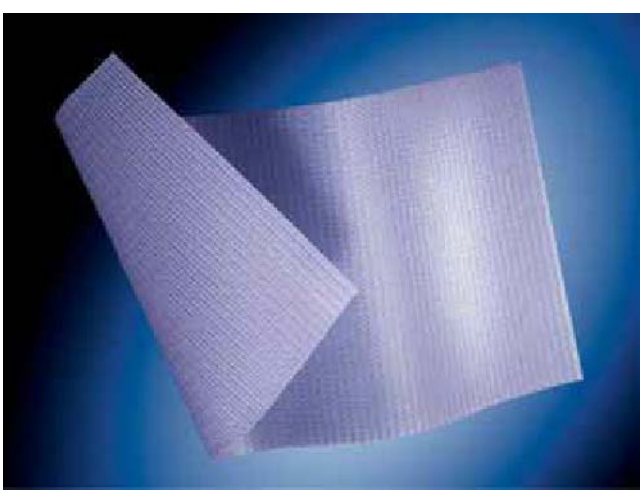

**Figure 23.5** Sepramesh® IP Composite. Sepramesh is a registered trademark of Genzyme Corporation licensed to C. R. Bard, Inc.

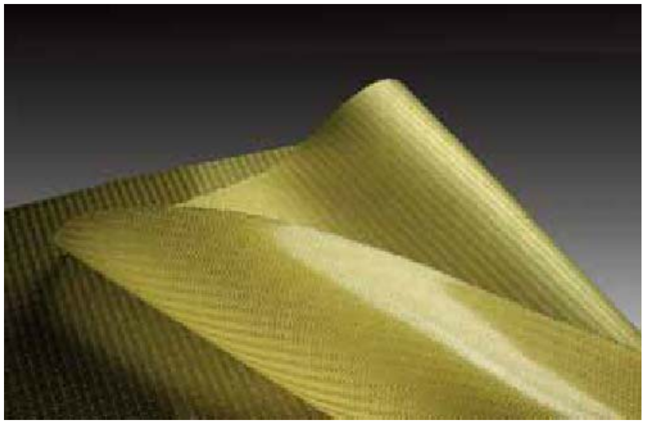

**Figure 23.6** C-QUR mesh. (Image courtesy of Atrium Medical Corporation.)

# Selecting an Optimal Mesh

There are more than 70 meshes available on the market making the variety of meshes to choose from seem almost endless. How does a surgeon choose which one to use in a given case? This would be an easy question if there were an ideal mesh on the market, but a "one size fits all" is not available. To determine which mesh to use, there are at least six issues to consider.

## Location of Use

The key component of this question is whether or not the mesh will be exposed to the intraabdominal contents. The use of a barrier-coated or a two-sided mesh is the only logical choice if one side of the mesh will be exposed to the intraabdominal viscera. This raises the question of which mesh is the best at reducing adhesion formation on the one side while incorporating well into the abdominal wall on the other side.

## Method of Implantation

The desired handling characteristics for a mesh in an open repair may be different from that in a laparoscopic repair. In an open hernia repair, a mesh that is reasonably stiff allows for easy handling and implantation. The opposite is true for a laparoscopic repair, where the mesh is tightly rolled in order to be placed in the abdomen through a small hole. This has to be done without disrupting any of the coating that protects the bowel from the mesh. And, after it is placed in the abdomen, it has to be unrolled so it can be secured in place. Ease of handling becomes a very subjective evaluation. Each surgeon has his or her desired feel for a mesh as it is being implanted. Though this may have little to do with the final performance of the mesh, it probably plays a larger role in mesh selection than is given credit.

## Hernia Repair Characteristics

Is the mesh used to bridge a gap or to reinforce a fascial closure? This is where the weight or density (usually measured in $g/m^2$) of the mesh comes into consideration. Although there is no industry standard independent from manufacturing marketing terminology to determine if a mesh is heavyweight or lightweight, several companies manufacture a lighter version of their meshes and call it "lightweight" mesh. The theory is that the lighter weight mesh would have a lower foreign body reaction and greater flexibility than the heavier weight mesh. This could lead to the formation of a scar "net" instead of a scar "plate" with there being less mesh erosion into surrounding tissues and less long-term pain. The difficulty is that there is no real data to determine what is the optimal mesh density. Two studies have shown that for an inguinal hernia repair, there was less pain and a decreased feeling of a foreign body by patients with a lightweight mesh compared to those with a heavyweight mesh. For these reasons, one should consider moving to a lightweight mesh, especially when the mesh is being used to reinforce a fascial closure. The jury is still out when it comes to bridging a large fascial defect. Even though lightweight mesh may be very appropriate for an inguinal hernia repair or fascial reinforcement when the fascia can be primarily closed, it may not withstand the rigors of bridging a large gap in an abdominal wall hernia in a morbidly obese patient or the repetitive intraabdominal forces in all patients.

## Clinical Efficacy

The ultimate goal in any abdominal wall hernia repair is restoring a functional abdominal wall to the patient in keeping with the patient's goals of the operation. Clinical efficacy is a wide net catching such concepts as recurrence, chronic pain, abdominal wall compliance, and mesh erosion. Precious few studies pit different meshes head to head to compare such issues as recurrence. In an inguinal hernia repair, for example, the recurrence is so low with a mesh repair that it is reasonable to expect that a study will never be done that will show one synthetic mesh superior to another. The same is true for abdominal wall compliance and erosion.

There should be a word about enterocutaneous fistulas and mesh. The formation of an enterocutaneous fistula is a serious complication, with mortality reported to be at least 7%. Leber studied the long-term complications of using a prosthetic repair for an incisional hernia by doing a retrospective review of 200 patients who underwent repair. Four different types of prosthetic materials were used for an open incisional hernia repair during this 10-year period. The polyester mesh (Mersilene) had a 15.6% incidence of fistula formation and the polypropylene (Marlex) had a 1.7% incidence, whereas the double-filament (Prolene) and ePTFE (Gore-Tex) meshes had none. However, others have reported excellent results with polyester mesh, challenging Leber's conclusion. Still others have reported enterocutaneous fistulas with ePTFE and polypropylene meshes.

## Safety

In the end, we want to implant a material that will be safe for the patient. Some materials such as polypropylene, polyester, and PTFE have been used in humans for such a long time that the question of them being carcinogenic has evaporated. But, the question of safety must never leave our mind, especially when a new allograft or xenograft biologic mesh enters the market. For ourselves and for our patients, we must have utmost assurance that there is no carcinogenic, allergenic, hypersensitivity, or transmission of tissue-borne pathogen risk to the patient from a materials perspective. This is especially true when a new mesh enters the market, as there are alternatives that have stood the test of time.

## Cost and Availability

Though the exact cost of a specific piece of mesh may be a little difficult to obtain, it should not be ignored when making a selection for repair. There are plenty of good choices of mesh made of the same materials and with very similar physical characteristics that cost should be considered in purchasing. Granted, the more specialized barrier-coated meshes and especially the biologic meshes are harder to compare side by side.

## Patient's Cultural and Religious Background

The choice of a mesh must not be made without engaging the patient in the discussion. This is usually not an issue with patients when choosing a prosthetic such as polypropylene, polyester, or ePTFE. It can be a much larger issue when deciding on a biologic mesh. For example, it would be wise to seek informed consent from a person from India before using one of the bovine-based meshes before implantation. In a similar manner, religious commitment may prevent patients from accepting a human-based mesh. Though these objections will be fairly rare, it would be a good practice to inform every patient with whom you plan to use a mesh, biologic or otherwise, of its composition and seek that person's permission to use the mesh you are considering before putting it in the patient. This can save a lot of grief on your part and the part of the patient in the future.

## Field: Infected or Not

Finally, the mesh should be selected in consideration of the field in which it will be placed. Is this a contaminated wound or clean wound? What is the likelihood that the mesh will become exposed? ePTFE, for example, performs very poorly if it becomes infected and almost always has to be removed. Polypropylene and polyester, on the other hand, might be salvaged with antibiotics if they become infected. And, if a piece of it becomes exposed, the space between the strands is of a sufficient size in some of the meshes to allow granulation tissue to grow between them. This could then be managed without removal of the mesh. If the wound were grossly infected, consideration of a biologic mesh would be in order. An alternative would be to fix the hernia with an absorbable mesh, such as Vicryl, and plan for a more definitive repair at a later time when the conditions are more favorable.

# CONCLUSION

The ideal mesh has yet to hit the market. Unfortunately, most patients cannot wait until the right one does come along, and therefore surgeons must choose a mesh available on the market now. With over 70 to choose from, that can be a bit onerous. By giving a general outline of what should be looked for in a mesh and what is available, we hope this helps surgeons make a reasonable selection in the clinical situations they face in daily practice of hernia repair.

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# 24 Giant Prosthetic Ventral Hernia Repair

**Gina L. Adrales**

## INDICATIONS/CONTRAINDICATIONS

Giant hernia (Fig. 24.1 and 24.2) has been defined arbitrarily in the literature as greater than a diameter of 10 to 15 cm or an area of 170 to 200 $cm^2$. As the survival of complex trauma and abdominal catastrophe patients has increased, the frequency and complexity of repairing the giant ventral defect have escalated. Obesity and loss of domain pose additional challenges. The relative indications and contraindications for giant synthetic prosthetic hernia repair are as follows:

*Indications*

- Incisional or ventral hernia causing pain or obstructive symptoms

*Contraindications*

- Ongoing wound infection is a contraindication to permanent synthetic mesh repair. Biologic mesh may be considered.
- Prior significant wound infection, particularly involving methicillin-resistant *Staphylococcus aureus,* is a relative contraindication to permanent synthetic mesh repair.
- Prohibitive operative risk in a patient without acute obstruction.

## PREOPERATIVE PLANNING

Careful evaluation of the patient is essential. Particular attention should be paid to the presence of obstructive pulmonary disease, chronic cough or constipation, prostatism, immunocompromised status, and obesity. Such factors, such as severe obesity, may alter the operative approach due to concern for abdominal compartment syndrome or may preclude a robust repair due to constant increased abdominal pressure. Thorough review of previous operative notes is helpful to discern the type and position of previous prosthetic material. Previous intraperitoneal mesh placement may be associated with increased abdominal adhesions. The surgeon should also inquire about previous wound or mesh infection.

**Figure 24.1** CT scan of giant hernia.

Physical examination of the patient should include the following:

- Measurement of the hernia defect(s)
- Location of the defect(s) in relation to bony structures (e.g., iliac crest, pubis, xiphoid)
- Chronic infection, foreign body reaction or skin breakdown, fistula
- Palpable prior mesh
- Presence of pannus and relation to hernia sac
- Skin inspection (e.g., skin graft, eczema, psoriasis, cutaneous Candidiasis, chronic infection). Chronic skin conditions should be treated optimally, and fungal infection should be cleared prior to surgery.


**Figure 24.2** Patient with giant recurrent, incisional hernia (diameter 19 cm) after previous mesh infection. Through counseling, dietary adjustment, and light exercise, this patient was able to lose 50 lbs in preparation for open repair.

**Figure 24.3** CT scan of loss of domain. Note the large pannus. Proximity of the fascial defect to the bony pelvis also increases the complexity of this large hernia.

Preoperative imaging is not imperative for all ventral hernias. However, such imaging can prove useful in the case of the giant ventral hernia. Preoperative CT or MRI should be obtained to determine the size of the fascial defect, presence of additional fascial defects, the proximity of the hernias to bony structures, degree of lateralization of the abdominal musculature, attenuation of the abdominal musculature, extent of bowel involvement, and loss of domain (Fig. 24.3).

## Preoperative Risk Reduction

Due to the adverse effects of smoking and obesity on postoperative infection and wound complications, the patient must be counseled regarding preoperative smoking cessation and weight loss. While it may be unrealistic to require significant weight loss, a reasonable goal may often be set with the patient through comprehensive counseling regarding dietary and behavioral changes and the adverse effect of obesity on surgical outcome.

For patients who have loss of domain, preoperative treatment with progressive pneumoperitoneum or implantation of tissue expanders may be utilized to facilitate abdominal wall reconstruction and reduced risk of abdominal compartment syndrome. Botulinum injection has also been reported with success, though widespread data are lacking.

Chronic skin conditions should be treated optimally prior to surgery to reduce the risk of infection. Eradication treatment should be implemented for patients with recurrent infections with methicillin-resistant *S. aureus*.

# SURGERY

### Surgical Selection

Ideally, the surgical treatment of the giant hernia should result in a durable repair that also matches the goals of the patient. There is no universal algorithm to address the giant hernia. Instead, the care of these complex patients requires a tailored, individualized approach generated from the best medical evidence and modulated by both patient

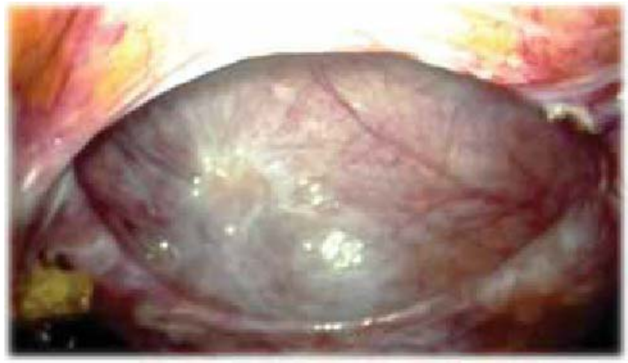

**Figure 24.4** Laparoscopic view of large defect.

factors and the patient's concerns. Consideration should be given to the presence or history of wound or mesh infection, obesity, loss of domain, skin loss or excessive scar such as prior skin graft, and the main concerns of the patient (e.g., pain, hernia recurrence, scar revision, laxity). Giant hernias are often the result of previous complex abdominal surgery and associated skin grafts, leaving the patient with significant loss or retraction of abdominal musculature and undesirable scarring. Open hernia repair with midline abdominal reconstruction with mesh reinforcement and scar excision or revision is the procedure of choice for the patient whose primary concerns are cosmesis and lack of abdominal support. This is also the preferred procedure for patients who are not candidates for permanent synthetic mesh and require a biologic mesh. A laparoscopic approach is associated with a lower risk of wound complications and infection and is favored for other patients, particularly the obese (Fig. 24.4). A hybrid repair, involving endoscopic component separation and open midline reconstruction with mesh reinforcement bridges the gap between the two techniques, providing a midline reconstruction but a lower risk of wound complications. Similarly, endoscopic component separation and laparoscopic midline sutured closure with permanent synthetic or biologic mesh reinforcement is also feasible for select patients.

# Laparoscopic Giant Herniorrhaphy

The technique of laparoscopic ventral hernia repair is described elsewhere in this manuscript. There are several additional measures that should be considered for laparoscopic repair of massive hernias, particularly cases of loss of domain. Due to the limited working space available at the onset of the surgery as well as further decreased space as the hernial contents are reduced, appropriate lateral port placement and frequent adjustment of patient position during the surgery are necessary for adequate visualization. The giant hernia also requires special considerations for dissection and mesh handling. Importantly, extra precautions should be taken throughout the procedure to avoid thermal intestinal injury related to use of electrosurgical instruments.

## Positioning and Port Placement

- The patient is positioned supine with the arms tucked. The patient should be secured well, as rotation of the operating table during adhesiolysis and mesh placement may be needed.
- Veress needle access or open Hasson technique is used according to the surgeon's expertise and comfort. The location of prior incisions or mesh and the degree of obesity will dictate the feasibility of either technique.
- Lateral port placement is imperative (Fig. 24.5).
- At least two 5 mm trocars and one 10 to 12 mm trocar for mesh insertion are used. Extra trocars are often needed to facilitate adhesiolysis and mesh fixation.
- An angled 5 mm laparoscope is used.

**Figure 24.5** Laparoscopic repair of a giant incisional hernia. An occlusive skin barrier and multiple lateral ports are used.

## Technique

- Meticulous adhesiolysis is performed with limited to no use of energy sources in an effort to avoid thermal visceral injury. Clips should be used for hemostasis where appropriate.
- The bowel should be inspected as the enterolysis is performed and afterward to ensure the absence of bowel injury. If this is uncertain or if a full thickness bowel injury has occurred, a staged repair is advised. The prosthetic mesh placement is delayed a few days until bowel function has returned and there is no clinical evidence of infection. This approach is supported in the literature. Alternatively, conversion to an open procedure and midline reconstruction with biologic mesh reinforcement is a viable option.
- Adjustment of patient position to enable adhesiolysis and mesh fixation is helpful.
- Reduction of the pneumoperitoneum pressure or switch to nitrous gas may be needed during a lengthy adhesiolysis.
- Defect measurement is performed internally, a more accurate method compared to external measurement. Using spinal needles inserted at the longest and widest margins of the defect, the defect is measured by stretching a length of suture between the two needles in the vertical and transverse directions intraperitoneally. The suture is then removed from the abdomen and measured extracorporeally.
- The large prosthesis can be unwieldy. Folding the mesh in half prior to rolling it facilitates faster handling intraperitoneally; the edges of the folded mesh are grasped and splayed apart intraabdominally to quickly unfurl the mesh.
- Mesh fixation is accomplished by securing the four anchor sutures, followed by circumferential tacks. Additional transfascial sutures are placed every 3 to 4 cm around the periphery of the mesh. Fixation of the mesh to the anterior superior iliac spine or pubis with bone anchors is needed for the large defect that encroaches the bony pelvis. The goal is to provide at least 5 cm of mesh overlap.
- As described by Baghai et al., mesh fixation in the patient with loss of domain is accomplished while working above the mesh through additional port placement, with visualization above and below the mesh to ensure no visceral injury, and frequent changes in patient positioning for visualization and protection of the bowel.

# Open Giant Herniorrhaphy with Mesh

The open repair allows excision of the prior surgical incision and skin graft. A number of techniques and modifications have been described.

### Rives–Stoppa Repair

Employing the Rives–Stoppa repair in the management of the giant ventral hernia may require a modification to intraperitoneal mesh placement with a barrier-type mesh to reduce intraabdominal adhesions. This is the equivalent of a laparoscopic approach but may be preferred in cases where a hostile abdomen precludes laparoscopic adhesiolysis or when scar excision is desired. Due to the large defect and the wide lateralization and shortening of the rectus abdominis muscles, anterior fascial closure over the mesh may not be possible. The mesh should be secured laterally with transfascial sutures using a laparoscopic suture passer or Reverdin needle. Intramuscular placement between the internal oblique and transversus abdominis layers has also been described.

### Component Separation with Prosthetic Reinforcement

Introduced by Ramirez et al. in 1990, midline abdominal reconstruction through separation of the myofascial components of the abdominal wall has become increasingly popular with varied results. The shortcomings of the repair, namely seroma and wound complications and lateral herniation, have been addressed through sparing of the perforator vessels and umbilicus and umbilical pedicle, endoscopic component separation to avoid the large skin and subcutaneous flaps, and prosthetic reinforcement to include underlay coverage of the lateral release sites at the semilunar lines. A modification of the original technique with release of the posterior rectus sheath and reapproximation of the medial border of the posterior sheath to the lateral border of the anterior sheath bilaterally, then reapproximation of the medial anterior sheathes at the midline was described by DiCocco et al. to increase the degree of mobilization of the myofascial components for the large defects encountered after damage control trauma laparotomy. Endoscopic component separation should match the open approach with continuation of the release of the external oblique into the muscular portion above the costal margin and with release of Scarpa's fascia. Midline fascial closure should be performed with a four to one suture length to wound length ratio, with frequent but small fascial bites.

## POSTOPERATIVE MANAGEMENT

Preoperative counseling and discussion of expected postoperative pain and recovery is essential in preparing the patient for a successful postoperative course. Early ambulation and incentive spirometry are encouraged. An abdominal binder provides the patient with the abdominal support to meet these goals. Preemptive anesthesia with local anesthetic injection may reduce postoperative pain and narcotic use. Persistent suture site pain is treated with rest, anti-inflammatory medications, and local anesthetic injection for refractory pain.

Vigilance in the early postoperative period for missed or thermal bowel injury should be exercised. Often, tachycardia is the first and only sign of this complication in the early postoperative period.

Suprafascial drain placement during open repair is recommended to evacuate the postoperative seroma. Patients should be counseled preoperatively regarding the likelihood of seroma formation. Seroma after laparoscopic ventral hernia repair is expected and is typically left undisturbed to resorb naturally.

# Outcomes

Due to the variations in reported technique and mesh type, definitive rates of complications for each surgical approach are difficult to determine from the surgical literature. Additionally, reported outcomes for the repair of giant hernias, in particular, are limited to a few case series. Overall, ventral and incisional hernia recurrence rates are lowest for laparoscopic mesh repair (2.9% to 12.5%) and Rives–Stoppa mesh repair (5% to 6%).

Open component separation is associated with a significant risk of wound complications (52% to 57%) and hernia recurrence (20% to 37%). The American College of Surgeons National Surgical Quality Improvement Program reports a lower 30 day morbidity after laparoscopic repair (6%) compared to open repair (3.8%), with the widest disparity for strangulated and recurrent hernias. While the laparoscopic approach has been shown to be feasible and safe for the giant hernia, considerable expertise with the technique is required to meet the technical challenge posed by these large hernias.

## CONCLUSIONS

- The surgical approach to the large ventral hernia is guided by patient factors and the patient's goals for repair.
- Open technique is used when
  - scar revision is desired
  - laxity is a concern and midline abdominal wall reconstruction is preferred
  - permanent synthetic mesh is prohibited and biologic mesh is needed (e.g., enterocutaneous fistula)
- The laparoscopic approach may be challenging and may require frequent patient position changes, reduction of pneumoperitoneum, or fixation of the mesh from above the mesh (as in the case of loss of domain).
- Wound complications are the most frequent adverse event after open giant hernia repair.
- Hernia recurrence risk varies widely depending on the surgical approach, though studies focusing solely on giant hernia are lacking.

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# 25 Massive Ventral Hernia with Loss of Domain

**Alfredo M. Carbonell**

## INDICATIONS/CONTRAINDICATIONS

- Definition of loss of abdominal domain.
  - There exists no consensus in the literature on the definition of loss of abdominal domain. Determination of this condition is subjective and typically refers to massive hernias with a significant amount of intestinal contents, which have herniated through the abdominal wall into a hernia sac, forming a secondary abdominal cavity.
  - On physical examination, the inability to reduce the herniated contents below the level of the fascia when the patient is lying supine should raise suspicion of the diagnosis.
  - Although the surgeon can often make the assumption that a patient has loss of domain on physical examination (Figs. 25.1 and 25.2), we utilize computed tomography (CT) to determine the true nature of the hernia.
- Measuring loss of domain
  - We arbitrarily define a loss of abdominal domain on CT scan as greater than 50% of the intestinal contents lying outside the native abdominal cavity in the hernia sac. This may be more accurately defined when the ratio of the volume of the hernia sac to the volume of the abdominal cavity is $\geq 0.5$.
  - A sagittal reconstruction of the CT scan is used to measure the length of the hernia sac from the top to the bottom of the sac. The length of the abdominal cavity is measured from the top of the diaphragm to the top of the symphysis pubis (Fig. 25.3).
  - Axial reconstructions are used to measure the width of the hernia sac and abdominal cavity at their widest point. The height of the hernia sac is measured from an imaginary line drawn across the hernial orifice to the apex of the hernia sac at its tallest portion. The height of the abdominal cavity is measured from the anterior portion of the fourth lumbar space to an imaginary line drawn across the hernial orifice (Fig. 25.4).
  - Using the formula to measure the volume of an ellipsoid ($V = 4/3 \times \pi \times r1 \times r2 \times r3$), the hernia sac and abdominal cavity volumes can be measured and compared.

**Figure 25.1** Preoperative picture of a patient with a midline loss of domain.

**Figure 25.2** Preoperative picture of a patient with a subcostal loss of domain.

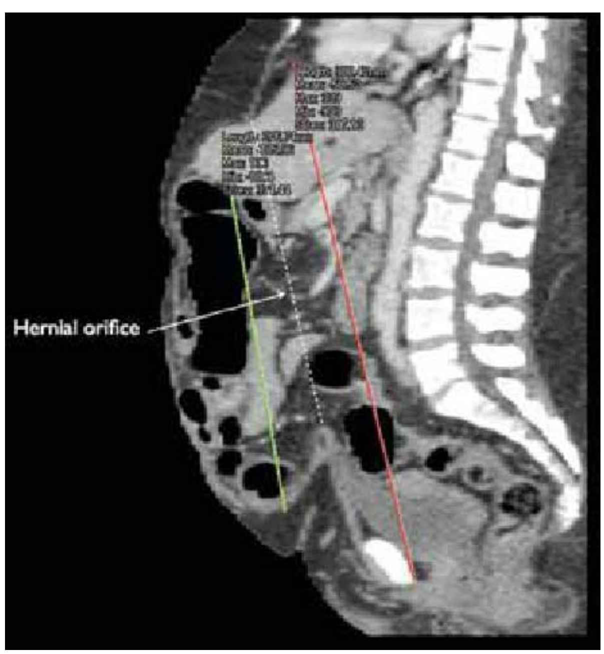


**Figure 25.3** CT with sagittal reconstruction used to calculate the ratio of the hernia to abdominal cavity volume. Dotted white line represents hernia aperture. Red line indicates length of abdominal cavity, and green line the length of the hernia sac.


**Figure 25.4** CT with axial reconstruction. Dotted white line represents hernia aperture. The blue line indicates the width, and the green line, the height of abdominal cavity. The light blue line indicates the width, and the purple line, the height of the hernia sac.

To simplify the ellipsoid volume equation, multiply the length, height, and width measurements of the cavities times a factor of 0.52 ($V = 0.52 \times L \times H \times W$). Loss of domain exists when the ratio of the volume of the hernia sac to the volume of the abdominal cavity is $\geq 0.5$.

- Physiology of hernias with loss of abdominal domain
  - In patients with loss of abdominal domain the bowels reside outside the abdominal cavity. As intraabdominal pressure decreases to approach atmospheric pressure, abdominal viscera become edematous and their vasculature become engorged. This makes simple hernia reduction near impossible.
  - Respiratory function is altered secondary to the loss of diaphragmatic support, and anterior spinal support fails leading to lordosis.
  - The difficulty in repair of these hernias is that, not only are the herniated contents difficult to relocate back into the abdominal cavity, but doing so abruptly may result in postoperative physiologic collapse due to the creation of abdominal compartment syndrome.

# Abdominal Wall Reconstruction Techniques

- Reconstruction techniques for hernias with loss of domain must focus first upon the ability to relocate the herniated contents back into the native abdominal cavity and secondly, the ability to re-approximate the midline fascia overtop a retromuscular-implanted prosthetic mesh.
- To re-accommodate such a large volume of herniated contents, the surgeon must employ a modality which increases the volume of the abdominal cavity. This can only occur by lengthening the abdominal wall musculature via either:
  - Mechanical traction
  - Anatomic alteration
  - Synthetic replacement
  - Combination of techniques
- **Mechanical Traction**
  - *Progressive preoperative pneumoperitoneum*
    - Insufflation of the peritoneal cavity acts as an intraperitoneal pneumatic tissue expander and lengthens the abdominal wall musculature, increasing the volume of the abdominal cavity. This allows for adequate accommodation for the herniated contents and is our preferred preparatory technique.
    - It also attenuates the adverse physiologic effects associated with ventral hernia repair in patients with a loss of abdominal domain, by slowly creating a chronic abdominal compartment syndrome. With decreased diaphragmatic excursion,

the patient is forced to overcome the inherent decreased inspiratory capacity. In addition, the adverse cardiovascular effects of acute abdominal compartment syndrome are attenuated by the slow introduction of intraperitoneal air.

- *Laparostomy with progressive mesh excision*
  - This technique employs a synthetic mesh sewn to the edges of the hernia defect as an inlay. Over multiple successive operations, a central portion of the mesh is excised, and the mesh re-sutured in the midline. This provides a slow and progressive mechanical traction on the midline fascia, allowing for eventual fascial re-approximation. Although effective, this technique is cumbersome, and requires multiple operations.
- *Tissue expanders*
  - Synthetic tissue expanders can be placed between abdominal wall muscle layers and slowly expanded over the course of several weeks. The expander balloon lengthens the abdominal muscles by exerting a mechanical traction. We prefer this technique for skin expansion alone, when there is a concern over potential inadequate skin coverage during hernia repair.

- **Anatomic Alteration**
  - *Component separation*
    - This technique provides an increase in abdominal circumference with the possibility of subsequent fascial closure by disconnecting musculofascial layers, which lengthen the overall abdominal wall musculature. We employ a unique posterior component separation technique with retromuscular mesh reinforcement of the abdominal wall reconstruction.
- **Synthetic Replacement**
  - *Silo technique*
    - This technique is utilized for hernia defects so wide that no preparatory techniques or intraoperative maneuvers available would allow for native fascial re-approximation. These hernias require that a synthetic mesh span the entire defect and contain the herniated intestines like a silo, similar to the technique used for treatment of congenital abdominal wall deformities such as omphalocele and gastroschisis. The only difference here, being that the prosthetic is left *in situ* with skin and subcutaneous coverage alone. This is the least desirable of all the techniques; however, it may be the only option in select patients.

## PREOPERATIVE PLANNING

- Physical examination
  - The physical examination alone is often helpful in determining whether a patient has loss of domain. With the patient lying supine on the examination table, the surgeon should attempt to reduce the herniated contents below the fascia. If the hernia does not reduce due to the amount of herniated contents, the patient likely has a component of loss of domain.
  - The abdominal wall should be examined for elasticity. Although some massive hernias may be irreducible, the patient's abdominal wall musculature may have such elasticity so as to accommodate the herniated contents easily at the time of surgery. This finding would obviate the need for any preparatory procedures such as progressive preoperative pneumoperitoneum, since a single stage repair may be feasible.
  - The quality of the skin should be examined to determine if any adjunctive maneuvers will be required to obtain safe skin closure at the time of hernia repair.
  - Widened thin scars, skin ulceration, thin subcutaneous tissue with tense and immobile skin, and large pannus flaps should all raise concern over skin closure. Consultation with a plastic surgeon may help to determine the need for preoperative tissue expanders, panniculectomy, or complex skin closure at the time of hernia repair.

- Computed tomography (CT)
  - As previously described, the volume of the hernia sac and abdominal cavity are calculated and compared. A volume ratio of the hernia sac to the abdominal cavity of ≥0.5 confirms loss of abdominal domain.
  - Other attributes of the abdominal wall should be examined on CT as they may help determine which adjunctive maneuvers will be required for hernia repair.
  - In our experience, patients with smaller defects and a significant amount of herniated contents benefit the most from progressive preoperative pneumoperitoneum.
  - Patients with round-shaped abdominal cavities on axial imaging and thick, robust rectus abdominis and oblique muscles may experience less muscle lengthening with preoperative pneumoperitoneum compared to those with a more ellipsoid appearance to the abdominal wall and thin atrophic musculature.
  - Patients with "open book" abdomens such as those with significant loss of abdominal wall substance (missing abdominal wall musculature) and hernia defects which span the entire abdominal wall may not benefit anatomically from preoperative pneumoperitoneum as there may not be enough abdominal wall musculature to stretch. The physiologic benefits may still be realized, however. These patients may be best served by the silo technique.
- Perioperative analgesia
  - Strong consideration should be given to the use of epidural anesthesia in the postoperative arena.
  - The cardiac and pulmonary benefits of epidural anesthesia have been proven and in these patients, preservation of pulmonary function is often critical to their recovery.

# SURGERY

- Our preferred approach to hernias with loss of domain is progressive preoperative pneumoperitoneum, to prepare patients both physiologically and anatomically for the repair.
- This is followed by the posterior component separation technique with retromuscular mesh placement.
- We will also discuss the laparostomy with serial mesh excision technique as well as the silo technique.

## Progressive Preoperative Pneumoperitoneum and Posterior Component Separation Technique

- Stage I
- Placement of percutaneous vena cava filter
  - Progressive preoperative pneumoperitoneum significantly elevates the intraabdominal pressure and creates a chronic abdominal compartment syndrome. As a result, there will be decreased venous return through the vena cava and patients are at risk for thromboembolic events.
  - Percutaneous vena cava filters protect patients from life-threatening pulmonary emboli. They do not, however, prevent deep venous thrombosis.
  - We place patients on thrombotic chemoprophylaxis with heparin sodium.
  - Despite these aggressive measures, we have still had patients develop significant deep venous thrombosis and near caval occlusion. Full dose anticoagulation may be indicated in the more at-risk patients.
- Exploratory laparoscopy with placement of percutaneous catheter system
  - Exploratory laparoscopy allows for minimally invasive access to the abdominal cavity for direct visualization and placement of a percutaneously placed intraperitoneal catheter system for the pneumoperitoneum.

**Figure 25.5** Laparoscope placement in the right subcostal region for exploratory laparoscopy.

  - We utilize a 5 mm optical viewing trocar placed at the lateral hypochondrium (Fig. 25.5).
  - A peritoneal dialysis catheter is placed under direct vision utilizing the Seldinger technique with a percutaneous, tear-away introducer sheath (Fig. 25.6A, B).
  - The catheter cuff is placed into the subcutaneous tissue and the catheter sutured in position (Fig. 25.7).
  - The pneumoperitoneum is evacuated and the trocar site incision closed with an absorbable subcuticular suture.
- Patient care plan
  - The patient is admitted to a stepdown unit for close monitoring of pulse oximetry and all vital signs.
  - Chemothromboprophylaxis is begun postoperatively.
  - A full liquid diet with protein supplementation is started immediately.
  - The patient is instructed to utilize incentive spirometry and ambulate daily.
- Stage II
- Progressive preoperative pneumoperitoneum
  - Peritoneal insufflation begins on the first postoperative day, and is performed daily.

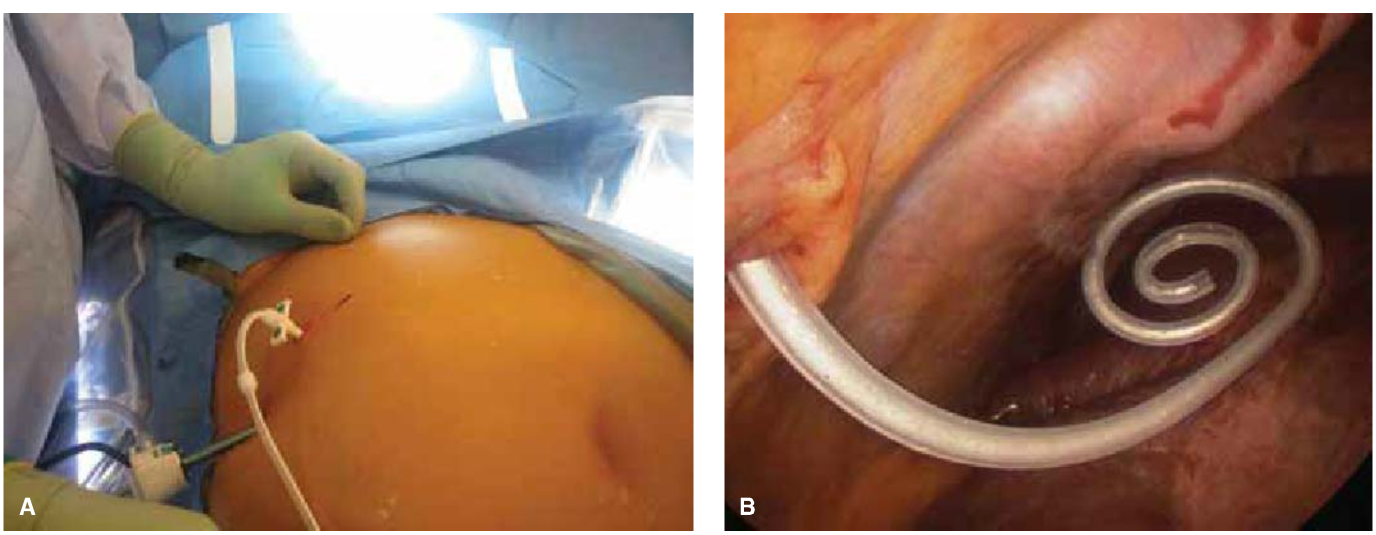


**Figure 25.6** **A:** Percutaneous placement of the peritoneal dialysis catheter to be used for daily insufflation. **B:** Laparoscopic view of intraperitoneal portion of peritoneal dialysis catheter.

**Figure 25.7** Catheter placement complete with the catheter cuff placed below the skin.

- Laparoscopic insufflation tubing is utilized to connect the air hose at the patient's bedside to the peritoneal dialysis catheter (Fig. 25.8).
- The air is turned on slowly to begin insufflation. The patient is closely monitored for signs of distress.
- The insufflation proceeds and the patient will begin to complain of abdominal tightness followed by mild flank discomfort. Once the patient begins to experience some shortness of breath or mild anxiety, the insufflation is stopped. There is no specific volume of air that should be injected nor the intraperitoneal pressure measured. The endpoint of insufflation will always be the patient's level of discomfort.
- The skin should be moisturized daily as pneumoperitoneum can lead to skin dryness and cracking.

**Figure 25.8** Air is insufflated via the wall air outlet and flowmeter via laparoscopic insufflation tubing connected to the patient's peritoneal dialysis catheter.

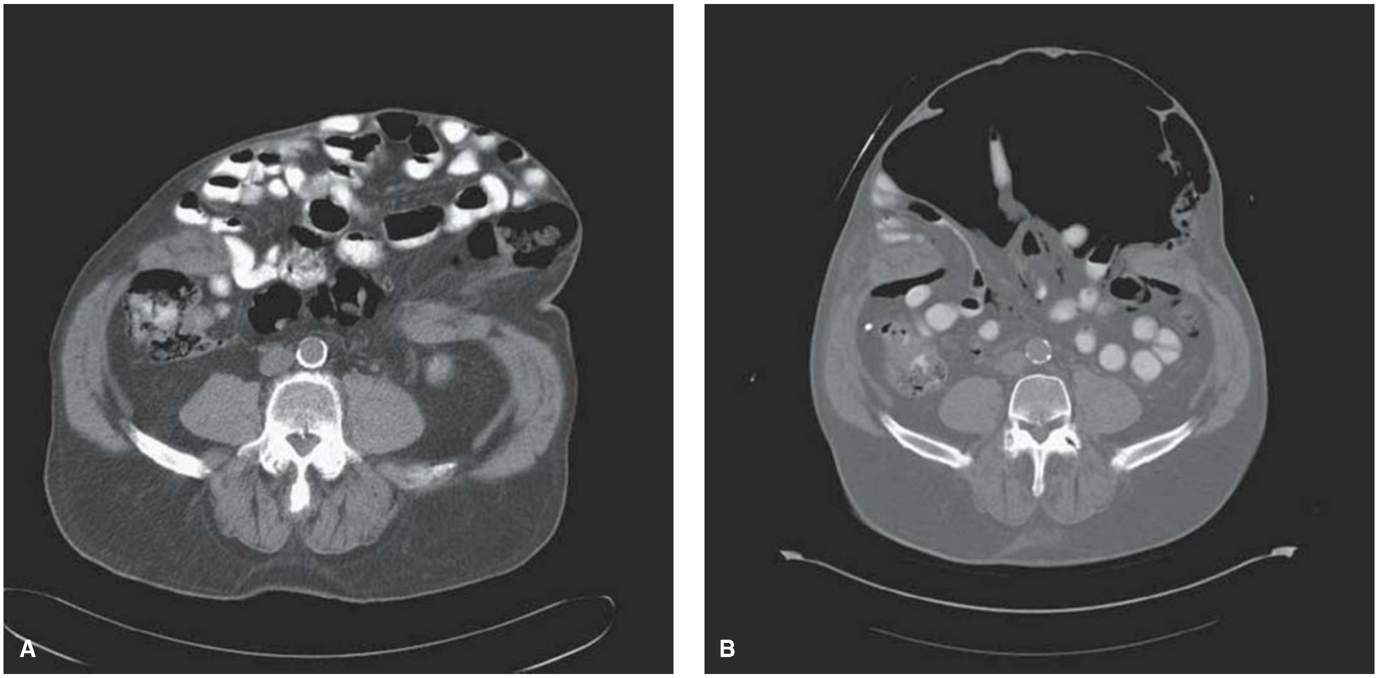


**Figure 25.9** **A:** Preoperative CT scan demonstrating herniated contents with loss of domain. **B:** CT in same patient after progressive preoperative pneumoperitoneum demonstrates that bowel contents have fallen below the level of the hernia orifice.

    - If at any point during this process the patient becomes hemodynamically unstable or develops decreased urine output, the pneumoperitoneum can be evacuated by wall suction aspiration.
- Repeat CT scan to determine suitability for Stage III
    - After 7 days of daily progressive preoperative pneumoperitoneum, a CT scan is performed to determine the suitability of the abdominal wall for repair.
    - The CT should demonstrate that the herniated contents have fallen back into the native abdominal cavity and now lie below an imaginary line drawn across the hernial orifice. (Figs. 25.9A, B and 25.10)


**Figure 25.10** CT in another patient similarly demonstrates that the bowel contents have fallen below the level of the hernia orifice.

    - If the bowel has not fallen back into the abdominal cavity and the volume of the abdomen does not look to have increased significantly, then pneumoperitoneum should continue for 4 to 5 more days and a repeat CT performed. If at this point there is no change, it is unlikely progressive preoperative pneumoperitoneum will work as a pneumatic tissue expander and consideration should be given to either tissue expanders, the silo technique, or even rotational or free myofascial flap closure of the abdominal wall.
- Stage III
- Abdominal wall reconstruction
    - Every effort should be made to ensure rectus abdominis re-approximation in the midline with ventral fascial closure overtop the mesh.
    - Our preferred method for abdominal wall reconstruction in these patients is the Rives–Stoppa retromuscular hernia repair technique with or without the addition of a posterior component separation (PCST).
    - The posterior component separation technique allows for similar midline fascial re-approximation in large defects as compared to the anterior, Ramirez component separation.
    - With the PCST, the transversus abdominis muscle (posterior) is disconnected from the internal and external obliques (anterior), which remain attached to the rectus muscle. By release of the posterior component, the anterior components can advance medially.
- Rives–Stoppa with PCST
    - After a complete lysis of adhesions a towel is placed intraperitoneally to protect the underlying viscera.
    - The posterior rectus sheath is divided vertically 1 cm or less from the edge of the linea alba and the division continues 5 cm cephalad to the hernia defect edge and 5 cm caudal to it (Fig. 25.11).

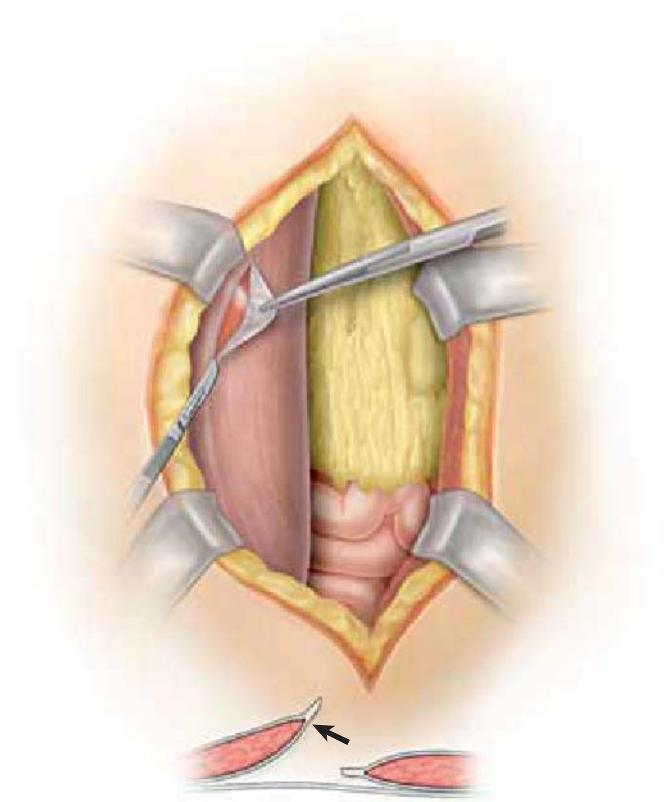

**Figure 25.11** Retromuscular hernia repair begins by entering the posterior rectus sheath 1 cm or less from the edge of the linea alba.

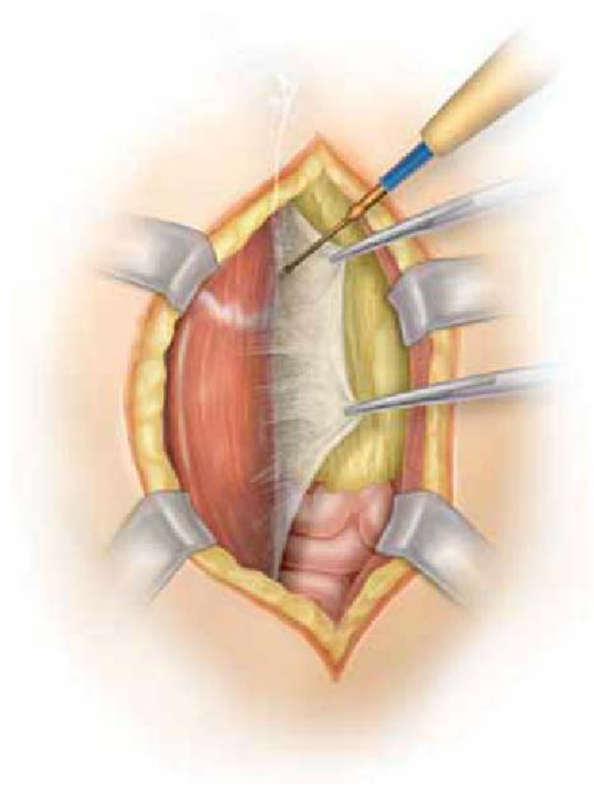

Figure 25.12 The posterior rectus sheath is reflected posteriorly under tension and the rectus muscle is gently dissected off the ventral aspect of the sheath.

- The posterior rectus sheath is reflected posteriorly under tension and the rectus muscle is gently dissected off the ventral aspect of the sheath (Fig. 25.12).
- A similar dissection is performed on the contralateral side.
- If it does not appear that the posterior rectus sheath will re-approximate in the midline under little to no tension, a PCST will be required.
- For the PCST, the dissection is carried to the lateral most extent of the rectus sheath. With a Richardson retractor reflecting the rectus laterally at this lateral extent, a subtle ridge will become evident. This ridge is formed by the rolled over anterior leaf of the internal oblique aponeurosis as it fuses with the transversus abdominis aponeurosis to form the posterior rectus sheath (Fig. 25.13).

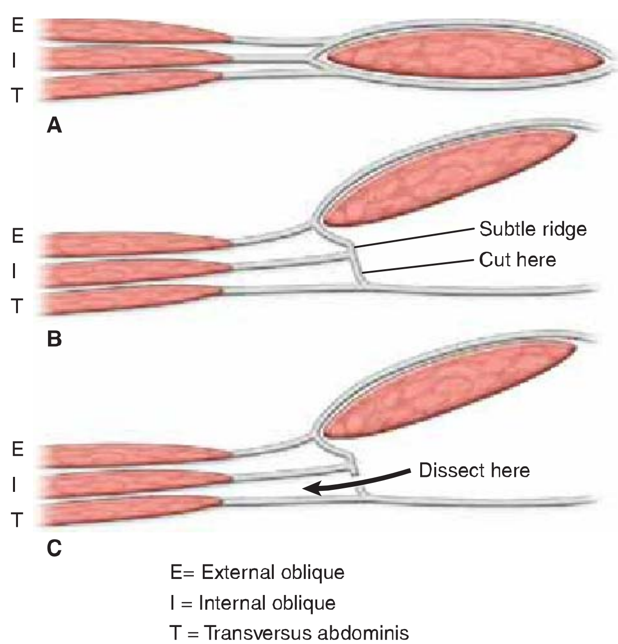


Figure 25.13 The Richardson retractor reflects the rectus muscle laterally at this lateral-most extent of the rectus sheath. A ridge is formed by the rolled over anterior leaf of the internal oblique aponeurosis as it fuses with the transversus abdominis aponeurosis to form the posterior rectus sheath.

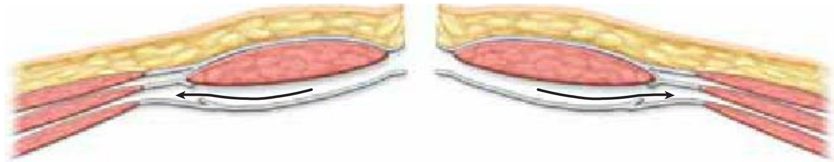

Figure 25.14 The fascia is incised 1 to 2 mm medial to the aforementioned ridge, gaining access to the interparietal plane between internal oblique and transversus abdominis muscle.

- By incising the fascia 1 to 2 mm medial to this ridge, the interparietal plane between internal oblique and transversus abdominis muscle will be accessed, and the incision is continued for the entire length of the skin incision and beyond (Fig. 25.14).
- Motor innervation of the rectus and oblique muscles is provided by the intercostal, sub-costal, iliohypogastric, and ilioinguinal nerves.
- The intercostal nerves of T7 to L4 run between the transversus abdominis and internal oblique muscles, and enter the undersurface of the rectus abdominis muscle at the junction of its lateral and medial third. These nerves will be encountered during the PCST and are routinely divided should they interfere with wide mesh placement. In our experience, this has not led to any abdominal wall paralysis or denervation bulge.
- The interparietal plane is dissected far out laterally. This dissection disconnects the transversus abdominis muscle from the anterior components, allowing medial advancement of the posterior rectus sheath for complete peritoneal closure as well as medial rectus advancement for total abdominal wall reconstruction. PCST provides a well-vascularized and wide space for mesh placement with similar advancement to the Ramirez component separation without the need for a subcutaneous skin dissection and its attendant morbidity.
- The protective towel, which was placed intraperitoneally, is removed now and the posterior rectus sheath is re-approximated in the midline with a slow-absorbing monofilament suture (Fig. 25.15).
- The synthetic mesh is placed in the retromuscular space and fixated with full-thickness permanent transabdominal sutures utilizing the Reverdin needle.

- See Fig. 25.16A, B, C.
  - The anterior sheath is closed in the midline ventral to the mesh utilizing a slow-absorbing monofilament suture utilizing a 4:1 suture to wound length ratio.
- See Fig. 25.17A, B.
- Intraperitoneal onlay of mesh (IPOM)
  - If the retromuscular space is inaccessible due to inflammation, fibrosis or rectus muscle absence, or the defect is lateral, then an alternate place for mesh placement needs to be chosen.



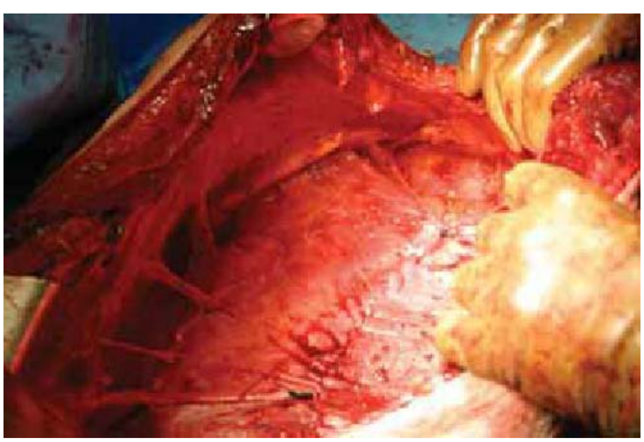

Figure 25.15 The posterior rectus sheath is re-approximated in the midline with a slow-absorbing monofilament suture.

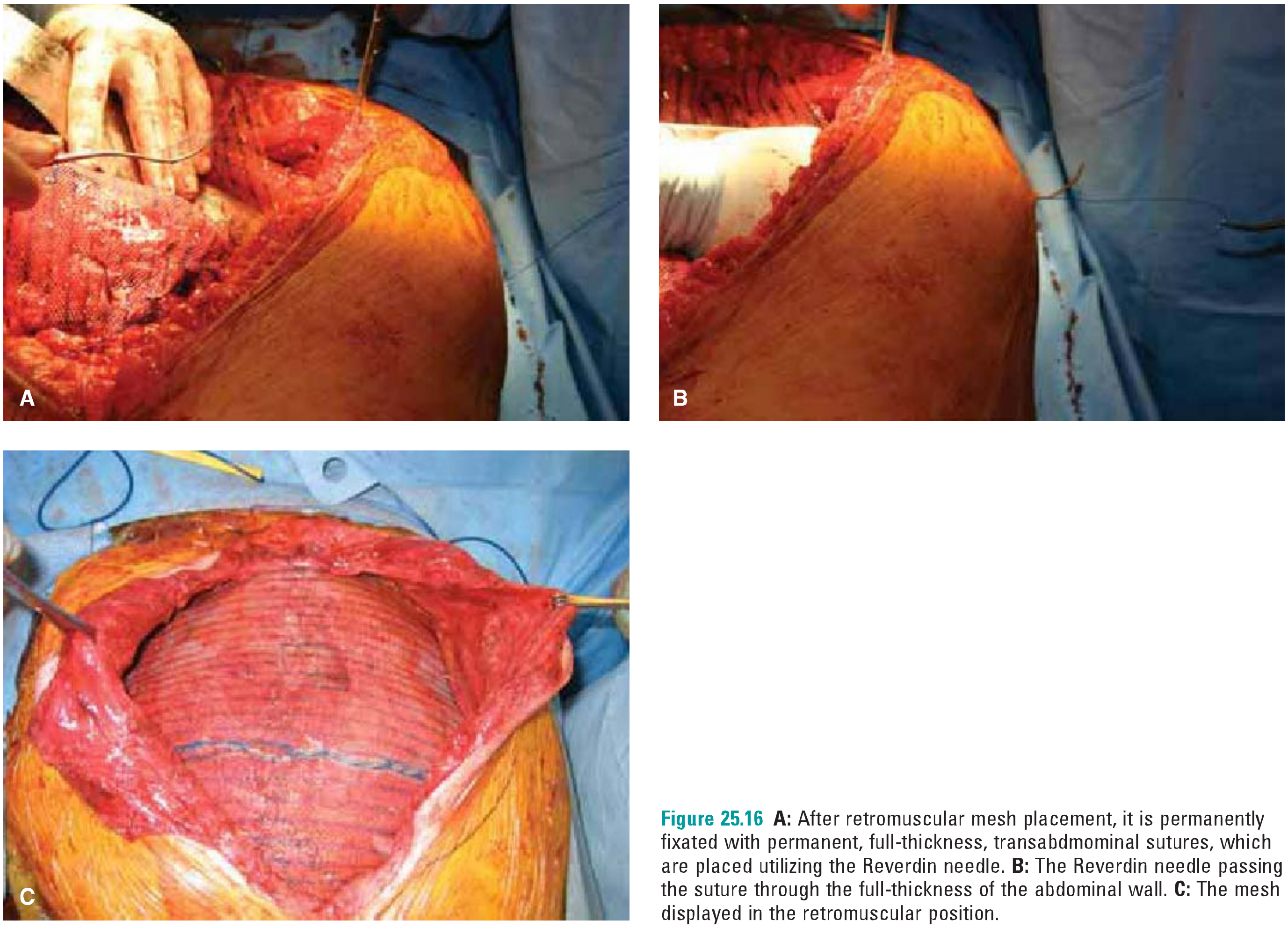

**Figure 25.16** **A:** After retromuscular mesh placement, it is permanently fixated with permanent, full-thickness, transabdmominal sutures, which are placed utilizing the Reverdin needle. **B:** The Reverdin needle passing the suture through the full-thickness of the abdominal wall. **C:** The mesh displayed in the retromuscular position.

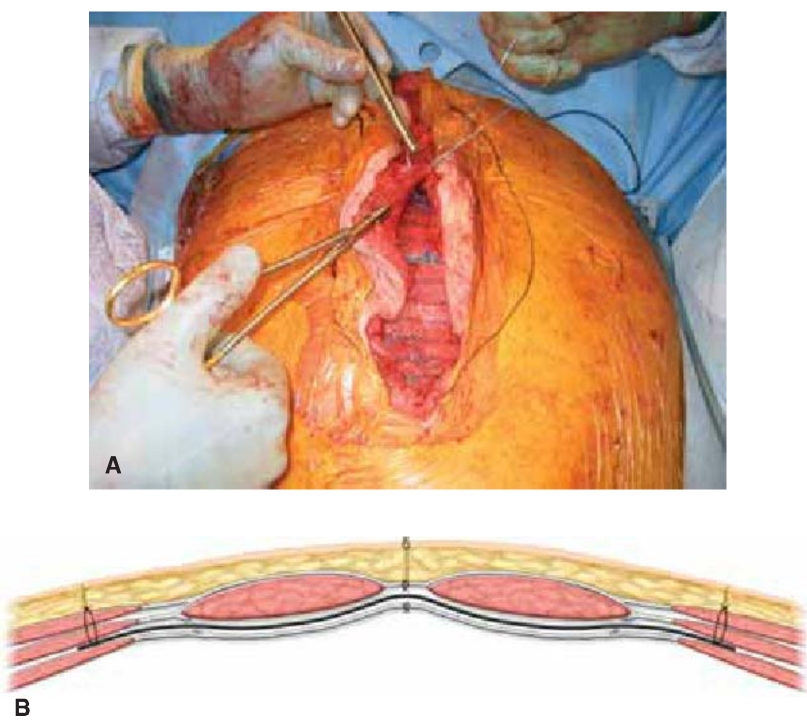

**Figure 25.17** **A:** The linea alba is sutured in the midline with a continuous, running, absorbable suture. **B:** Schematic demonstrating the completed posterior component separation with retromuscular mesh placement and midline fascial closure.

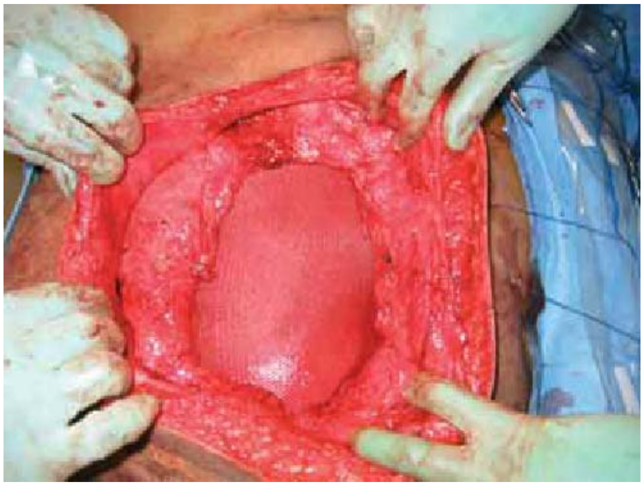

**Figure 25.18** Mesh placed as an intraperitoneal onlay.

- To ensure medial rectus re-approximation, a traditional, anterior Ramirez component separation technique may be performed.
- A tissue-separating mesh is then placed in the intraperioneal position and suture fixated circumferentially with a wide overlap (greater than 5 cm) and full-thickness permanent transabdominal sutures utilizing the Reverdin needle (Fig. 25.18).
- To prevent the mesh from buckling within the peritoneal cavity once the fascia is re-approximated above it the mesh should be placed intraperitoneally under some tension.
- Tension is held on the linea alba towards the midline as the mesh is being fixated on that same side. The maneuver is then repeated on the contralateral side. This ensures equal tension so that the mesh will be taut within the intraperitoneal cavity upon abdominal wall closure.
- The anterior sheath is then closed in the midline ventral to the mesh utilizing a slow-absorbing monofilament suture utilizing a 4:1 suture to wound length ratio.

- Silo technique
  - This is a useful strategy to employ for defects so wide that abdominal wall reconstruction is unfeasible.
  - Since skin and subcutaneous tissue will be the only coverage over the synthetic mesh, every effort should be made to ensure that there will be adequate, viable skin coverage available.
  - It is crucial to anticipate this potential roadblock so that skin tissue expanders can be placed preoperatively.
  - A tissue-separating or barrier-coated mesh is deployed in the intraperitoneal position and suture fixated circumferentially with a wide overlap (greater than 5 cm) and full-thickness permanent transabdominal sutures utilizing the Reverdin needle, just as described in the IPOM section.
  - Contrary to the IPOM, however, the silo technique makes no effort to re-approximate the line alba in the midline, so that the synthetic mesh acts as a bridge, spanning the hernial orifice, and contains the voluminous bowel loops.
  - Due to the significant amount of herniated contents, the mesh fixation to the abdominal wall should begin on one side of the abdomen and progress circumferentially, all the while protecting the bowel as the mesh slowly forms a cocoon over the abdominal cavity.
  - Due to the massive size of these hernia defects, it may be necessary to suture together multiple pieces of mesh like a quilt. In this event, we recommend suturing one mesh to each side of the hernia defect, and then suturing the two pieces of mesh together in the midline (Fig. 25.19).

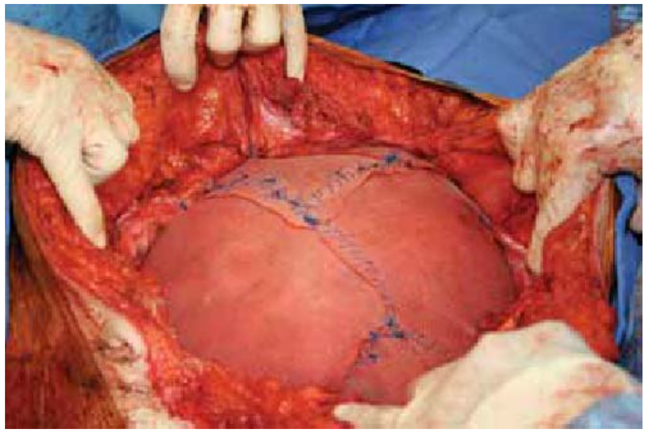

**Figure 25.19** Multiple pieces of mesh sutured together and placed in the intraperitoneal position as a silo to contain the viscera.

- Laparostomy with serial mesh excision technique
  - A large piece of DualMesh® (Gore WL, Elkton, MD) is circumferentially sewn to the fascial edge of the hernia defect, and the skin temporarily closed over the top of the mesh (Fig. 25.20).
  - Every 3 days the patient returns to the operating room where a central ovoid shape of the mesh is excised and the cut mesh edges re-approximated. This technique slowly pulls the abdominal wall muscles to the midline (Fig. 25.21A).
  - Once the remaining fascial gap is less than 5 cm, the mesh is completely excised and a Ramirez component separation is performed with fascial reinforcement (synthetic, biologic, or bioabsorbable) for complete abdominal wall reconstruction.

## POSTOPERATIVE MANAGEMENT

Standard postoperative care is instituted in these patients with loss of domain.

If there are concerns over elevated intraperitoneal pressures after abdominal wall closure, consideration may be given to maintaining endotracheal intubation with muscle paralysis for several days to allow the patient to recover. We have found the need for this to be exceedingly uncommon since employing the technique of progressive preoperative pneumoperitoneum.

Standard thromboembolic chemoprophylaxis is resumed postoperatively. Supplemental oxygen therapy is administered as needed and incentive spirometry is strongly encouraged. Early ambulation is important, and a diet is begun as soon as the surgeon is comfortable doing so.

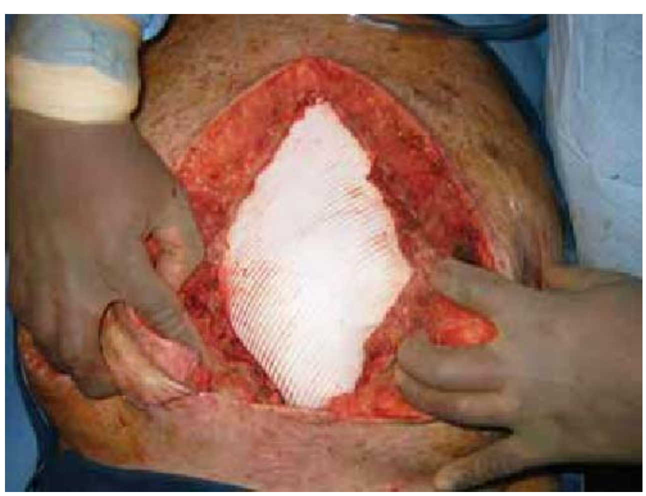

**Figure 25.20** Large piece of DualMesh Plus (Gore WL, Elkton, MD, USA) sewn directly to the fascial edges, temporarily containing the viscera in preparation for serial mesh excision.

**Figure 25.21** A narrow central sliver of mesh is excised every few days and the mesh re-sutured in the midline, allowing the fascia to slowly be pulled midline.

## COMPLICATIONS

Postoperative ileus is common in these large hernia repairs. Vigilance to the patient's symptoms and abdominal distention helps to identify this complication early. A postoperative bowel obstruction, however, should raise the suspicion of an interparietal hernia, particularly after the retromuscular hernia repair. Here the posterior rectus sheath closure may have partially come apart allowing a loop of intestine to slip through the defect into the created space between the posterior rectus sheath and the mesh (Fig. 25.22). We have reported on this complication in the literature.

Surgical site infection (SSI) is unfortunately more common in the repair of hernias with loss of domain than in other smaller defects. We have experienced a significantly higher degree of SSI in patients in whom the anterior fascia could not be re-approximated overtop the mesh. Other investigators have demonstrated the same finding. We treat SSI very conservatively. Typically, washout with negative-pressure wound therapy will allow prompt resolution of this problem. If the mesh becomes exposed in the wound, mesh removal is not recommended until a conservative trial of salvage has been attempted. In our experience, polytetrafluoroethylene, and polyester-based mesh exposures often require complete or partial mesh



**Figure 25.22** Bowel entrapped within an intraparietal hernia defect which forms when the posterior fascial layer becomes disrupted and bowel migrates between the mesh and the posterior rectus sheath.

**Figure 25.23** UltraPro (Ethicon Inc., Somerville, NJ, USA) mesh which has become exposed after a wound complication. Notice the rich granulation tissue growing between the interstices of the low-density filament, wide-pore mesh.

excision. Wide pore, decreased density polypropylene mesh seems to perform the best when exposed and will almost universally allow for granulation and healing through the mesh (Fig. 25.23).

## Special Considerations

### Obesity

Most patients with massive hernias and loss of domain are obese. Every effort should be made to have the patient lose weight preoperatively.

There is no standard rule, however, a weight loss of 20 to 30 lb can make a large difference in the ability to obtain fascial closure and complete abdominal wall reconstruction.

Our patients undergo a 4 to 8 week preoperative physician-observed meal replacement program, which consistently achieves our target weight loss goal.

### Contaminated Abdominal Wall

Patients with enteral or urinary stomas or enterocutaneous fistulas are candidates for progressive preoperative pneumoperitoneum. Attention should be paid to the stoma to ensure that ischemia does not develop during insufflation.

Patients with infected mesh and massive hernia with loss of domain pose a special problem. Although still candidates for preoperative pneumoperitoneum, serious consideration should be given to mesh removal and skin closure first followed by PPP at a second stage. An abdominal wall with infected mesh will be indurated and edematous; as a result, little muscle lengthening would occur with PPP. Additionally, mesh removal will undoubtedly damage some abdominal wall making the immediate reconstruction all the more difficult.

## CONCLUSIONS

Hernias with loss of domain present the most challenge to the general surgeon. Treatment of these patients requires a thorough understanding of the patients' abdominal wall anatomy, a meticulous preparation for surgery, and a complete armamentarium of adjunctive maneuvers and repair techniques available to ensure a safe and effective hernia repair.

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# 26 Recurrent Hernia in the Morbidly Obese

**David B. Earle**

## INDICATIONS/CONTRAINDICATIONS

The indications and contraindications for treating any disease process are the same, and the treatment of recurrent hernia in the morbidly obese patient is not different. The indications are either the relief of symptoms, or the prevention of future problems. It is therefore important for the surgeon to establish exactly what symptoms the patient feels are related to the hernia, the likelihood that the symptoms are related to the hernia, and the severity of the symptoms, particularly those limiting quality of life in a negative way. It is also important for the surgeon to put the potential deleterious effects of untreated hernia disease in a proper perspective in an unbiased manner. By way of example, a physician may tell a patient with a small asymptomatic hernia at the umbilicus that no treatment is necessary unless the hernia becomes bothersome. On the contrary, the physician may relate a story of a patient with a small umbilical hernia that became acutely incarcerated, requiring emergency surgery. This example illustrates how easy it is for the surgeon to influence the patient's decision with anecdotal evidence, and how important it is to clearly establish the possible outcomes, risks, and potential benefits, of observation versus treatment in an unbiased manner.

For hernia disease, common problems related to existing hernias of any size include pain (mild, moderate, or severe), enlargement, physical deformity, skin ulceration, difficulty fitting clothes and performing daily activities due to the deformity, and recurrent bouts of acute incarceration. Establishing a direct cause and effect relationship between the hernia and the symptoms is sometimes not possible, and the surgeon should give his or her best estimate.

In summary, the indications for fixing a recurrent ventral hernia in the setting of morbid obesity should be for symptom relief and/or prevention of future problems with the hernia. Relative contraindications to electively repair of recurrent hernia in the setting of morbid obesity include the repair of large defects without some sort of preoperative weight loss, particularly if there is some element of loss of domain. This is also true in the emergency setting where options for repair are limited—for example, operating for the bowel obstruction in the setting of a large, recurrent hernia in the setting of obesity. This type of case may best be treated by simply closing the skin after treating the bowel obstruction, and leaving the complex hernia repair for another day. These indications and relative contraindications however are not absolute, and highly dependent on the clinical situation. The surgeon must take into account the primary goals and objectives as well as the myriad of individual patient factors when making a treatment decision regarding recurrent hernia in the morbidly obese patient.

### Indications

- Relief of existing symptoms
- Prevention of hernia-related problems (risk–benefit ratio particularly important)

### Relative Contraindications

- Elective repair of large defects (greater than 10 cm between rectus muscles) without preoperative weight loss and/or smoking cessation
- Complex hernia repair in the setting of the treatment of another intraabdominal surgical emergency (skin/subcutaneous tissue closure alone may be appropriate)

## PREOPERATIVE PLANNING

The preoperative planning process for recurrent hernia in the setting of morbid obesity is very important. Firstly, it is important to establish the specific goals of the hernia repair for the patient, and then align the surgeon's goals with those of the patient. Next, it is important to elicit details from previous hernia repairs, particularly infectious related complications. A history of previous mesh infection or wound infection would place the patient in a higher risk category in terms of infectious complications during hernia repair. Additionally, a history of intermittently draining abdominal wall sinus is important as old suture and prosthetic material may harbor pathologic bacteria for many years. Exploration of chronic and intermittent sinus tracts should be performed to search for and remove the foreign body responsible for its persistence. Details of the previous hernia repairs such as suture type and technique as well as prosthetic type and technique are also important to elucidate to avoid performing the same technique, and expecting a different outcome. In addition to reviewing the old operative reports, reviewing the anesthesia record is important to determine the length of the operations, and reviewing the discharge summary will help determine what the postoperative course in length of stay were like. This information is extraordinarily helpful in terms of informing the patient what their anticipated course will be like, as well as for scheduling purposes for both the operating suite and the surgeon. Finally, determining the size of the hernia is important for choosing a technique. For midline hernias, the size should be based on the distance between the medial borders of the rectus muscles. A common error is to determine the size and number of punched out defects within a hernia sac or scar tissue, and ignore the entire area encompassed between the rectus muscles. Treating the patient based on multiple defects within an area rather than the area as a whole may lead to inadequate planning, and poorer outcomes. Abdominal CT scans without enteral or intravenous contrast are the most effective way of determining the distance between the rectus muscles, and the precise size and shape of the defect regardless of location. I consider three categories of midline hernia related to the size, or width between the medial borders of the rectus muscles. "Small" hernias are associated with defects less than 5 cm in width, "medium" sized defects from 5 to 10 cm in width, and "large" defects greater than 10 cm in width.

## SURGERY

The surgical procedure is dependent on the specific clinical situation. Once the goals of the operation have been established and aligned, the surgeon must choose the technique that will be most likely to achieve those goals. When considering the

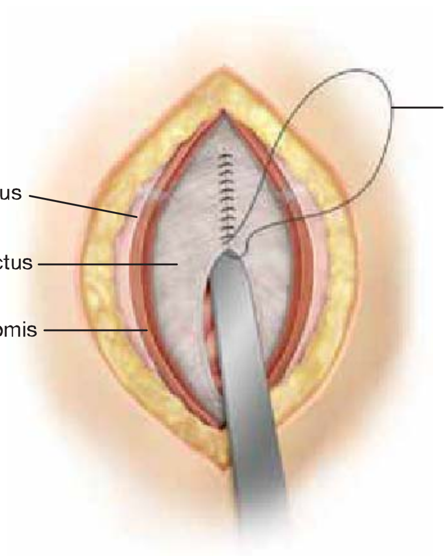


**Figure 26.1** Sublay technique.

technique, the relative risks and expected benefits of the technique relative to others should be analyzed.

## Options for Repair

- Open primary repair—not viable
- Open repair with prosthetic "inlay"—sewed to the edges of the defect with little (<3 cm) to no overlap—not viable
- Open repair with permanent, synthetic prosthetic (sublay or onlay)—viable; relatively higher chance for wound complications compared to laparoscopic repair
- Laparoscopic repair with permanent, synthetic prosthetic—viable; low risk of wound complications; technically challenging; does not allow closure of defect for medium to large defects
- Open repair with component separation and prosthetic (sublay or onlay)—viable; technically challenging; component separation has many varieties; prosthetic choice variable; allows closure of midline with "short-stitch" suturing technique (Figs. 26.1 and 26.2)
- Laparoscopic repair with component separation and prosthetic (intraperitoneal)—viable; technically challenging; prosthetic choice variable; laparoscopic assisted techniques with suture passing devices do not allow for fine suture technique to close midline

This is best illustrated in a clinical example: A 55-year-old female with a body mass index of 45 who has pain as her primary complaint (relief of pain being the primary goal for operation) from a recurrent incisional hernia. Her original operation was an open gastric bypass through an upper midline incision. The subsequent incisional hernia was repaired primarily, utilizing permanent suture material in a running fashion where the surgeon noted that "extremely large bites" were taken. A recent CT scan performed during an emergency room visit for her abdominal pain revealed the herniation of a relatively large amount of small bowel through a small punched out defect in the abdominal wall. The medial borders of the rectus muscles are 9 cm apart, and they gradually come together at the upper and lower borders of the old incision. The defect lies in the middle of the area between the rectus muscles. Without an obvious abdominal wall deformity, and the primary goal of pain relief, a laparoscopic hernia repair without component separation utilizing a permanent, synthetic prosthetic is probably the best choice to achieve the goal of symptom relief, and prevent recurrent hernia. If the patient were to have had an original operation for Crohn's disease, and have a relatively higher chance of requiring subsequent abdominal operation, an open

**Figure 26.2** Sublay technique with almost closed anterior sheath.

repair with component separation with primary repair utilizing "short-stitch" suture technique of the midline and either no prosthetic, or a biologic prosthetic may be the most appropriate choice. The relative risks and benefits of these choices should be discussed with the patient, so they can make an informed decision regarding the operative plan.

## Laparoscopic Repair

This technique is performed with the patient in the supine position. The arms should be tucked, particularly if a portion of the operation will occur at or below the umbilicus. A 3-way bladder catheter should be placed before prepping and draping to allow easy filling of the urinary bladder if dissection of the pubic symphysis and Cooper's ligaments will be required, such as would be the case for a lower midline incision. This is helpful to delineate the borders of the bladder in order to prevent injury to it. The drapes should be placed as lateral as possible, and maintain exposure of the pubis, and xiphoid process, even after insufflation. This will require placing the drapes approximately 4 to 5 cm above the costal margins and below the pubis prior to insufflation.

Access to the peritoneal cavity should generally be performed under direct visualization utilizing an open technique, or closed technique with an optical trocar. The lysis of adhesions should be performed with a combination of blunt and sharp dissection, with only sparing and careful use of an energy source when necessary for hemostasis. Once the adhesiolysis is complete, the defect should be precisely measured, and a prosthetic chosen that will appropriately cover the defect with at least 5 cm of overlap. The amount of overlap depends on the size, shape and location of the defect. In general, the larger the defect, the more the amount of overlap is required. Certainly, for midline defects, the prosthetic should at least extend beyond the lateral borders of the rectus muscles. The superior and inferior overlap will depend on the location of the defect. Defects near the pubis should have the prosthetic anchored with permanent fixation to Cooper's ligaments after appropriate dissection. Defects near the xiphoid should have the prosthetic anchored directly to the abdominal wall after taking down the falciform ligament, and may require overlap extending to the diaphragm. Anchoring the prosthetic to the diaphragm should be done with caution, and utilize permanent sutures rather than tacks, particularly if the anchoring location is not immediately adjacent to the thoracic wall. Suturing will allow the surgeon to pull the diaphragm caudad while placing the suture, as opposed to pushing a tacking device against the diaphragm which could injure underlying tissue such as the lung and heart.

Whether or not the defect is closed prior to placing the prosthetic is the topic of much debate. This is generally accomplished by utilizing one of a variety of needle-sized suture passing devices. Laparoscopic suturing with intra- or extracorporeal knot tying techniques may also be utilized. Defects less than 5 cm are generally much easier to close than those greater than 5 cm, where defect closure gradually becomes more difficult.

## Open Repair

Since primary repair, and "inlay" or "edge-to-edge" prosthetic repair of recurrent ventral hernia in the morbidly obese should be abandoned in the vast majority of clinical scenarios, it will not be discussed. In addition, since there is wide variability of the precise technique, only important general principles will be discussed. Positioning can generally be accomplished with the arms out on arm boards, unless the hernia is lateral or an endoscopic component separation is being performed. The same principles of a 3-way urinary bladder catheter, dissection of the falciform ligament, and prosthetic placement apply to open hernia repair as described in the laparoscopic section above. If a skin graft or large scar is present, these should be excised to allow skin closure utilizing healthier, relatively normal tissue. Alternatively, a dermal flap can be created and closed with a "pants-over-vest" technique. This is accomplished by de-epithelializing the scar and/or excess skin on one side of the incision with a knife or specialized face-lift scissors. Drains should be used liberally where any potential space in the subcutaneous space remains after skin closure.

If the prosthetic is going to be placed intraperitoneal, one should be chosen that is designed for intraperitoneal use, and care must be taken to avoid gaps between the fixation points laterally. If the prosthetic is going to be placed in the retromuscular position, outside the peritoneal cavity, the posterior sheath (above arcuate line) and peritoneum (below arcuate line) should be closed. If complete closure is not possible, the omentum should be secured to the edges of the remaining opening (usually in the center of the incision) to avoid herniation of viscera above this layer, but below the prosthetic. If this is not possible, intraperitoneal placement should be performed.

If the prosthetic will be placed anterior (the so-called "onlay") to the musculo-aponeurotic layers of the abdominal wall, the midline should be closed. If it is not possible to completely close the midline, then the reaming edges of the defect should have the mesh secured circumferentially as described above with the omentum and the posterior sheath. If this is not possible, a retromuscular prosthetic placement should be performed. How far lateral the prosthetic needs to be placed is not well understood, but some degree of overlap should generally be performed, which will require the same degree of skin flap development. This will somewhat increase the risk of wound complication, and generally requires the use of drains in the subcutaneous space adjacent to the prosthetic.

## Component Separation

Component separation, originally described by Ramirez in 1990 is a technique to assist in the closure of larger midline defects, and restore abdominal wall contour where large deformities exist. It consists of separating the connective tissue between the oblique muscles, detaching the medial attachment of the external oblique aponeurosis, and mobilizing the posterior rectus sheath. The portion involving the oblique muscles can be performed by raising wide flaps of skin and subcutaneous tissue along the length of the incision, or utilizing a variety of minimally invasive techniques designed to preserve the peri-umbilical vessels near the rectus muscles. In general, this component of abdominal wall reconstruction is employed with medium to large-sized defects, particularly those associated with significant abdominal wall deformity in which the correction of the deformity comprises one of the goals of operation. While this technique may be employed with laparoscopic, laparoscopically assisted, or open techniques to close the midline, only the open method can utilize the "short-stitch" suturing technique that has been shown to be stronger, and more durable than the current "standard" technique. Details of the suturing technique will be described below. If a prosthetic is also used, its placement can be the same as that described for open repair above.

### Suturing Technique

Abdominal wall closure techniques of midline laparotomy incisions have been the subject of much study and debate. While the optimal method may still be evolving, the best technique involves a running suture comprised of long acting, absorbable suture material. Most surgeons worldwide utilize this technique by taking at least 1 cm bites of tissue, and traveling about 1 cm between bites. Recently, the culmination of 20 years of clinical experience and experimental study culminated in a randomized controlled trial comparing 1 cm bites with smaller bites between 5 and 8 mm. The so-called "short-stitch" technique not only distributes the tension across the incision to a greater degree, but also significantly lowers the rate of suture line failure and surgical site infection. The mechanism of action is likely due to a stronger wound closure due to the tension distribution and less ischemia of the tissue by encompassing less tissue within the suture line. One of the hallmarks of this technique is to precisely approximate the aponeurosis without incorporating muscle, excess subcutaneous tissue, and scar. For recurrent ventral hernias, this can pose a challenge due to scarring from the previous operations. The extra time and effort to accomplish this should however be rewarded with improved outcomes in terms of hernia recurrence and infection rates.

## POSTOPERATIVE MANAGEMENT

Postoperative care is the same as with any abdominal operation, but there are a few unique features depending on the technique utilized. For techniques that rely solely on the prosthetic, such as the laparoscopic method without defect closure, activity may be resumed as tolerated. Activity will be limited by pain however, and the operation is frequently associated with more pain the original open procedure that resulted in the hernia. However, the overall recovery period is shorter, and the wound complication rate is lower compared to open techniques. The etiology of the pain is likely related to the trans-fascial fixation sutures, and most of the patients will be approximately 75% back to their usual activity level in 3 to 4 weeks.

Techniques that rely on tissue healing such as those that re-approximate the midline (with or without component separation and/or prosthetic placement) will require the patient to minimize stressful contractions of the abdominal wall for 6 to 8 weeks, when the wound should be at approximately 90% of its ultimate strength. This means that the the patient should be educated about forceful coughing and sneezing, vomiting, forceful bowel movements, lifting heavy objects, and performing significant physical activity related to work or sport. The patient should be told that it is impossible to eliminate these activities completely, but that they may be significantly reduced by the patient education process. It should also be emphasized that the patients do not curtail their activity to the point of severe de-conditioning or muscle contracture. Any drains left in place should be left until the drain output is less than approximately 30 cc per 24 hour period for at least 2 days in a row, provided the drain is functioning properly.

## COMPLICATIONS

Complications can be general, and those related specifically to the hernia repair itself. Generally, urinary retention is common, and the bladder should be decompressed with a catheter for approximately 2 days. Postoperative ileus occurs in about 15% of patients, and there should be liberal use of anti-emetics and nasogastric decompression to avoid vomiting, and its associated pain, discomfort, and increased stress on the abdominal wall closure if that technique was employed.

Wound necrosis and infection rates will vary depending on the technique used and the patients' surgical history, and should be managed in a standard fashion. Infection and exposure of a permanent synthetic prosthetic do not necessarily mandate removal of the prosthetic. Standard wound care measures are frequently appropriate, and often resolve the problem with partial or no prosthetic excision. There are many factors associated with the decision to leave a prosthetic in including the clinical course and type of prosthetic. In general, macroporous prosthetics perform better in contaminated environments than do microporous prosthetics.

Postoperative seroma may develop within the hernia sac, the subcutaneous space, or around the prosthetic. The normal healing process involves the presence of some wound fluid, and seroma should only be considered a complication if it is causing a clinical problem, or exists longer than 6 to 12 months. The exact location of the prosthetic will depend on the technique used. The majority of laparoscopic ventral hernia repairs will develop a seroma in the old hernia sac. If this does not follow the usual course of spontaneous resolution within 6 to 12 months, the surgeon should consider operative drainage and excision and/or ablation of the lining of the cavity because persistent seromas pose a long-term risk of infection by seeding from other sites of infection such as the respiratory, urinary, or GI tract, or a dental infection. Seromas may need to be drained earlier if they are associated with pain secondary to pressure or overlying inflammatory changes of the skin. Percutaneous drainage may suffice, but recurrence is high. A small, percutaneously placed drain should not be left in, particularly if there is concern that some gelatinous material remains, or the collection is loculated. In this scenario, there is a high risk of infection of the cavity. Operative drainage should be undertaken in these situations.

Recurrent hernia is always a possibility, regardless of the technique. Mechanisms of failure include inadequate dissection, inadequate coverage by the prosthetic, and suture line failure depending on the technique. In some scenarios, large recurrent hernias repaired with a component separation technique may recur, but to a lesser extent than preoperatively. Although technically a complication, if the patient is left in a better situation with more options, and resolution of the preoperative problems, there is still an aspect of success.



## RESULTS

Because of the wide variety of techniques and relatively inadequate long-term follow-up data, precise numbers for specific techniques are impossible to know. Additionally, when gauging outcomes after hernia repair, it is important to define the outcome as either a treatment success or failure. Regarding hernia repair, the metrics would then be either symptom resolution or hernia recurrence. Symptom resolution would require that the preoperative symptoms and goals of operation were defined preoperatively, something that is absent in the vast majority of studies involving outcomes related to hernia repair. Recurrence rates are easier to define, but still suffer from poor long-term follow-up.

It is generally agreed upon however that the recurrence rates of primary incisional hernia repair is in the 60% to 80% range, regardless of the size of the hernia defect. Use of a prosthetic reduces the chance for recurrence to less than 30% when considering all types of prosthetic repair technique together. Laparoscopic hernia repair of recurrent ventral hernia in the morbidly obese is approximately 20%, and higher than the same technique utilized in their non-recurrent, non-obese counterparts.

Open component separation with non-perforator sparing skin flaps is associated with a 20% to 30% major wound complication rate ranging from superficial infection and wound edge necrosis to full thickness flap necrosis. Recurrence rates with open primary repair utilizing the older suture technique and no prosthetic are also in the 20% to 30% range. While this is high, the majority of patients undergoing this procedure have large, complex hernias and do not recur.

Extrapolating the existing data, it is reasonable to assume that utilizing a component separation technique with the newer "short-stitch" suturing technique would have a recurrence rate less than 20% to 30%, and the addition of a prosthetic in any fashion should reduce the recurrence rates even further.

## CONCLUSIONS

In summary, the variables associated with ventral hernia repair make it nearly impossible to scientifically and ethically study each aspect. We are then left with utilizing the existing clinical experience and laboratory data to make logical choices regarding the repair of recurrent hernia in the morbidly obese. It is imperative for the surgeon to arrive at an accurate diagnosis and obtain details of previous operations, particularly related to previous techniques and complications. It is then necessary to explicitly define the goals of operation, and align the goals with the surgeon and the patient. The unique clinical scenario of the patient must be considered, especially with regard to the patient's medical history and medication use, and how that related to wound healing and future need for subsequent abdominal operation.

Once the clinical issue for the patient has been elucidated, a technique can be chosen that will have the best chance at realizing the goals of the operation that have been previously defined. Once the technique has been chosen, a logical prosthetic choice that is appropriate for the technique and clinical scenario can be chosen. Going through this process for every patient may take some extra time, but will provide both the patient and the surgeon with the best possible outcomes.

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# 27 Infected Field Hernia Repair

**Emanuele Lo Menzo and Adrian Park**

## INDICATIONS/CONTRAINDICATIONS

More than two million laparotomies are performed annually in the United States, and between 2% and 20% will result in incisional hernias. Typically, hernias become clinically apparent in the first 5 years after laparotomy.

Since the early description of temporary abdominal wall closures, their utilization has exponentially increased, particularly in trauma surgery. Their wide application inevitably leads to increased incidence of large skin-grafted ventral hernias with potential loss of domain. Subsequent abdominal wall reconstruction techniques are challenging and have led to disappointing short- and long-term results as well as to significant complication rates. Because of the physical disability resulting from the large hernias, for instance, afflicted individuals are often unable to carry on their duties, especially those entailing manual labor.

Overall no consensus on abdominal wall reconstruction exists with regard to preferred technique (open vs. laparoscopic), position of mesh (onlay, sublay, intraperitoneal), or type of reinforcement material (synthetic vs. biologic, permanent vs. absorbable, large vs. small pore). More unanimous is the agreement on the need for the use of mesh for the repair of abdominal wall defects resulting from previous incisions, especially if recurrent.

Wide acceptance of prosthetic mesh for the tension-free repair of ventral hernias—especially when used in contaminated fields—presents potential for increased incidence of mesh infections. Treatment of infected meshes and the repair of hernias in infected fields pose significant challenges to the surgeon. In general, the risk of wound infection following synthetic ventral hernia repair varies from 4% to 16%. A prior history of wound infection predisposes the patient to subsequent wound infection in 40% of cases. The fact that wound and mesh infections are risk factors for recurrence creates a vicious cycle potentially resulting in multiply recurrent complex hernias.

The management of wound infections following hernia repair often requires removal of the prosthetic material, leaving a greater defect within an infected field. The treatment alternatives historically have included staged repair with absorbable mesh (polyglycolic acid, i.e., Dexon or polyglactin 910, i.e., Vicryl) or primary repair with myofascial mobilization. Both techniques, unfortunately, are characterized by a high incidence of

**TABLE 27.1 Synopsis of the Most Commonly Utilized Biologic Meshes**

| Brand Name | Manufacturer | Source | Cross-linking |
|---|---|---|---|
| AlloDerm® | LifeCell | Human Dermis | No |
| AlloMax | Tutogen | Human Dermis | No |
| CollaMend™ | Bard/Davol | Porcine Dermis | Yes |
| FlexHD® | Ethicon | Human Dermis | No |
| Periguard | Synovis | Bovine Pericardium | Yes |
| Permacol™ | Covidien | Porcine Dermis | Yes |
| ProPatch® | CryoLife | Bovine Pericardium | No |
| Strattice™ | LifeCell | Porcine Dermis | No |
| Surgimend | TEI Biosciences | Fetal Bovine Dermis | No |
| Surgisis® | Cook | Porcine intestinal submucosa | No |
| Tutopatch® | Tutogen | Bovine Pericardium | No |
| Veritas | Synovis | Bovine Pericardium | No |
| XenaMatrix™ | Bard/Davol | Porcine Dermis | No |
| Xenform® | Boston Scientific | Fetal Bovine Dermis | No |

recurrence (75% for the former and as high as 52% for the latter). Direct contact of absorbable synthetic meshes with the viscera may also result in adhesions and fistula formation. Recently, a newer generation of synthetic absorbable meshes (e.g., Bio-A®) has been introduced. Although limited literature is available on these new products, initial reports are promising. The new synthetic meshes offer definitive superiority in terms of cost compared to the biologic meshes, so they can be considered as an option.

The introduction of biologic grafts has opened a new chapter in the management of complex, contaminated abdominal wall defects. The concept behind these grafts—despite their variance in origins as well as in composition and mechanical properties—is similar: They provide an extracellular matrix scaffold that allows the host cells to start the remodeling process that will result in the laying down of mature collagen, indistinguishable from the native tissue (Table 27.1). The temporary nature of these biomaterials in addition to their ability to promote neo-vascularization, allow them to be implanted in both clean-contaminated and (at least) theoretically contaminated fields. Use in heavily contaminated fields affects the tensile strength of these products and thus leads to higher chance of recurrence. The slower and incomplete remodeling processes of the cross-linked variants of these biologic meshes can further lead to foreign body reactions and chronically draining wounds. Cross-linking is a chemical process (not unlike the tanning of leather) which adds more stability to the extracellular matrix and thus provides graft resistance to the *in situ* degradation caused by the host collagenase enzymes abundant in contaminated fields. Lack of enzymatic degradation, unfortunately, also adversely affects the neo-vascularization and remodeling process, promoting graft encapsulation and foreign body reaction.

On average, biologic grafts are up to ten times more expensive than their synthetic counterparts. The issue of cost containment where safely feasible in the OR can no longer be ignored by surgeons. The durability of hernia repairs in contaminated fields with biologic grafts has not been adequately prospectively studied. As well the definition of "failures and recurrences" is not always well described in the literature, and some of the thinning and "ballooning" effects seen following biologic graft repair are often not reported as recurrences.

The choice between synthetic and biologic mesh is then dictated by the technique chosen (laparoscopic vs. open), the familiarity of the surgeon with the products, and the cost and the potential for complications, in particular infection.

As previously mentioned, controversies exist in regard to the technique of hernia repair, the need for mesh reinforcement, and the appropriate material to use. One effort in standardizing the approach to complex hernia has been undertaken by the ventral hernia working group (VHWG), a recently established and—though funded by a biologic mesh manufacturer—credible group. They have sought to evaluate new technologies in hernia repair and to stratify the patients on the basis of their risk of surgical-site occurrence (SSO), particularly surgical-site infection.

# PREOPERATIVE PLANNING

Approach to the complex hernia requires use of preoperative risk assessment algorithms that take into account both patient and hernia characteristics (Table 27.2; Algorithms 27.1–27.5). A careful history should include not only the potential patient co-morbidities but also an accurate review of previous abdominal operations with particular emphasis on hernia repairs and a history of prior wound or mesh infections. Review of previous operative reports, whenever possible, can provide information about the type and location of the implanted mesh. In general, the presence of a previously placed mesh in an overlay position decreases the chance of dense visceral adhesions compared with an intraabdominally placed mesh.

Physical examination should focus on location of the defect (midline vs. eccentric), proximity to bony confinements that might limit mesh overlap (subxiphoid, suprapubic, flank), presence of skin graft or granulation tissue that might become devitalized once the hernia is reduced, and assessment of potential loss of abdominal domain.

In order to minimize potential complications, certain patient risk factors can be optimized prior to surgery (Table 27.2).

Preoperative imaging studies are helpful for defining the anatomy, especially in the setting of multiple previous repairs. Although CT scan is considered the gold standard preoperative test, MRI can be helpful in differentiating "ballooning" or pseudo-recurrence from true recurrence after previous biologic mesh repair. Ultrasonography is rarely used as a preoperative screening tool for complex hernias.

## Contaminated or Potentially Contaminated Operative Fields

Clinical scenarios that may lead to an infected or potentially contaminated hernia field include early abdominal wall reconstruction after open abdomen damage control procedures, incarcerated hernias, infected mesh, enteric exposure, presence of ostomies or fistulae.

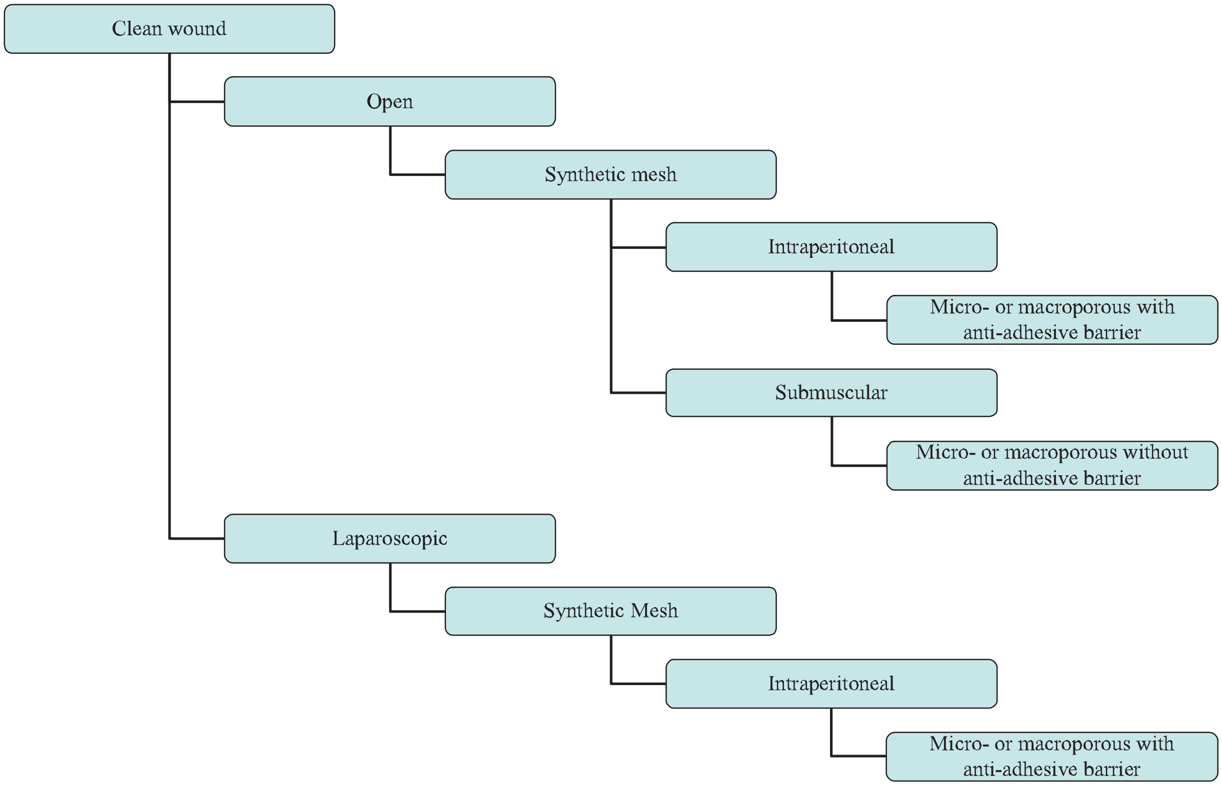
The main decision points when approaching these complex problems include:

Operative strategy (one-stage vs. multi-stage)
Operative approach (laparoscopic vs. open)
Type of repair (primary vs. mesh)
Type of mesh (synthetic vs. biologic)
Location of mesh (onlay, sublay, interposition)

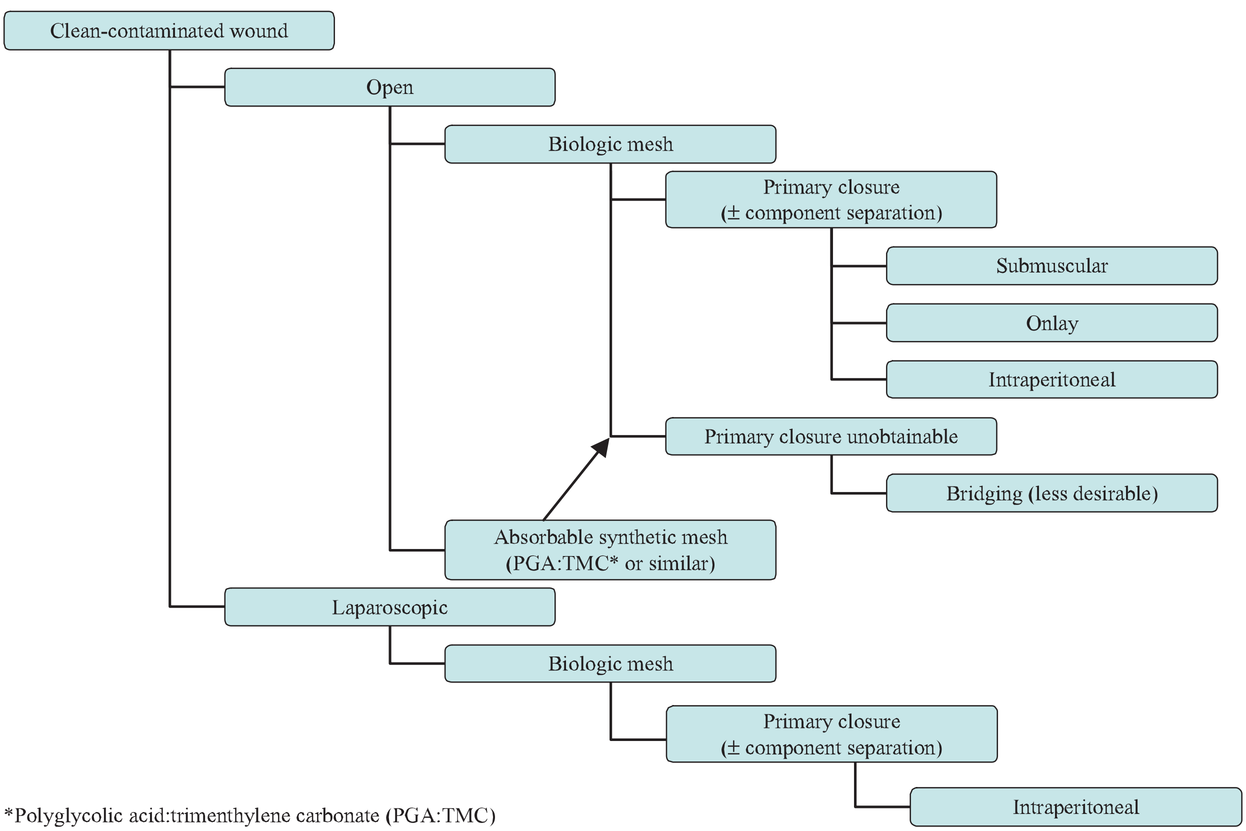


**TABLE 27.2 Risk Factors for Complication of Hernia Repair**

| Preoperative | Postoperative |
|---|---|
| Age >75 | Wound infection |
| Obesity | Abdominal distension |
| Diabetes | Early re-exploration |
| Smoking– chronic obstructive pulmonary disease (COPD) | Technique |
| CAD | |
| Malnutrition | |
| Emergency laparotomies | |
| Immunosuppression–chronic steroid use | |
| Multiple previous repairs | |

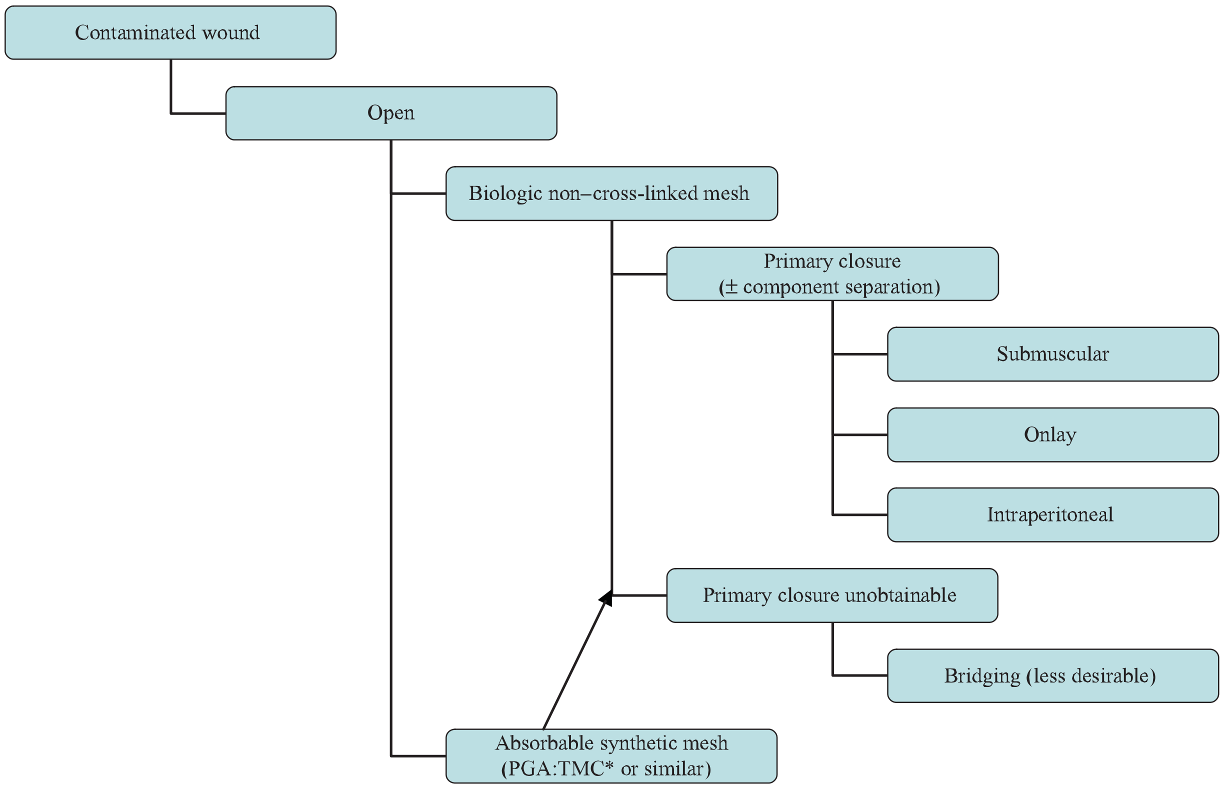



**Algorithm 27.1** Algorithm to approach of a clean ventral hernia.



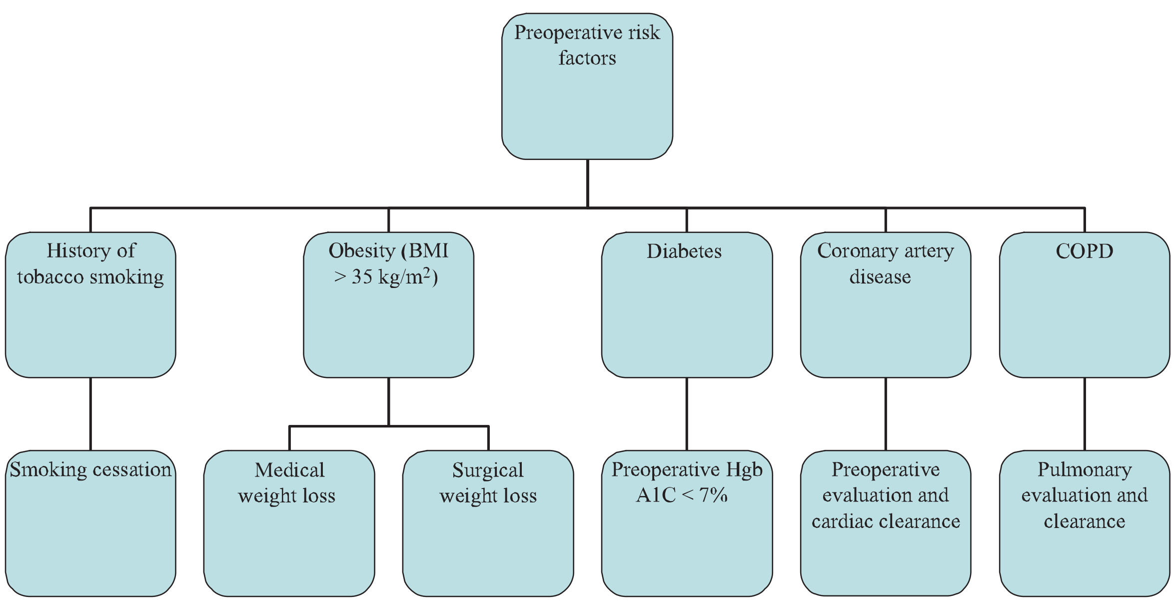

*Polyglycolic acid:trimenthylene carbonate (PGA:TMC)

**Algorithm 27.2** Algorithm to approach of a clean-contaminated ventral hernia.




*Polyglycolic acid:trimenthylene carbonate (PGA:TMC)

**Algorithm 27.3** Algorithm to approach of a contaminated ventral hernia.




**Algorithm 27.4** Correctable preoperative risk factors.

### Operative Strategy (one-stage vs. multi-stage)

Temporary abdominal wall closure is common in the trauma setting when re-exploration is deemed necessary and when the clinical condition warrants expeditious return to the intensive care unit for continuing resuscitation. Evolution in techniques and materials has contributed to use of the temporary abdominal wall closure in the non-trauma setting as well, especially in highly contaminated surgical fields. Once the decision to not close the abdomen is made, the patient is almost guaranteed a ventral hernia. The different absorbable meshes used to close difficult abdomens—in particular polyglycolic acid and polyglactin 910—have resulted in ventral hernias in up to 52% of cases, and adhesions and fistula formation have been described in spite of the absorbable nature of these mesh products. Perhaps the newer absorbable synthetic meshes will provide better short- and long-term results with significant advantage compared with the biologic meshes, although more data is necessary.

The advent of biologic meshes was initially seen as a potential solution to the dilemma of open abdomen/infected field management. It soon became clear, however, that these products have their limitations. First and foremost, they cannot be used to bridge a gap or defect. If so used, hernia recurrences or marked postoperative bulging (pseudo-recurrence) will occur. This is particularly true for products of dermal origin containing a significant elastin component. In addition, these products—when used in infected fields—demonstrate high rates of acute mechanical failure, mesh disintegration, and poor mesh integration (73%, 92%, and 70%, respectively). An alternative one-stage approach with acceptable complication rates in this situation would be component separation and primary fascial closure.

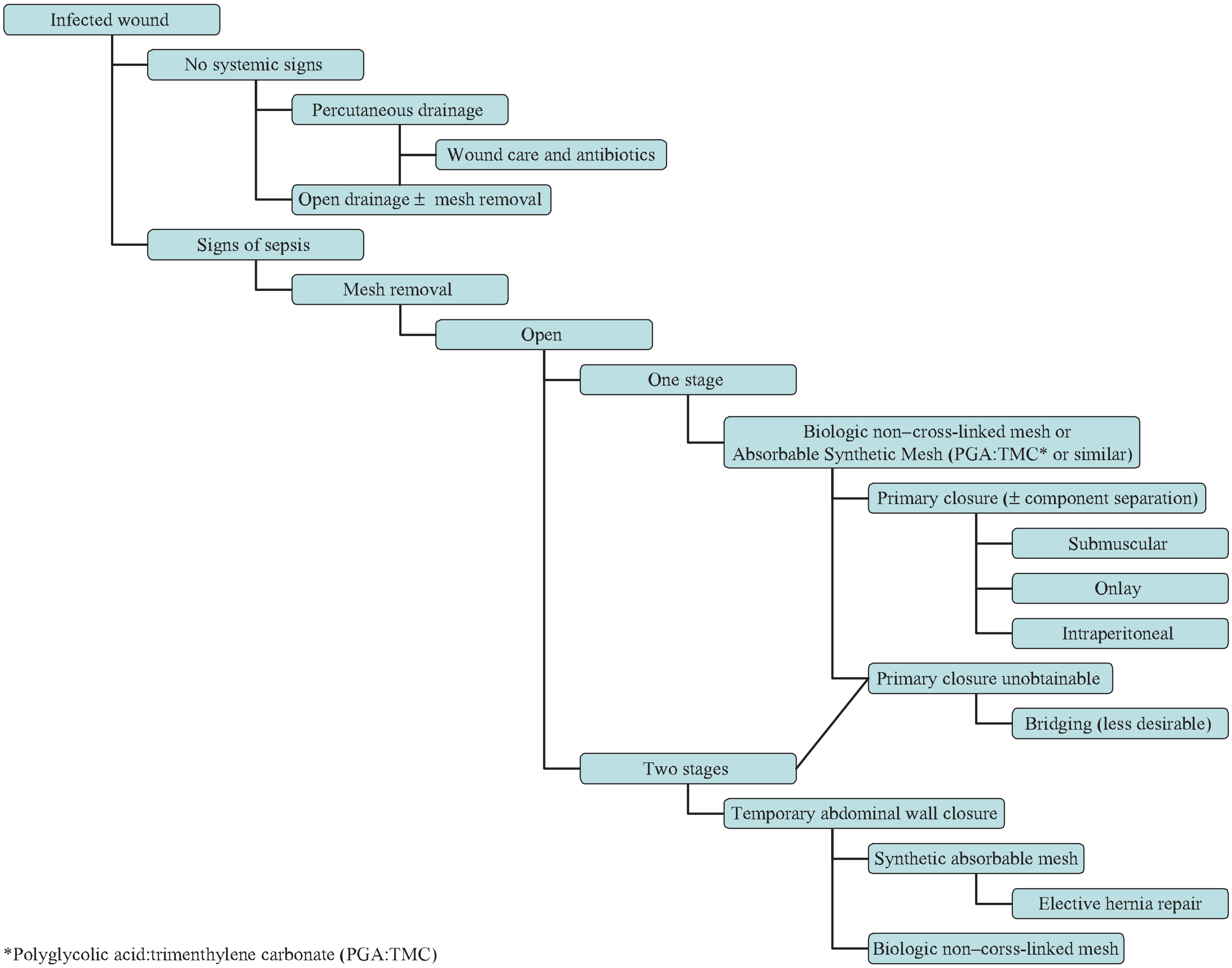
### Operative Approach (laparoscopic vs. open)

The choice between laparoscopic and open approach depends on the clinical scenario (Algorithm 27.1–27.5) and the surgeon's experience and comfort level. Clear advantages of the laparoscopic approach include lower wound-related complication rates, smaller incisions, and shorter hospital stay. Clear disadvantages of the laparoscopic approach, by contrast, include the inability to effectively manage the skin redundancy and hernia sac and the lack of restoration of functional abdominal wall unity. Recently, laparoscopic techniques have been described to obtain primary closure of the fascia in an effort to recreate the functional results obtained with the open repair. Elaboration of these techniques, however, is beyond the scope of this chapter. In general, in the presence of skin grafts and/or infected fields and the loss of abdominal domain, the open approach is preferable. The choice of mesh might also dictate the approach. In fact, if a biologic mesh as reinforcement is chosen, an open repair is usually necessary to obtain primary closure of the defect. Hybrid approaches have also been described in case series, where the main role of laparoscopy is in placing the mesh under adequate stretch and overlap after the hernia defect has been primarily repaired in an open fashion.

### Type of Repair (primary vs. mesh)

This decision presents little difficulty. As mentioned previously, compelling data exists that discourages the primary (non-mesh) repair of ventral hernias, especially those recurrent in nature. The component separation technique and its variants provide a different degree of medialization of the myofascial complex based on location along the abdominal wall. Even in these cases when a repair without "undue" tension can be obtained, recurrence rates are reported as high as 52%. The recurrences result usually from failure of the midline closure, although the lateral release sites (Spigelian type) are also sites of recurrence. For this reason and because of the availability of newly engineered meshes, many authors have modified their techniques to include a biologic graft in the repair. Others have been using more objective measures on the basis of measurement of the tension at the repair site to establish the need for mesh in the repair.

In the presence of significant loss of domain—despite extensive component separation—primary fascial closure might not be achievable and for the necessary bridging synthetic mesh is preferable (Fig. 27.1). When the potentials for wound infection and breakdown are present, however, it might be necessary to use a biologic graft despite its association with poor outcome when used to bridge defects.




*Polyglycolic acid:trimenthylene carbonate (PGA:TMC)

**Algorithm 27.5** Algorithm to approach of an infected ventral hernia.

**Figure 27.1** Bridging with synthetic mesh after extensive component separation

**TABLE 27.3 Hernia Grading System According to the Ventral Hernia Working Group (VHWG)**

| Grade 1<br>*Low Risk* | Grade 2<br>*Co-morbid* | Grade 3<br>*Potentially Contaminated* | Grade 4<br>*Infected* |
|---|---|---|---|
| Low risk of complications | Smoking | Previous wound infection | Infected mesh |
| No history of wound infection | Obesity | Presence of ostomy | Septic dehiscence |
| | Diabetes<br>Immunosuppression<br>COPD | Violation of the gastrointestinal tract | |

**Type of mesh (synthetic vs. biologic)**

The first decision in mesh selection is whether an absorbable or non-absorbable synthetic or biologic mesh is best indicated. The main factor to consider is the potential risk for infection. The need for a more objective stratification of the potential risk for surgical site infection has led the VHWG to develop a grading system (Table 27.3). The purpose of this four grade system that is based on patient as well as hernia defect characteristics is to assist the clinician in choosing the safest material for the clinical scenario encountered.

For grade 1 low-risk patients, the use of the appropriate synthetic mesh (microporous, macroporous with anti-adhesive barrier, or composite for intraabdominal location in contact with viscera) with the appropriate technique (submuscular or intraperitoneal whenever possible) has, reportedly, the best cost–complication–recurrence profile. The use of biologic grafts in this patient category is not supported by level I evidence.

Although the use of synthetic mesh is appropriate for grade 2 scenarios, the risk of surgical site complication is at least fourfold that of grade 1. The use of biologic mesh may be justified for management or avoidance of potential wound complications.

Where the biologic grafts have certainly the best application is in the grade 3 or the potentially contaminated field. Examples of this scenario include previous history of wound infection or presence of ostomies, whether or not intestinal anastomoses are planned as part of the procedure (Figs. 27.2 and 27.3). Still, the use of biologic grafts

**Figure 27.2** Incisional hernia with signs of previous infection and ileostomy.


**Figure 27.3** (**A and B**) Large recurrent incisional hernia from previous skin-grafted abdominal wall closure.

in this scenario has rendered mixed results. On the basis of the technique and type of graft utilized the wound complication rate can, in fact, be as high as 39%, and the recurrence rate can vary from 6% to 44%. This may be an indication for the use of the newer re-absorbable synthetic meshes made of a copolymer (polyglycolic acid: trimethylene carbonate PGA:TMC Bio A®) that is gradually absorbed by the body. In fact, three-dimensional PGA:TMC matrix can serve as a scaffold for tissue regeneration similarly to biologic grafts. Besides the obvious decreased cost, the PGA:TMC meshes offer the advantages of larger sizes (up to 20 × 30 cm), longer shelf life, and ease of handling.

The grade 4 or grossly infected scenario is certainly the most challenging one. Use of a permanent prosthetic mesh is not recommended in such circumstance because of the high incidence of mesh-related complications. The use of biologic grafts has been suggested for consideration although it has led to more failures (mechanical failure, wound dehiscence, early graft re-absorption and recurrences) than when used in the potentially contaminated field. It could be argued in this case that placing a type of mesh would make more sense, accepting the high likelihood of recurrence, and planning for a definitive repair when the clinical scenario will allow. The other alternative is the use of PGA:TMC meshes, although no objective data is available yet. Whenever uncontrolled gross contamination persists, a staged repair should be considered. Examples of grade 4 scenarios include gross enteric contamination and infected mesh from previous repairs (Figs. 27.4 and 27.5).



**Figure 27.4** Exposed expanded PTFE mesh secondary to chronic wound infection.

**Figure 27.5** Intraoperative drainage of chronically infected expanded PTFE mesh.

If a prosthetic mesh is preferable, the choice among the different types resides primarily in the risk of mesh exposure to the intraperitoneal viscera. In fact, if contact with viscera is expected, then a barrier type of mesh needs to be used. Although ePTFE meshes are commonly used, their hydrophobic nature and small pore design make them more difficult to deal with in case of infection. A lightweight polyester or polypropylene mesh may be the best choice.

### Location of Mesh (onlay, sublay, interposition)

The underlay positioning of the mesh is the preferred approach both for open and laparoscopic techniques, and the overlay should only be considered when the fascia has been closed. Interposition techniques should be reserved for those cases in which fascial closure cannot be safely achieved.

## Management of Infected Mesh

The wide acceptance of tension-free hernia repair has led to a significant increase in prosthetic mesh utilization. Although mesh manufacturing and engineering has evolved with the needs of surgeons and their patients, mesh-related complications remain a significant problem. In particular, mesh infection is reported with an incidence between 0.1% and 33% on the basis of hernia characteristics and patient risk factors.

Although most mesh infections occur early after implantation, they can also (rarely) occur months or years later. This delayed presentation is especially seen with more resilient microorganism that can remain dormant in the wound for prolonged periods of time (e.g., methicillin-resistant Staphylococcus species).

The clinical presentation of an infected mesh can be limited to local manifestation of inflammation (pain, erythema, swelling), or associated with systemic signs and symptoms (fever, chills, malaise). Antibiotic prophylaxis decreases the rate of mesh infection and some authors have suggested that the addition of antiseptic impregnated meshes can lower this risk further.

It is accepted that mesh pore size plays a key role not only in the risk of infection but also in the success rate of its eradication. In general, monofilament large pore (>75 μm) meshes are considered to present the lower infectious risk compared with microporous PTFE-based meshes. Aside from a few sporadic case reports, microporous, PTFE-based meshes have been associated with a much lower chance of mesh salvage if an infection occurs. The current theory is that wider mesh pores facilitate mesh incorporation (and vascularization) in the surrounding tissues and migration of leukocytes when necessary. The variable percentage of absorbable component in some of the wide-pore meshes is credited with further facilitating leukocyte migration. In spite of multiple reports and case series of macroporous meshes utilized successfully in clean-contaminated fields, their use in this scenario would not yet be considered the standard of care.

According to a large review, mesh salvage was more successful in patients who had undergone first-time operative repair compared with recurrences and on the basis of these findings the authors do not recommend mesh preservation strategy for recurrent hernias. Studies by others, however, differ.

Management of surgical site infection that involves prosthetic materials has evolved recently. The presence of an infected site in the setting of systemic sepsis dictates mesh removal. Lesser degrees of localized and controlled infection in selected cases can be managed with limited excision or without prosthesis removal. In considering the non-operative option, the type of mesh involved in the infection should be known since, as previously noted, the mesh salvage rate is significantly higher for large pore meshes. The data on mesh salvage is limited to small series, and retrospective analysis. Mesh removal results in hernia recurrence and need for additional surgical reconstructions.

Additional factors influence the management of infection. Approaching intervention with the correct strategy requires attention to the technique of mesh placement utilized in the repair that led to the infection. In the case of an extruded overlay mesh, for instance, its removal is unlikely to result in evisceration or bowel injury.

The time between the hernia repair and the onset of infection is also critical to know. A chronic infection and extrusion of mesh, even if previously placed in an intraperitoneal position, will likely be accompanied with the formation of a "pseudo-peritoneum," making the mesh removal operation safer in terms of bowel injury (Fig. 27.6). By contrast, a more recent repair that warrants mesh removal poses the challenge of optimal closure of the abdominal cavity. Options include temporary closure with staged repair, one-step repair with biologic graft, or absorbable synthetic mesh. The one-step repair, whenever possible, is our preferred approach. Consisting of primary abdominal wall closure with the aid of component separation and placement of underlay or overlay biologic non–cross-linked mesh. The cross-linking process retards the modeling process of the biologic mesh and as a result the graft becomes incapsulated and impenetrable by leucocytes. In fact, chemically cross-linked products have been associated with a higher rate of wound complications and removal (11% to 16%) compared with the porcine intestinal submucosa (12%) and the acellular human dermal product (6%).

In the case of infection, the primary goal consists of managing the local source. This is usually accomplished by drainage (percutaneous or open) with antibiotic coverage tailored to the wound culture results. In cases of infected seromas or localized infection amenable to percutaneous drainage, local antibiotic irrigation has recently been



Figure 27.6 "Pseudo-peritoneum" after chronically infected mesh removal.

described in a few case reports to salvage the mesh in addition to providing systemic antimicrobial treatment.

In the case of open wounds, local wound management becomes paramount. For smaller wounds (usually <2 cm), dressing changes with fluid-absorbent material and silver-containing dressing are indicated. In the management of larger wounds, vacuum-assisted dressings (VAC, KCL Inc., San Antonio, TX) have significantly improved wound closure rates and, possibly, mesh salvage. In fact, the continuous interstitial fluid and bacterial load reduction facilitates wound contraction and apposition of granulation tissue. It is important to remember that to minimize potential for fistulization to hollow viscera, a polyvinyl alcohol soft foam sponge (white), which is a denser sponge with smaller pores, should be utilized. Whenever fistulization is no longer a concern and a more effective granulation and wound contraction is necessary, the polyurethane foam sponge "black" or silver impregnated can be utilized.

## Prevention

Prevention of wound infections remains a challenging task. Only a few mesh infection prevention strategies are supported by scientific data. It is well established that a previous history of wound infection poses a higher risk for patient re-infection. This is particularly true for specific microorganisms notoriously difficult to treat (e.g., MRSA and VRE), to the extent that some authors discourage the use of any synthetic material in patient with a history of methicillin-resistant Staphylococcus infection. Basing the choice of mesh on the specific clinical scenario is particularly important. We do not recommend using microporous mesh in the setting of a previous history of infection or in a patient believed to be at higher risk for wound-related complications. The decision then resides between a large-pore meshes (>75 μm), preferably lightweight or monofilament or a non–cross-linked biologic graft.

The benefits of preoperative prophylactic antibiotics are well detailed in the literature. A single dose of preoperative prophylactic antibiotic is recommended but not the routine use of extended post operative doses. The prolonged use of antibiotics after the first preoperative prophylaxis dose has been suggested to decrease the chance of mesh salvage in the instance of an infection developing due to the selection of more resistant organisms. Antimicrobial impregnated meshes have been shown to reduce the incidence of mesh infection, although most of the ones in this category are microporous, ePTFE-based, which carry the highest rate of explantation in case of infection.

Local irrigation with antibiotic solutions at the time of mesh implantation and the use of antibiotic-impregnated collagen tampons remain controversial and not uniformly accepted. Clearly patient selection plays a key role in the prevention of wound-related complications. It has been well demonstrated how obesity, uncontrolled diabetes, smoking, immunosuppression medications, and malnutrition contribute significantly to the development of wound infections. Surgical technique may contribute to the development of wound infection and the superiority of laparoscopic repairs from this perspective has been well established. Finally, the duration of surgery—with every additional 15 minutes of operative time increasing the odds of wound infection—has been identified as a risk factor by several authors.

## POSTOPERATIVE CARE

The postoperative care of patients undergoing complex hernia repairs is similar regardless of the type of repair utilized. The vast majority of these patients are extubated in the operating room, unless concern about significant fluid shift and intraabdominal hypertension exists. Early postoperative mobilization is always recommended. Standard deep vein thrombosis prophylaxis with mechanical compression devices and subcutaneous fractionated or unfractionated heparin is recommended.

Nasogastric drainage tubes are utilized if prolonged ileus is expected from extensive dissections and prolonged operative time. Our routine approach is to use closed suction drains whenever extensive cutaneous flaps are created. The drains are removed after 10 to 14 days or when the output decreases to <30 cc/day. The use of elastic abdominal binders might help in decreasing the incidence of seromas and improving postoperative discomfort.

## COMPLICATIONS

Although component separation provides an autologous reconstruction for complex hernias, it is not without risks. The large subcutaneous dissection which may scarifice the epigastric perforating arteries, the already compromised abdominal wall arterial supply from previous operations, and the long operative times are associated with a high incidence of wound complications. Complications such as seromas, flap necrosis, hematomas, and wound infections are reported in up to 67% of cases.

It is well established that local wound complications contribute to hernia recurrence. Due to usually extensive bowel manipulation, postoperative ileus is reported in about 30% of cases. Cardiac and pulmonary complications can manifest in an isolated form or as part of postoperative abdominal compartment syndrome.

# Unique Scenarios

### Ventral Hernias and Morbid Obesity

With obesity now an epidemic worldwide and morbid obesity a well-established risk factor for developing ventral hernias, one can anticipate increasing numbers of obese patients in need of hernia repairs. The best timing for hernia repair in this patient population remains controversial. The options include hernia repair without weight loss, surgical weight loss followed by hernia repair, or simultaneous bariatric procedure and hernia repair.

Although laparoscopic hernia repair has been safely performed in morbidly obese patients, longer operative times and postoperative stay in addition to higher recurrence and overall complication rates have to be expected. In addition—if the procedure has to be converted to open—rates of perioperative complications and recurrence increase significantly. This is due largely to the multiple risk factors common in morbidly obese patients, including medical co-morbidities, increased intraabdominal pressure, larger hernia defects, increase likelihood of previous failed repairs, and intraoperative difficulties that result in longer operative times.

Weight loss prior to hernia repair is the ideal. Since medical weight loss has been shown to be largely ineffective, a surgical weight loss procedure should be considered. Once adequate weight loss is achieved, hernia repair can be performed with better short- and long-term results. The arguments favoring this approach are based on successful case series and the higher recurrence rates (up to 100%) associated with hernia repair performed concomitantly with the bariatric procedure. As a significant number of post-bariatric surgery patients require panniculectomies, it becomes intuitive to simultaneously perform the delayed hernia repair. In the setting of clean-contaminated bariatric procedures, associated high recurrence rates can be explained by the limited choice of repair (primary or biologic mesh). A contrary argument advocates for simultaneous hernia repair at the time of the bariatric procedure, on the basis of the claim that—even if recurrence rates might be higher—deferring the hernia repair can lead to an incarceration and emergency operation rate of up to 35%.

It is our approach whenever feasible to offer weight loss surgery prior to hernia repair in the absence of symptoms warranting more urgent repair. It is also our practice to avoid reduction of the hernia at the time of the bariatric procedure. In cases where the hernia must be reduced in order to complete the bariatric procedure, a form of repair has to be implemented to avoid incarceration during the subsequent weight loss period. The choice of repair is guided by the size of the defect. Small (2 cm or less) umbilical defects can be repaired primarily, whereas larger defects require the use of biologic mesh, preferably underlay for reinforcement and not to bridge the defect. We do not advocate the use of a synthetic material in the setting of a clean-contaminated bariatric procedure.

One last option consists of prophylactic mesh insertion at the time of bariatric surgery. As is the case in other locations (e.g., parastomal), evidence exists that the prophylactic use of mesh prevents hernia formation without increase in local complication rates. On the basis of these findings and the fact that the majority of the bariatric procedures are conducted laparoscopically, we do not advocate for prophylactic hernia repair with mesh.

## Loss of Domain

The presence of a hernia containing a large amount of viscera can result in the development of a "second" abdominal cavity. The chronic changes that occur in the mesentery, venous and lymphatic returns, subcutaneous and epidermidis, contribute to the irreducibility of the hernia. Over time, the progressive contraction of the abdominal muscles reduces the capacity of the abdominal cavity, resulting in loss of domain. Although often a prosthetic mesh of adequate size can overcome the loss of domain, the risk of developing abdominal compartment syndrome, wound breakdown, and mesh exposure is quite significant. Additional methods used to overcome loss of domain include tissue expanders, debulking (of both omentum and bowel), and component separation techniques. Whenever an extensive component separation is not sufficient to obtain abdominal wall closure, a bridging mesh has to be utilized (Fig. 27.1). Due to the high incidence of wound complications in such a scenario, the choice may be limited to the use of biologic graft even with the known limitations of utilizing such material to bridge rather than to reinforce an autologous repair.

During the preoperative assessment, the finding of loss of domain is usually obvious (Fig. 27.3). Whenever doubt regarding domain loss exists, preoperative CT scan with measurement of both hernia sac and abdominal cavity volumes can assist in the diagnosis (Figs. 27.7 and 27.8).

An additional approach that has been well described is the progressive preoperative distention of the abdominal cavity (progressive preoperative pneumoperitoneum). Different technical variations have been described, but in general this approach consists of insufflating air or nitrous oxide via a peritoneal dialysis catheter or similar intraperitoneal access catheter over the course of 1 to 2 weeks. In general and on the basis of patient

**Figure 27.7** Loss of domain in a right flank hernia.

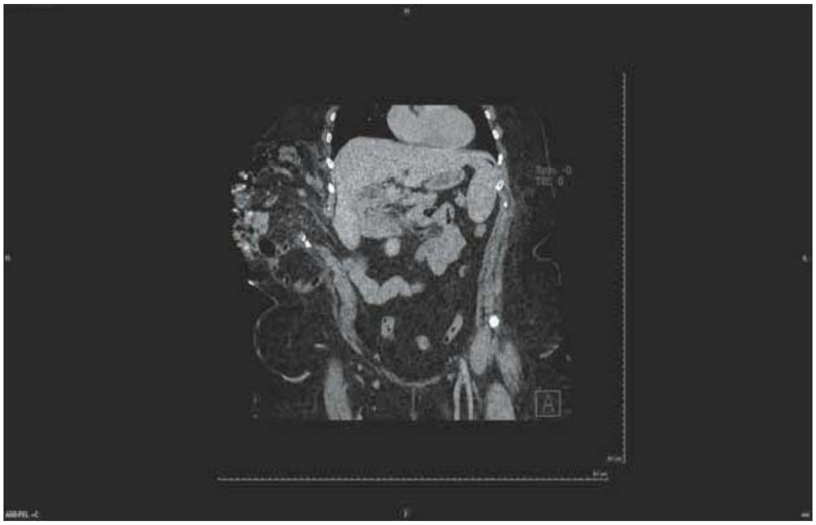


**Figure 27.8** Coronal view of the same right flank hernia with loss of domain.

tolerance, daily insufflations of volumes between 500 to 2,500 cc are used (Fig. 27.9). The progressive nature of abdominal distention is done to avoid the possible acute complications of abdominal compartment syndrome that might develop with one-stage repair. Nevertheless pulmonary and renal functions have to be monitored closely perioperatively. The overall results of progressive preoperative pneumoperitoneum are variable and are limited to case series. Our preferred technique consists in the utilization of a subcutaneous port-a-cath similar to the one utilized for chemotherapy, with the catheter implanted in the peritoneal cavity under laparoscopic guidance. Once or twice a day the air insufflations proceed in variable amount guided by the patient's tolerance. The onset of abdominal discomfort, shoulder pain, and respiratory complaints are considered endpoints for insufflation. Occasionally, a CT scan will be obtained to confirm the adequacy of the space-forming procedure (Fig. 27.9). Once adequate abdominal expansion is obtained, a repair with prosthetic mesh or component separation with biologic mesh reinforcement will follow.

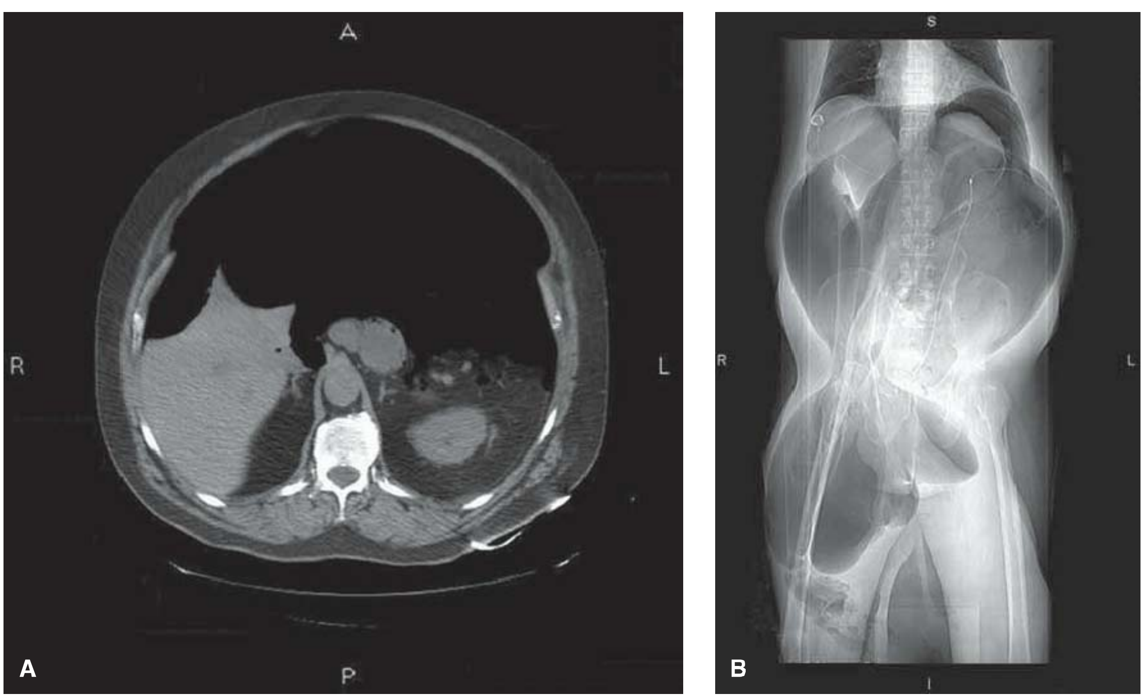


**Figure 27.9** (**A and B**) CT scans of patient receiving progressive preoperative pneumoperitoneum indicating adequacy of the insufflation.

# RESULTS

Complex hernia repairs remain a challenging problem for the surgeon, especially when carried out in a contaminated or infected field.

A thorough knowledge of the different synthetic and biologic mesh characteristics can guide selection that best fits the clinical scenario.

Use of newer large-pore lightweight meshes in clean-contaminated fields remains—in spite of several reports on their safety—controversial. Certainly, in the presence of the heavily contaminated and infected field, the choice of repair is limited to a primary repair, staged procedure or the use of a biologic mesh. Although biologic meshes generally give adequate results in contaminated fields when used as reinforcement, their performance in infected fields remains uncertain.

Finally, in case of mesh infection, selective non-operative treatment might be attempted when systemic and local factors allow.

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# 28 The Contaminated Abdominal Wall

**Robert Lim and Scott Rehrig**

## Introduction

A ventral hernia repair in a contaminated or clean-contaminated case should be considered as similar to a complex ventral hernia (CVH). When contemplating abdominal wall reconstruction for the repair of CVH, three basic questions must be considered: (1) What is the definition of a complex hernia, (2) how to best repair the abdominal wall to restore form and function, and (3) how to best handle the abdominal wall skin to prevent flap necrosis.

There are several clinical instances, which seem to identify certain hernia repairs as "complex." They are those that result from damage control laparotomy and the serial closing of the abdominal fascia. Hernias that involve contaminated wounds such as ostomies, enterocutaneous fistulas, or prior superficial or deep space infections. Hernias are associated with morbidly obese and the sequelae of the metabolic syndrome (see Table 28.1). Hernias, in these patient populations, are considered complex because their infection rates, recurrence rates, and overall complication rates are higher when compared to hernias in patients without these risk factors (see Fig. 28.1).

Regardless of the source or timing of contamination, the most common organisms responsible for prosthetic mesh infection are gram-positive species specifically *Staphylococcus aureus*. Belansky et al. detailed the pathogenesis as follows: The mesh is contaminated by bacteria within the first 24 to 48 hours; as the unincorporated mesh has no surrounding blood supply the bacteria gain an irreversible foothold resulting in an "impenetrable" capsule known as a biofilm. Once a biofilm occurs on the surface of a prosthetic mesh, the ability to eradicate the infection is essentially zero necessitating the need for reoperation and mesh explanation.

The undamaged and properly functioning abdominal wall yields a platform that supports pulmonary, digestive, and urologic function as well the locomotion of the thoraco-abdominal musculature. The net effect of a damaged and weakened abdominal musculature is the imbalance of intraabdominal and abdominal wall pressures leading to a hernia defect. In the undamaged abdominal wall, muscles contract isometrically to counter intraabdominal forces causing an equilibration of pressures. In the damaged abdominal wall, the muscles contract isotonically leading to a non-uniform of forces that have the net effect of progressively expanding the abdominal wall defect. Prosthetic

**TABLE 28.1 Factors that Make Ventral Hernias Complex**

| | |
|---|---|
| BMI > 35 kg/m$^2$ | Enterotomy |
| Smoking | Bowel Resection |
| DM | Emergent procedure |
| Steroid Use | Trauma hernias after sequential closing of abdominal wounds |
| CHF | Prolonged operative time |
| COPD | Preoperative wound infection |

BMI, body mass index; DM, diabetes mellitus; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease.

mesh repairs serve as simple patches that function to hopefully redistribute abdominal wall forces evenly according to Pascal's principle. In cases where hernia defects are small—less than 10 cm—patching a defect with mesh may be adequate; but in complex hernias that are large, have severely weakened tissues, and/or are prone to recurrence or infection, what is required is to restore the abdominal musculature to its proper position and function.

## INDICATIONS AND GUIDELINES FOR THE PLACEMENT OF MESH

### Mesh Placement in Contaminated and Potentially Contaminated Environment

The major controversy regarding the use of mesh to repair abdominal wall defects are the risk of infection compared to the risk of recurrence. The literature suggests that recurrence rates are significantly lower with the routine use of mesh as compared to tissue only repairs; paradoxically, the risk of infection is significantly higher in those patients treated with mesh due to the presence of a foreign body. The incidence of infection in mesh hernia repair in clean-contaminated and contaminated cases can be as high as 40%. Other factors like steroid use, smoking, and prolonged operative times further increase the risk of infection.

Until recently, the true risk of morbidity associated with the contaminated abdominal wall was unclear. Choi et al. from Mount Sinai in New York reviewed nearly 34,000 patients who underwent ventral hernia repairs with mesh using National Surgical Quality Improvement Program (NSQIP) data. The authors compared clean-contaminated


**Figure 28.1** Contaminated abdominal walls secondary to **(A)** blast injury **(B)** ostomy and infection.

and contaminated to clean cases using an odds ratio method. Not surprisingly, they found superficial site infections (SSI) occur 2.5 and 3.8 times more often in clean-contaminated and contaminated cases respectively compared to clean cases. Moreover, deep space surgical infection was over 6 times more likely to occur with the use of permanent mesh. The findings of this study are important as they clearly suggest that the use of prosthetic mesh for ventral hernia in the setting of any level of contamination is associated with prohibitive risk. With the increasing emphasis on patient safety and scrutiny of clinical outcomes, it behooves the surgeon to look to evidence-based guidelines when attempting to manage these complex patients. No level one data is currently available but guidelines are slowly being developed.

With the application of laparoscopy to the repair ventral hernia, infection rates, hospital length of stay, and postoperative pain have all decreased compared to open repair. Surprisingly no difference in recurrence rates exists between laparoscopic and open techniques. Analogous to the increased incidence of bile duct injury in laparoscopic cholecystectomy, compared to open cholecystectomy, the bowel injury rate in laparoscopic ventral hernia repair is up to two times that of open repair techniques attesting to the technical challenges of laparoscopic lysis of adhesions. For patients with CVH not due to a contaminated environment, a laparoscopic repair with permanent mesh is acceptable. However, in planned ventral hernia repairs where concomitant gastrointestinal, biliary, or genitourinary procedures are performed, the complication rates are too high to safely use permanent mesh. Therefore, we recommend that a laparoscopic approach be avoided since it requires the implantation of prosthetic mesh. CVH repairs that occur concomitantly with fistula repair or ostomy takedown have the highest recurrence and infection rates, which holds true for both permanent and biologic mesh. In these patients, a conservative approach is to do a staged repair whereby the surgeon treats the fistula or performs an anastomosis in one setting accepting a ventral hernia and plans the definitive abdominal wall repair with mesh at a later time. This, of course, would expose the patient to another anesthetic event, and possibly a loss of abdominal domain making the subsequent surgery more challenging.

In laparoscopic hernia repairs with unplanned contamination due to gastrointestinal, genitourinary, or biliary sources, the safest option is to repair the visceral injury and not implant prosthetic mesh at the same time. Instead, one would plan to return to the operating room in a few weeks for the definitive hernia repair. Another option would be to convert to an open procedure performing a Rives–Stoppa (RS) or component separation (CS) technique with a biologic mesh.

Emergency surgery situations associated with hernias also confer increased risk for prosthetic mesh infection. CVH is best treated with a biologic mesh placed in a retrorectus position if the patient can tolerate the longer operation. If the patient is too unstable, then placement of an absorbable mesh, like polyglactin (Vicryl), as an interposition and temporizing measure should be considered for its expedience. The use of absorbable mesh is associated with a very high incidence of infection; but this may be more due to the patient's underlying condition that lead to the emergency, rather than the mesh itself.

The efficacy of biologic mesh is still being studied. No randomized controlled trials exist demonstrating its superiority compared to the use of permanent mesh for CVH repair. Furthermore, few prospective studies extend beyond 2 years to suggest that long-term recurrence is significantly less. Most believe that the infection rate is significantly less with the use of biologic mesh. Interestingly, however, the largest multi-center, albeit retrospective, study shows that the surgical site infection (SSI) rate is not lower than those hernias repaired with permanent mesh. The recurrence rate is still better than those hernias repaired with tissue only. Fistula development and mesh explantation requirement, though, are higher after permanent mesh use.

There are several types of mesh currently available. (See Table 28.2) The current data does not show that a certain type of biologic mesh is superior to another. Biologic meshes are significantly more expensive than permanent ones.

**TABLE 28.2 Common Mesh Types**

| Mesh | Manufacture Name | |
|---|---|---|
| **Synthetic** | | |
| Polypropylene | Mersilene® | |
| Expanded polytetrafluoroethylene (ePTFE) | Gore-Tex® | |
| Bio-A® | Gore® Bio-A® tissue reinforcement | Synthetic but fully absorbable |
| Polyester | Atrium®, Marlex®, Prolene® | |
| **Biologic** | | |
| Porcine dermis | XenMatriX™ | Not cross-linked |
| | Strattice® | Not cross-linked |
| | Permacol™ | Cross-linked |
| | Collamend | Cross-linked |
| Porcine small intestine | Surgisis™ | Not cross-linked |
| Bovine pericardium | Peri-guard® | Cross-linked |
| | Veritas® | Not cross-linked |
| Bovine dermis | Surgimend® | Not cross-linked |
| Human dermis | Alloderm® | Not cross linked |
| | AlloMax™ | Not cross-linked |

### Treatment of Infected Mesh

When a contaminated prosthesis is encountered the consensus is to remove the infected mesh completely. Options for managing the resultant hernia defect again include the RS and CS repairs. Again there is some data that suggests that augmenting that repair with mesh improves the outcomes but there are no long-term and randomized studies to confirm this. Currently, there seems to be a trend towards an RS repair with mesh to reinforce the repair. Again, biologic mesh has not been compared to permanent mesh in this instance, nor has a CS repair been compared to an RS one in this setting.

### Abdominal Wall Reconstruction in the Military During the Recent Conflicts

With the initiation of the wars in Iraq and Afghanistan, military surgeons have adopted civilian trauma techniques in order to salvage service members (SMs) who have undergone devastating multi-system blast injuries. Chief amongst these techniques has been the use of damage control resuscitation and laparotomy, which subsequently has generated a large cohort of severely wounded SMs with an open abdomen. Military surgeons like their civilian counterpart have increasing employed abdominal wall reconstruction techniques to definitely manage these complex cases. Vertrees et al. reported on 86 military patients with a mean Injury Severity Score of 30 evacuated to Washington DC with open abdomen between 2003 and 2007. Fortunately, 67% of the cohort successfully underwent early delayed abdominal closure via a silo technique where gortex mesh was placed and sequentially tightened over weeks until fascial closure was obtained (see Fig. 28.2). In cases where the primary closure was not possible patients underwent abdominal wall reconstruction supplemented with early on prosthetic (62%) and later biologic mesh (31%). Long-term hernia recurrence was not reported.

## Abdominal Wall Reconstruction Techniques

Two major techniques exist to reconstruct complex abdominal wall defects. The RS retro-rectus repair and the abdominal component separation (CS) technique. The RS technique places mesh in a retro-rectus position anterior to the posterior rectus fascia

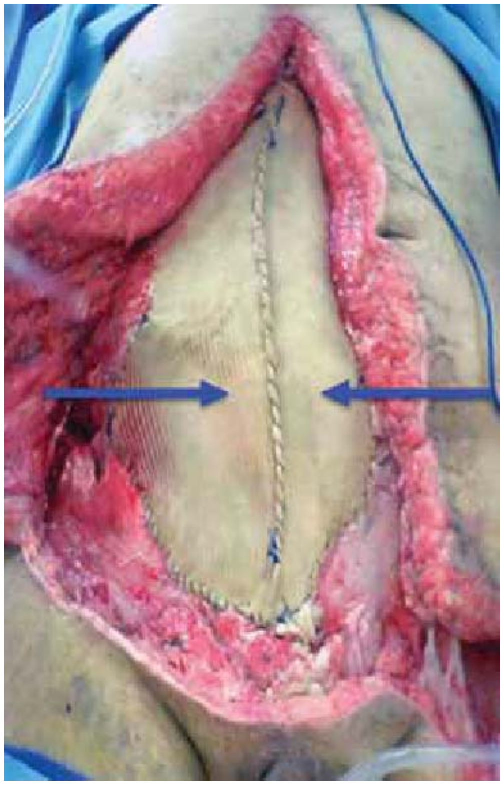

**Figure 28.2** Example of PTFE mesh used for serial closure of open abdomen. Mesh is serially advanced toward midline (see *arrows*), the excess trimmed, and secured with running suture until the fascia is approximated.

and posterior to the rectus muscle with a wide overlap of mesh greater than 10 cm. The net result is a tension-free repair covering a large surface area of mesh that is well incorporated and protected from contact with underlying viscera. The RS repair does not restore a fully functioning abdominal wall because it does not medialize the rectus muscles. This fact may be an important consideration in young patients who must perform physical activity for employment or those with very large defects where a failure to close the anterior fascia leaves mesh at high risk for infection in the event of wound dehiscence.

The CS technique described by Ramirez et al. involves the mobilization and medial transfer of the abdominal wall musculature in order to close large complicated ventral hernia defects. Via an approach lateral to the rectus muscles at the semilunar lines, the external and the internal oblique are separated leaving a neurovascularly intact rectus muscle complex that can be medialized up to 10 cm bilaterally (Fig. 28.3).

The technique of CS allows the surgeon to provide the CVH patient a superior outcome compared to simple prosthetic mesh repair because CS yields a functional dynamic abdominal wall. Prosthetic mesh repairs are in essence simply patches that cover the abdominal wall defect but do little to restore dynamic muscular function, which is key to restoring quality of life to these complicated and often debilitated patients.

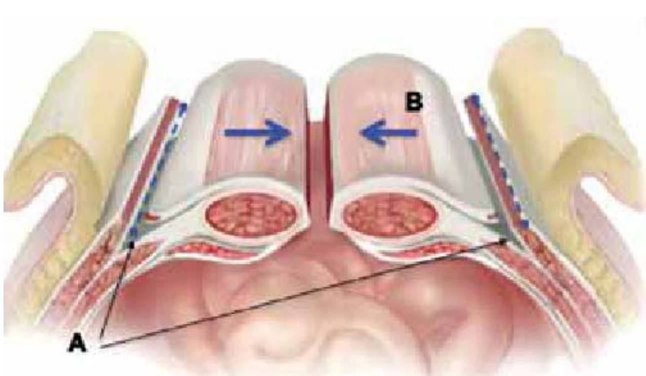


**Figure 28.3** **A:** Semilunar lines incised 2 cm lateral to edge of rectus abdominis. **B:** Medial transfer of the rectus muscles toward the midline (Lifecell Corporation with permission).

Researchers have described several technical modifications for CS that seek to address the third question noted above—how to prevent skin flap necrosis. Ramirez's original technique described the creation of large skin flaps lateral to the semilunar lines of the abdominal wall. Early reports have detailed major complications related to the creation of large skin flaps including hematomas, seromas, and flap necrosis.

Subsequently surgeons have sought to decrease these complications via the use of open tunneling or laparoscopic means to gain access to the semilunar lines from subcostal incisions. The open tunneling techniques focus on sparing the periumbilical perforator blood supply to the skin flaps located approximately 4 cm radially from the umbilicus. Others have described endoscopic techniques using laparoscopic hernia dissector balloons placed lateral to the semilunar lines and into the plane between the internal and the external oblique. Upon inflation, the balloon separates the external from internal oblique muscles. Using a laparoscopic scissor the external oblique muscles are incised 2 cm lateral to the semilunar lines via two additionally placed trocars.

The net effects of these modifications are to prevent skin flap ischemia, minimize skin necrosis and to decrease dead space leading to seromas and SSIs. Ko et al. in their review of 200 CS cases stated that one of the "major lesson learned … is that handling the skin is important … especially in patients with elevated body mass indices."

## PREOPERATIVE PREPARATION

The Ventral Hernia Working Group (VHWG) recently published evidence-based guidelines for the repair of CVHs. Amongst the principles sited by the VHWG, they consider the preoperative medical optimization of patient's co-morbidities of paramount importance. Multiple risk factors exist that are predictive of infectious complications after ventral hernia repair. They are tobacco use, diabetes (DM), chronic obstructive pulmonary disease (COPD), coronary artery disease (CAD), poor nutritional status, immunosupression, chronic corticosteroid use, low serum albumin, obesity, and advanced age.

Understanding and attempting to ameliorate the effects of these risk factors is essential for successful outcomes, as studies have demonstrated that the presence of a wound infection after ventral hernia repair confers a risk of recurrence up to 80% compared to one-third for the non-infected patient. Tobacco cessation is enforced for a minimum of 1 month before hernia repair as research has clearly demonstrated a negative effect on wound healing and 2-fold increased risk of infectious complication in active smokers. Medical consultations are sought for the control of DM with a targeted goal of blood sugars $<110$ mg/dL or H1Ac levels less than 7.0%. To improve oxygenation and optimize cardiac function, pulmonary and cardiac medications are maximized in patients with COPD and CAD, respectively. Nutritional status is assessed and optimized. Protein stores resuscitated, vitamin and mineral levels replenished, and medically supervised weight loss initiated. Concomitant infections of soft tissues or other sites such as intraabdominal abscesses are aggressively treated.

Patients with large ventral hernias and a BMI $>35$ kg/m$^2$ seem to have a high risk of recurrence; and consideration should be given to referring patients for a bariatric procedure and temporary closure followed by a more definitive hernia repair after significant weight loss is achieved. This seems to reduce recurrence. In patients with super morbid obesity (BMI $>50$ kg/m$^2$), their larger hernias are likely to present with a loss of domain. In such cases, it may be impossible to repair the hernia without significant associated weight loss.

Several authors have proposed algorithms to guide CHR reconstruction. Breuing et al. devised a four-tiered grading system stratifying patients on the basis of the risk of surgical site occurrence (Table 28.3). Using this system, patients are stratified into relative risk categories or grades. They further made recommendation for mesh type. Essentially grade 1 is the only category where prosthetic mesh is recommended. Grades 2 to 4 represent increasing risk for surgical site occurrence and thus the authors suggest biologic mesh as an alternative. Hadeed et al. reviewed 133 patients from Duke University Medical Center. Similar to the VHWG recommendation pertaining to CHR, Hadeed

**TABLE 28.3 Complications and Rates for Complex Ventral Hernia Repair Cases**

| | Tissue Only | Biologic Mesh | Permanent Mesh |
|---|---|---|---|
| Recurrence | 22.5–41.3% | 6.0–20.0% | 21.2–27.0% |
| Infection | 9–18.6 | 0–40% | 10.2–22.7 |
| Fistula formation | 11.5 | 0–18 | 6.6–20.8 |
| Mesh explantation | na | 17.1 | 50–90 |
| Death | 4.2 | 2.9 | 1.4 |

et al. strongly recommend the implantation of biologic mesh in an underlay fashion with a minimum of 3 cm overlap of mesh beyond the abdominal wall defect. Ko et al. reported on their cohort of over 200 patients undergoing abdominal wall reconstruction. The authors' algorithm focuses on repairing the abdominal wall to restore form and function, and minimizing the risk of skin flap necrosis. The conclusion from this large study suggests that the release and medialization of the abdominal components best restores abdominal wall function and minimizes recurrences. Skin flaps are best protected by avoidance of aggressive undermining and ligation of the perforating vessels to the skin especially periumbilically.

## SURGERY

The patients may undergo a mechanical bowel preparation at the discretion of the operative surgeon. The authors use bowel preparation only if restoration of intestinal continuity is planned in the setting of a fistula or ostomy. A cephalosporin is administered intravenously as prophylaxis against SSI. Subcutaneous heparin and a sequential compression device are used for deep venous thrombosis prophylaxis. The procedure is performed under general anesthesia with or without epidural anesthesia. As many patients are morbidly obese, patients undergo a sleep study and when indicated a continuous positive airway pressure (CPAP) machine is fitted and titrated for use perioperatively in the management of obstructive sleep apnea.

The patients are placed in the supine position. A midline laparotomy incision is performed from the xiphoid to the pubic symphysis. Split thickness skin grafts (STSGs) are excised. Patients are ready to return to the operating room after STSGs to the open abdomen when the skin is easy "pinched" and separates from the underlying tissues when assessed in the office preoperatively. In order to avoid injury to the bowel, the peritoneum is entered remote from the site of the herniation. The bowel and omentum are separated from the hernia sac. The sac is excised. Adhesions between the bowel and omentum and the posterior abdominal wall are lysed to the level of the colic gutters.

If a fistula or ostomy takedown and abdominal wall reconstruction are planned, then it is conducted at this point. In cases where ostomy takedown is not possible, this may limit but does not preclude CS on the side of the ostomy. Some controversy exists as to the timing and extent of these complex procedures. Johnson et al. recently reviewed this topic noting that no level 1 data exists to guide therapy. The authors suggest a staged approach where the patient is medically optimized and nutritionally resuscitated for several months at which point the fistula is taken down and the abdomen closed while fully expecting a ventral hernia to occur. After an interval of several more months passes, the patients undergo definitive abdominal wall reconstruction. In the case of young and active patients, the CS technique with mesh reinforcement may be employed in order to best restore form and function to the patient's abdominal wall.

After restoration of intestinal continuity, the cutaneous flaps are addressed. The authors do not advocate wide mobilization of the tissues off the anterior rectus fascia as this has clearly demonstrated to have an unacceptable rate of flap necrosis, dehiscence, and SSI. Dependent on a surgeon's experience and resources, several techniques are available for mobilization of the tissues.

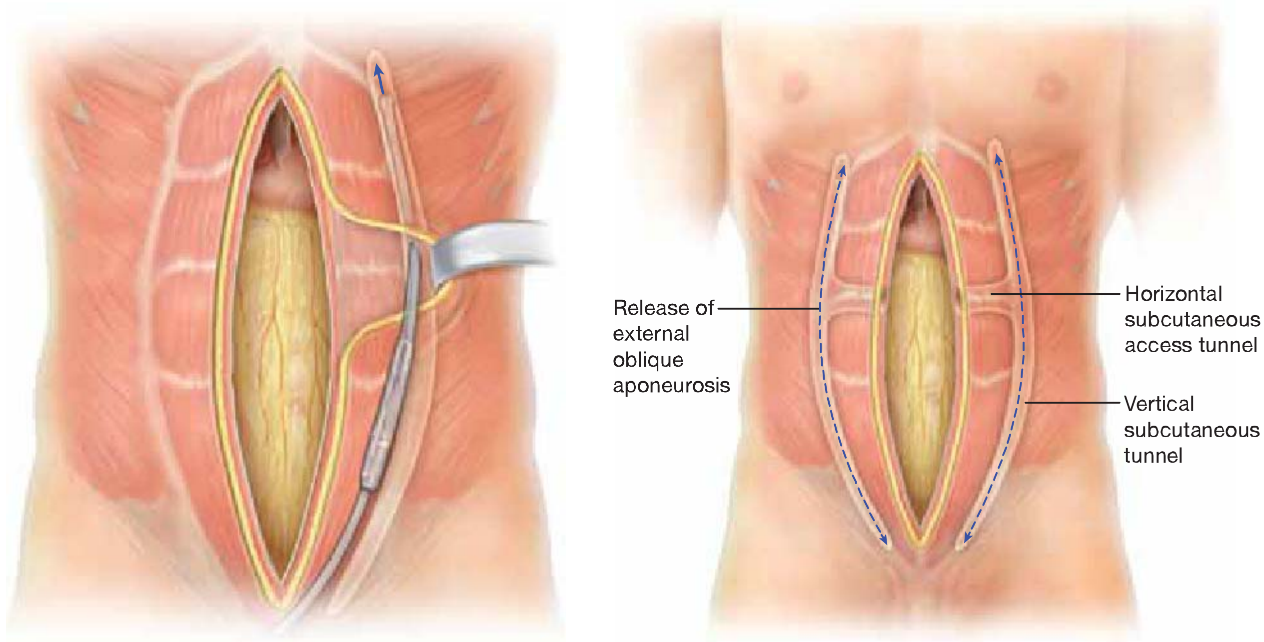


**Figure 28.4** A Yankauer suction handle is inserted through the opening created in the external oblique aponeurosis and is advanced in the avascular plane between the internal and external oblique aponeuroses just lateral to the junction with the lateral border of the rectus complex.Sweeping motions of the Yankauer suction handle are used to bluntly dissect this avascular plane. This is first performed inferiorly by inserting the Yankauer suction handle inferiorly toward the pubis and sweeping superiorly (not shown) and then inserting it superiorly to approximately 12 cm above the costal margin and sweeping inferiorly (shown). Minimal dissection should be performed cranial to the costal margin because excessive dissection would not contribute significantly to the degree of rectus complex medialization and intramuscular connections are encountered at this location. Modified from Butler CE, Campbell KT. Minimally invasive CS with inlay bioprosthetic mesh (MICSIB) for complex abdominal wall reconstruction. *Plast Reconstr Surg.* 2011;128(3):698–709.

In the open periumbilical perforator sparing technique, the goal is to spare at a minimum the blood supply to the periumbilical skin in a 4 cm radius emanating from the umbilicus. Butler et al. from MD Anderson has described an open modification that uses a minimal dissection technique creating a tunnel 2 cm below the costal margin allowing access to the semilunar lines bilaterally. A Yankauer suction tip serves as a guide and blunt dissector to incise the external oblique aponeurosis and separate the tissue planes, respectively. The components are freed 12 cm superior to the costal margin and inferiorly to the level of the pubis symphysis. Skin flaps are raised off the rectus muscles bilaterally only to the level of the first skin perforators (see Fig. 28.4).

Others have successfully demonstrated endoscopic CS techniques. Bilateral incisions are placed at the costal margin at border of the 11th rib. The external oblique fibers are split, the potential space between the internal and external oblique muscles is developed bluntly, and a TEPP hernia dissector balloon is inserted to the pubis. Upon insufflation the dissector balloon is removed and a 10 mm balloon-tipped trocar is placed. Next, the external oblique layer is incised 2 cm lateral to the semilunar line using laparoscopic scissors. The dissection is conducted from above the costal margin for several centimeters to the pubis inferiorly (see Fig. 28.5).

Responding to the ever-growing need to improve outcomes and think innovatively, researchers have described hybrid techniques for the reconstruction of complex abdominal wall defects. Cox et al. describe a technique combining a retro-rectus RS technique with endoscopic component separation. The authors cite data that demonstrate that infection rates double in the RS procedure when anterior fascial approximation over the prosthetic mesh is not possible. Therefore, they modified their technique adding an endoscopic component separation in order to address this issue. The authors noted low morbidity and no hernia recurrence at 14 months follow-up. Para et al. describe a hybrid procedure combining laparoscopic ventral hernia and minimally invasive CS techniques. The researchers cite a desire to decrease operative costs and simplify the

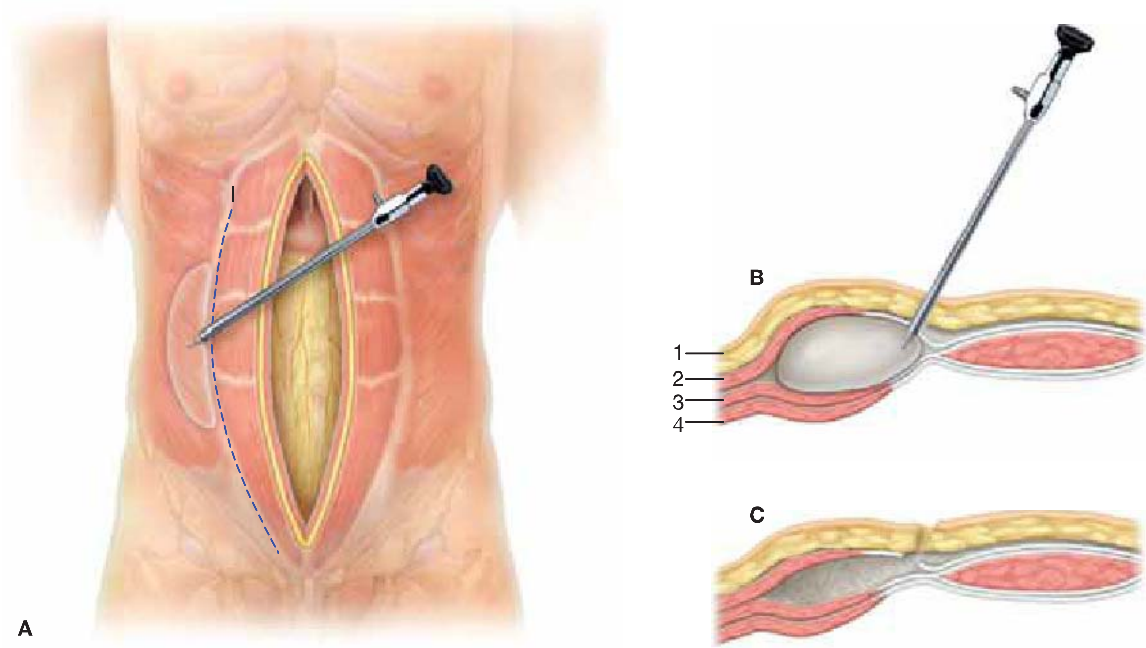


**Figure 28.5** Technique of the endoscopically assisted method. **A:** Through a 2 cm incision in the skin and aponeurosis of the external oblique muscle, a dilating balloon is introduced by a trocar into the avascular plane between the external and the internal oblique muscle. I, the medial border of the external oblique muscle where the aponeurosis is transected. **B:** The balloon is insufflated, separating the external (2) from the internal (3) oblique muscle. The skin and SC tissue (1) remain fixed to the underlying fascia. After removal of the balloon, the myoaponeurotic aponeurosis of the external oblique muscle is lifted with retractors and transected under video-endoscopic control through the skin incision. **C:** A compound flap is created that can be advanced over about 10 cm by stretching the internal oblique (3) and transverse abdominis (4) muscle. Modified from Maas SM, de Vries Reilingh TS, van Goor H et al. Endoscopically Assisted "Components Separation Technique" for the Repair of Complicated Ventral Hernias. *J Am Coll Surg.* 2002;194(3).

technical requirements of endoscopic CS while retaining the benefits of the prior techniques. The procedure entails an open minimally invasive tunneling technique to access and release the abdominal wall components combined with totally laparoscopic ventral hernia repair placing biologic mesh in an underlay position for contaminated cases. Thus, they avoid the high cost of disposable instrumentation somewhat offsetting the expense of the biologic prosthesis. At 1-year follow-up, Para et al. report no major complications or early hernia recurrence.



## POSTOPERATIVE MANAGEMENT

A Velcro abdominal binder is used for patient support and comfort. Prophylactic antibiotics are administered to all patients and discontinued after 24 hours unless clinically justified. Nasogastric tubes are not routinely used. The foley catheter is discontinued after 24 hours unless required by the presence of the epidural catheter. Aggressive pulmonary toilet is instituted and CPAP, if needed, ordered immediately postoperatively. Early ambulation is encouraged. Patients are likely to experience significant pain and so pain control should be aggressive. Drains are followed until outputs are less than 30 mL for 48 hours (see Fig. 28.6).

## COMPLICATIONS AND OUTCOMES

The outcomes of CVH repairs are generally disappointing regardless of technique. While they can be safely done in terms of mortality, the morbidity remains high. Recurrence rates are certainly more without the use of mesh but they are around 20% despite its use. Recurrence rates do not seem to differ between permanent and

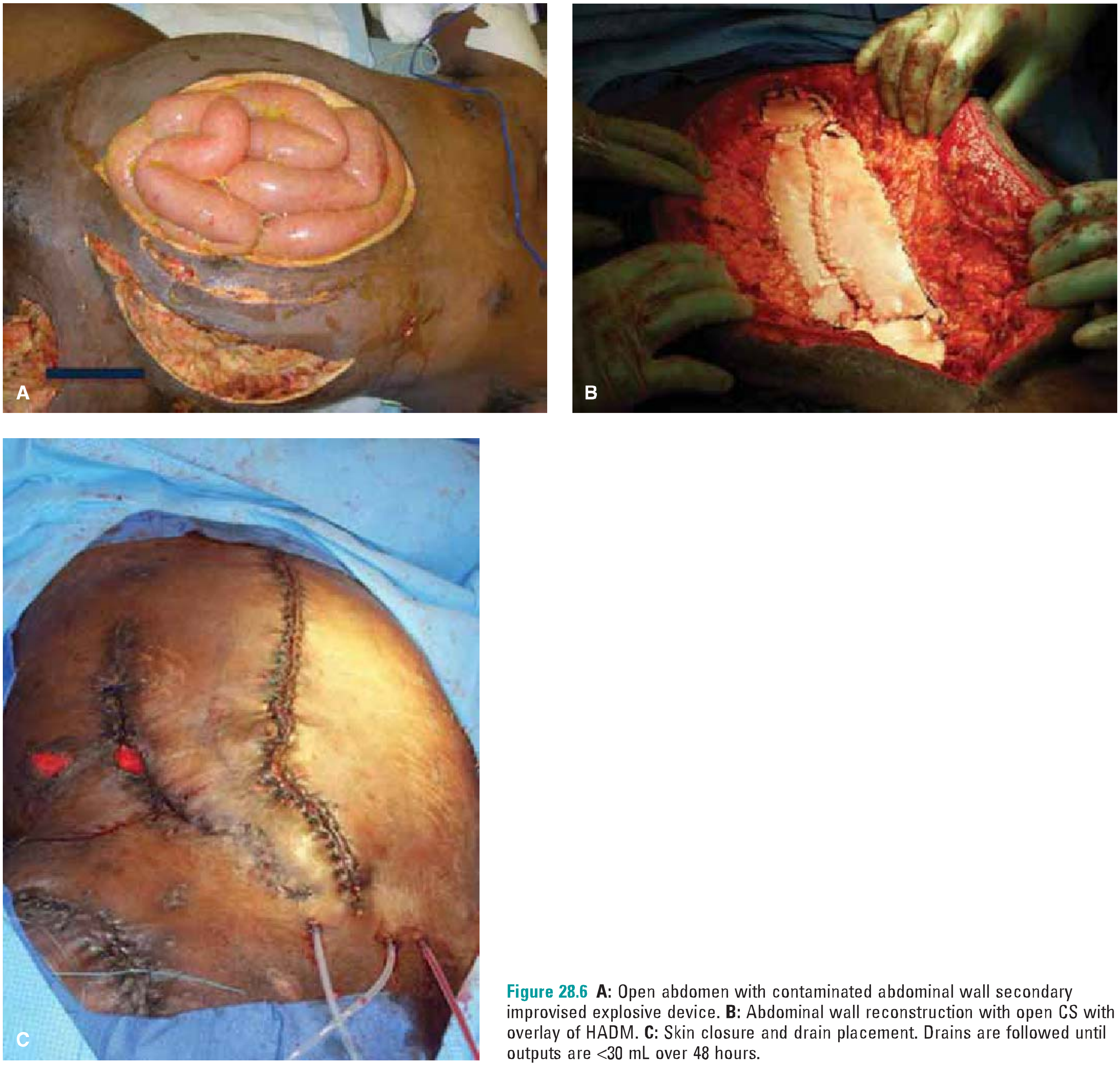

**Figure 28.6** **A:** Open abdomen with contaminated abdominal wall secondary improvised explosive device. **B:** Abdominal wall reconstruction with open CS with overlay of HADM. **C:** Skin closure and drain placement. Drains are followed until outputs are <30 mL over 48 hours.

biologic mesh. Infection rates in CVH repairs are substantial even without the use of mesh which points to the fact that the underlying disease and co-morbid conditions significantly impact the outcomes of CVH repairs. The incidence of infection does not seem to be less with the use of biologic mesh, but there is a paucity of data regarding the use of permanent mesh in contaminated cases. Even in the Choi review of over 33,000 patients, only 22 patients had permanent mesh placed in surgical class III cases. With the use of permanent mesh in cases where patients are higher risk, the rate of fistula formation and the need for mesh explantation seem to be higher.

Iqbal et al. from the Mayo Clinic reported the results of 254 RS repairs over 13 years. They noted 0% mortality, 13% morbidity, 87% follow-up and an overall recurrence of 5%. Amongst their conclusions, they stated that concomitant bowel procedures are a contraindication to the implantation prosthetic mesh. They reported a 30% hernia recurrence in cases where a wound infection occurred related to contamination in the operative field.

Tong et al. recently reviewed the literature detailing several CS techniques and outcomes. The authors noted 21 relevant studies that described open CS with and without mesh reinforcement of the midline as well as the so-called minimally invasive CS (MICS) techniques that use laparoscopic balloon dissectors to facilitate access and CS. They noted an overall of complication rate of 21%, 59%, and 32% for open CS with mesh, without mesh, and MICS, respectively. Hernia recurrence was highest for open CS without mesh reinforcement (27%) and lowest for MICS (17%). The authors concluded that patients undergoing complex abdominal wall reconstruction benefit from reinforcement of the repair with prosthetic mesh to decrease the recurrence rate. They found that the complications from open CS versus MICS were overall equivalent.

## CONCLUSIONS

There are many situations, heretofore underappreciated, that surgeons should recognize before embarking on a CVH repair. Hernias in obese patients, hernias that occur after sequential closing of the abdomen in trauma patients, hernias that result from previous wound infections, and hernias in patients with significant co-morbid conditions and other clinical factors mentioned above should be considered complex. CVHs, regardless of their infection class, should be regarded like contaminated hernias due to their propensity for recurrence and infectious complications. For these cases, the use of a biologic mesh should be considered to augment either an RS or a CS repair. Certainly, for CVH patients, we strongly suggest that prosthetic mesh not be implanted. Additionally, if one chooses a CS technique then the MICS technique may be superior in terms of skin necrosis. It is important to note that none of the techniques described are without a significant risk of recurrence or infection even with the use of a biologic mesh. If an infected mesh is encountered then removal of the mesh is paramount. There is no mesh that has proven superior to others in terms of recurrence or infection. Every attempt should be made to modify any other risk factors that increase the complication risks of complex hernia repairs like tobacco and DM and should include consideration of bariatric surgery for patients who are morbidly obese.



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# 29 Components Separation

**Derek E. Bell**

## Introduction

The massive ventral hernia presents a significant and poorly mastered reconstructive challenge (Fig. 29.1). Hernia develops in up to 11% of all primary laparotomies. It is estimated that over 250,000 ventral herniorrhaphies are performed each year in the United States. Recurrence rates of incisional herniorrhaphy are as high as 44% to 58%. Prosthetic mesh may lower recurrence rates but this is not without the increased rate of complications such as infection, extrusion, increased adhesions thus causing bowel obstruction or fistula formation. Primary closure has been found to have an unacceptable recurrence rate of up to 58%.

Ramirez first published an innovative technique for true reconstruction of the abdominal wall in 1990. This method entitled "component separation" utilized the rectus abdominis for reconstruction of midline defects. In this technique, the rectus abdominis is freed from the external oblique and in doing so this release allows for medialization of the rectus abdominis to the midline. The preliminary study which was performed on fresh cadavers allowed for medialization up to 10 cm of each muscle along the midline. This has become the basis for dozens of modifications of this technique since its first publication in 1990. This chapter will discuss the technique described by Ramirez, modifications of the technique and the benefits, patient selection, complications, and expected outcomes.

Even with component separation techniques, prior mesh repair has been demonstrated to be an independent risk factor for development of hernia recurrence. Repair of the massive ventral hernia can be performed with bioprosthetic or synthetic meshes although true repair of the coelomic defect is arguable. The reason for this is that repair with a multitude of meshes does not truly restore the dynamic function of the abdominal wall and predisposes the patients to complications such as fistulae, evisceration, infection, and death.

## Anatomy

The rectus abdominis is a bi-pedicled muscle flap or Mathis and Nahai type III flap with a dual vascular supply originating from the deep superior and inferior epigastric arteries. The fibers are vertically oriented and are contained anteriorly by the anterior rectus sheath and deep or posteriorly by the posterior rectus sheath. The muscle is attached to

**Figure 29.1** Patient with a massive ventral hernia after exploratory laparotomy and split thickness skin grafting of the granulated visceral contents.

the costal margin cranially and to the pubis at the caudal extent. The arcuate line of the abdomen, Linea semicircularis or Douglas' line is a horizontal line that demarcates the lower limit of the posterior layer of the rectus sheath. Inferior to this line, the internal oblique and transversalis pass anterior to the rectus sheath and generally this is also where the inferior epigastric vessels perforate the rectus abdominis. Superior to the arcuate line, the internal oblique aponeurosis split to envelope the rectus abdominis both superficial and deep to the muscle itself and helps to form the anterior and the posterior rectus sheath. The deep inferior epigastric originates from the internal iliac arteries and the superior epigastric arteries originate from the internal thoracic arteries otherwise known as the internal mammary arteries. The innervation to the rectus abdominis is via the intercostal nerves that traverse the abdominal wall in the plane between the internal oblique and transversalis.

The paired deep inferior epigastric arteries are the main blood supply for the abdominal wall. These are most commonly associated with two veins. These arteries often branch and have a variable aborization but generally remain deep to the rectus abdominis muscle caudal to the arcuate line. The branching system most commonly involves two major branches but may remain as a single dominant pedicle and least often as three branches. Eighty percent of the dominant blood supply is derived from the lateral branches of the deep inferior epigastric artery after its division. Perforating branches traverse the rectus abdominis to supply the skin surface. The perforators contribute to the subdermal plexus providing vascularity to the dermis and epidermis. The Cadaveric studies have revealed that very few perforators penetrate the linea alba or the external oblique aponeurosis and the greatest density of perforators is in the periumbilical region. Perforator sparing techniques have been employed as to minimize the risk of skin edge necrosis.

## PREOPERATIVE PLANNING

Timing of reconstruction has been of controversy. First and foremost there should be management of exposed visceral contents in the case of open abdomen. Patients who have undergone trauma laparotomies are treated with Vicryl or other absorbable mesh or a biologic neodermis which helps to contain the visceral contents and create a smooth surface for granulation to occur. After a healthy granulation bed has formed, split thickness skin grafting of the granulating wound can be performed. A wound VAC device helps to optimize the take of the graft and provide uniform compression of the graft to the wound bed during the postoperative graft incorporation process and this should not preclude weaning or extubating a patient if the patient's pulmonary dynamics would allow doing so. The overall minimization of perioperative complications with control of the open abdomen in this manner has been advocated. Planned, staged component separation reveals major complication rates to be acceptably low with recurrence of 5%. With this conservative approach to reconstruction, mortality is extremely low and approaching 0% at 24-month follow-up. Grafting of the coelomic contents, however, provides little strength or structural support otherwise to the abdominal wall. Loss of support of the abdominal wall centrally, with or without necessity of grafting, over time allows for the fascial defect to increase as the vector of the abdominal wall musculature is in a lateral and a posterior direction. In contrast to staged management of the open abdomen, patients undergoing early fascial closure in trauma patients have dismal results with mortality approaching 30%.

Patients with midline ventral hernias generally have a spectrum in the quality of the skin overlying the fascial defect. Adhesions must be given sufficient time to soften in order to easily obtain adhesiolysis and minimize the risk of inadvertent enterotomy. Patients who have undergone grafting of the viscera, this can be easily apparent by pinching the skin and elevating this away from the visceral content to determine the pliability from the underlying tissues. This would suggest that adhesiolysis could most easily be undertaken and in doing so minimize the risks of complications such as inadvertent enterotomy and fistulae (Fig. 29.2). In patients who have native attenuated skin along the midline, safe, cutaneous closure after resection can be determined by simply pinching the skin together along the midline. It is imperative that quality and pliability of the anticipated remaining skin needs to be considered as to obtain a tension-free cutaneous closure. Failure to do so will usually result in wound healing problems, dehiscence, and potential major complications. In obese patients, weight loss should be advocated to enhance the pliability of the overlying skin with loss of the subcutaneous adipose tissue and also optimize a successful reconstruction by eliminating visceral obesity as a risk for hernia recurrence.

It is a personal preference to obtain a preoperative CT scan of the abdomen and pelvis with both oral and intravenous contrast. This allows for preoperative planning as the rectus can be evaluated for both viability and distance from the midline. Distances of over 20 cm will likely require an interposition mesh or can be obtained with overlapping of the fascia of the anterior rectus sheath. Often patients have undergone a multitude of prior surgeries which will compromise the vascularity of the rectus abdominis or the overlying skin. Evaluating the superficial and deep epigastric arteries with CT



Figure 29.2 Pinch test demonstrating the pliability of the skin separation from the underlying adhesions.

pre-operatively is important as to avoid compromise of the abdominal wall skin post-operatively. In a circumstance where one of the epigastric vessels was compromised, a formal bilateral component separation should be avoided as to minimize failure of the repair, early wound dehiscence, and necrosis of the abdominal wall. Additionally, planning of the type or one of the several modifications of the component separation technique can be anticipated preoperatively. A CT defines the visceral anatomy within the hernia and may direct the safest approach for entering the coelomic cavity.

Debridement of necrotic or infected tissues including infected or exposed meshes should be undertaken prior to definitive repair. Wound infection significantly increases the risk of hernia recurrence to as much as 80%. Some authors advocate for control of ostomies or fistulae by restoring enteric continuity if planned in a staged fashion as well. The challenge this creates is that individualized patient anatomy may not allow for skin closure after such a procedure, so this must be taken into consideration.

Smoking cessation should be emphasized prior to surgery as to minimize skin edge necrosis and wound healing problems. In obese patients, weight loss should be considered and optimization of nutrition should be achieved preoperatively as well.

## INDICATIONS/CONTRAINDICATIONS

There are no formal indications for abdominal wall reconstruction via component separation technique; however, there are a multitude of instances when this treatment modality for abdominal wall reconstruction should be considered. General consideration for employing this technique includes large midline hernias, infected wounds or those that have exposed mesh and patients who have failed prior herniorrhaphy. The number of failed attempts at herniorrhaphy directly correlates with likeliness of additional failures with conventional mesh techniques and approaches 50% after three repairs.

One of the benefits of this technique is that autologous tissues are used. Thus, in wounds such as those with attempts with synthetic mesh repair and exposure or active infection of the mesh is noted, component separation is a good option for reconstruction. Most commonly this does not require the use of any synthetic or biologic mesh at all. Therefore, abdominal wall reconstruction can be undertaken in non-clean fields such as those with enterocutaneous fistulae or ostomy reversals. Some sources advocate for closure of fistulae, infection or reversal of ostomies in a preliminary procedure, and thus a staged fashion to prevent complications before undertaking definitive reconstruction. This proposed staged reconstruction would require intentionally leaving the patient with a hernia by either closing the skin only or placing a skin graft over granulated bowel or over a vascularized bioprosthetic mesh. The use of synthetic mesh is a relative contraindication with patients classified as having contaminated or dirty wounds and should be avoided in herniorrhaphy requiring such and a biologic mesh should be considered.

The component separation technique medializes the rectus abdominis and in doing so provides highly vascularized, neuritized dynamic muscular support to the midline. It has been postulated that by restoring the dynamic support across the hernias, the intrinsic weakness of this area is distributed along the entirety of the abdominal wall. Muscular closure eliminates this focal point of weakness although mesh repair does not. With this philosophy, many experts advocate that any ventral hernia should be repaired with muscle.

Defect size is of debate as to the appropriate approach to repair and minimization of recurrence rate. Mathes advocates for defects greater than 40 $cm^2$, while Shestak uses 6 cm as the arbitrary defect diameter for performing component separation. In a prospective analysis of sutured versus meshed repair of hernias greater or less than 10 $cm^2$, a failure rate of those hernias greater than 10 $cm^2$ was 63% in the sutured group versus 32% in the meshed repair. The group with defects less than 10 $cm^2$ the recurrences were greater than 17% with either repair. All modalities based upon Burger's analysis are of notable risk for recurrence based regardless of the size of the defect and arguably these patients may have lower recurrence with a component separation reconstruction of the abdominal wall.

The professional consensus is that any patient who has failed prior repair, and especially multiply failed repairs, should be considered for component separation. Poor viability of midline tissues such as the fascia warrants medialization of high quality tissues and releases to minimize tension at the midline. This should be taken into consideration in patients with lesser quality tissues such as those that are immunocompromised, diabetic, or older individuals in attenuated tissues require the tension-free repair that component separation provides.

Absolute contraindication for undergoing a component separation are those patients who lack the anatomy to perform this technique such as those who have lost abdominal domain for conditions such as a pancreatic fistula or necrotizing soft tissue infections of the abdominal wall. Patients considered to be of perioperative risk from multiple comorbidities should be closely considered for undergoing component separation as there may be perioperative morbidity or mortality from underlying medical disease. Unless symptomatic, necessity of repair in these high risk patients must be carefully considered. Patients with pulmonary disease have risk of further exacerbating pulmonary compromise although this has not been published in the literature. The rationale for such is that upon reconstruction of the abdominal wall, the coelomic contents will be shifted into the thoracic domain and affect lung capacity. Smokers are at increased risk for failure of repair. This is multifactorial in that the stresses to the abdominal wall caused when coughing increase rate of failure. Evidence-based medicine has shown that vasoconstrictive chemicals in tobacco are notably detrimental to the wound healing process. Radiated tissues have high rates of dehiscence and necrosis. In instances of radiation to the abdominal wall, to obtain successful reconstruction high-quality non-irradiated tissues should be delivered to the surgical site. This may involve pedicled or free flap reconstruction and is beyond the scope of this chapter. Patients with a history of multiple prior abdominal procedures with varied approaches should be addressed with caution as surgical dissection in performing component separation may result in partial or total abdominal wall necrosis.

## SURGERY/TECHNIQUE

The patient is marked in the preoperative holding area delineating the anticipated surgical approach. Usually a midline vertically orientated scar exists and an ellipse is drawn on the skin surface of the medial edge of the high-quality skin in a vertically oriented lenticular manner. The markings are reviewed with the patient using a full length mirror ensuring that the patient understands the procedure and areas of resection that often require umbilectomy. Thereafter, the patient is transported to the operative suite and placed supine on the operative table, sedated and intubated. The abdomen is widely prepped and draped from the table along the patient's flanks to the mid-sternal area and below the inguinal areas and upper thighs. The room temperature should be maintained above 80°F as to minimize postoperative infection.

In the patient who has an intact midline incision, a standard laparotomy incision is undertaken and in doing so poor quality scar is excised. The scar tissue between the skin and linea alba should be resected as re-opposition of the scar tissue will be detrimental to optimization of the tissues during healing. If the overlying bowel is skin grafted, an incision is made sharply along the perimeter of the lateral edge of the grafted area through the high-quality tissue. Thereafter, adhesiolysis of the grafted skin is undertaken. In either circumstance, adhesions of the bowel to the underlying abdominal wall is undertaken until the lateral extent of the rectus abdominis is identified bilaterally. Careless dissection in these areas could cause inadvertent transection of the epigastric vessels and render the rectus muscle or cutaneous angiosomes ischemic.

The anterior rectus sheath is freed from the soft tissues as tension is applied to the skin and subcutaneous adipose tissue with manual tension or metallic retractors such as a Richardson or Deavor. A loose areolar plane can be easily dissected in a medial to lateral manner. Staying in this plane allows for easy identification of the lateral aspect of the rectus sheath and minimizes over-dissection. With tension on the overlying tissues, the perforators which are of highest concentration in the periumbilical region can

**Figure 29.3** Perforator sparing technique; forcep tip at perforating periumbilical epigastric vessel.

be avoided (Fig. 29.3). In doing so, vascularity to the skin can be maintained as the majority of the cutaneous blood supply in this area is derived from the perforating vessels from the superior and inferior epigastrics. These run deep to the rectus abdominis and penetrate the muscle in a relatively predictable manner. If the perforators are sacrificed, the vascular supply to the skin is dependent on the subdermal plexus and superficial epigastrics, thus increasing the risk of skin edge necrosis.

Dissection is carried out to 1 to 2 cm lateral to the edge of the rectus abdominis at the linea semilunaris and along the entirety of the rectus from the costal margin to the pubis. This is performed bilaterally. The critical portion of the procedure is freeing the rectus from the external oblique. Inaccurate determination of the external oblique aponeurosis and its conjunction with the rectus abdominis can lead to non-release and a suboptimal or failed repair. Using very tip of the electrocautery, a small opening is made in the external oblique aponeurosis and the tip of a Tonsil clamp is passed with the tip pointed superficially and orientated in a cranial or caudal direction and gently teased into this plane. The tonsil should be approximated to the lateral portion of the rectus sheath as to ensure dissection through the oblique and not the anterior rectus sheath itself. If the tonsil clamp can be medialized or if the vertically orientated fibers of the rectus abdominis can be visualized, the layer of dissection must be corrected. The external oblique aponeurosis is transected in sagittal manner paying careful attention to avoid "passing point" and damaging the internal oblique. After the external oblique aponeurosis is released along the entirety, the rectus abdominis is brought to the midline. In doing so, the transected fibers of the external oblique aponeurosis should separate. Some authors describe elevating the external oblique to allow for sliding of the internal oblique in a myofascial sliding fashion. The original paper by Ramirez and later by Girotto describes incising the posterior rectus sheath along its lateral extent. Shestak has noted that this can increase the mobilization by 2 cm bilaterally.

The midline fascia is approximated with either running or interrupted sutures (Fig. 29.4). The author prefers a dual layer closure with looped 0 PDS in a running fashion and 1-0 Nurolon in an interrupted figure of eight fashion superficially. Drains in the posterior-lateral gutters are placed at the surgeon's discretion. Any redundant or vascularly compromised skin is trimmed at the midline, but in doing so allowing for a tension-free cutaneous closure. The fasciocutaneous layer is closed centrally with absorbable sutures in Scarpa's fascia and the skin is closed as per the surgeon's preference.

# Open Book Variation

The "Open Book" variation of the component separation technique has been proposed as a modification of the standard technique which allows for obtaining closure of midline

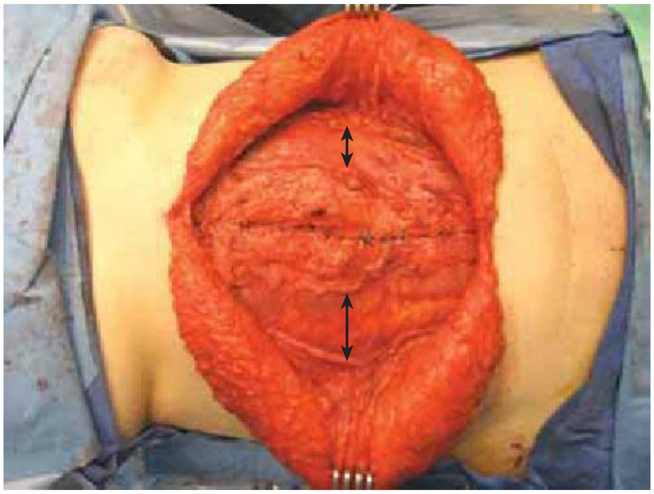

**Figure 29.4** Closure of the hernia with standard component separation technique. *Arrows* represent the cut edges of the external oblique aponeurosis and distance of release.

defects larger than those proposed by Ramirez. In my practice, I have found successful closure of defects measuring up 28 cm at the umbilicus using this method. This technique employs undergoing a standard approach by first removing poor quality skin at the midline and undertaking total adhesiolysis from the abdominal wall. The rectus abdominis is again freed from the overlying adipose tissue at the lever of the anterior rectus sheath in a medial to lateral direction until the aponeurosis of the external oblique can be identified. This is freed and the rectus is mobilized medially. If sufficient tension in closing the rectus is not alleviated, the anterior rectus sheath is elevated from the underlying muscle and brought across the midline in a vest over pants fashion (Fig. 29.5). This technique has a low recurrence rate, 7%, and alleviates the need for biologic mesh reinforcement. Extreme care must be undertaken in elevating the anterior rectus sheath as careless elevation of the muscular inscriptions will create holes in the sheath and compromise its integrity. The disadvantage of this procedure is that the perforating arteries must be sacrificed.

## Endoscopic Component Separation Technique

One of the criticisms of the conventional component separation technique is that this entails significant undermining of the skin and in doing so transection of the deep

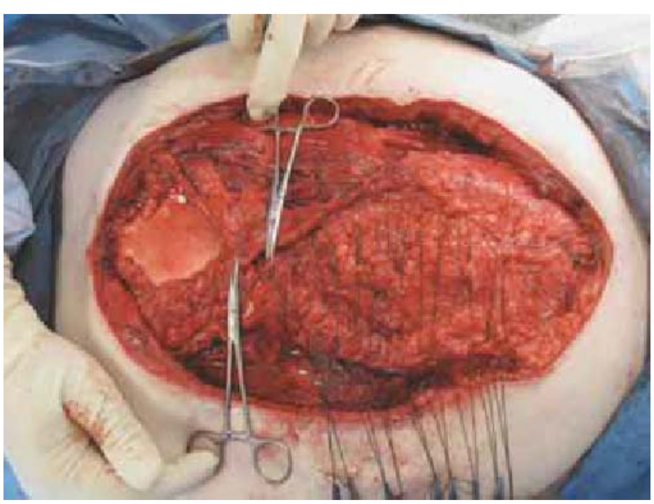

**Figure 29.5** "Open Book" variation with overlapping of the anterior rectus sheath in a vest over pants fashion.

epigastric perforators. This is postulated to contribute to skin edge necrosis. Undermining creates potential space for development of seromas and potential infection. The endoscopic technique entails creating a potential space between the external and internal oblique muscles and dividing the aponeurosis of the external oblique at its medial extent as is performed in the methodology of the open technique. The definitive herniorrhaphy is performed via conventional open approach through a midline laparotomy. Recurrence rates of 20% have been reported Clarke describes this technique in creating separate incisions along the inguinal region bilaterally and inserting a dissecting balloon between the internal and the external oblique. This allows for expansion of this potential space and the external oblique is released along its medial aponeurosis. When compared to conventional techniques, recurrence of the hernia was found to be similar in his work at 16% to 19%. There were no incidences of skin edge necrosis in the endoscopic technique and 25% of the open traditional technique. This would suggest the importance of perforator preservation.

## Reinforced Repair Technique

Re-enforcement with either synthetic or biologic mesh has been reported in conjunction with component separation. These have been used in an overlay fashion, underlay fashion, or both in a sandwich fashion above and deep to the rectus. This adds additional expense to the procedures and is not without complication, most common of which is infection and often requires re-operation and mesh removal. Synthetic mesh, especially Marlex has been shown to significantly increase the risk of adhesions and fistulae formation. Biologic meshes are extremely expensive comparatively but do deter visceral adhesions to the abdominal wall. Some small studies with bioprosthetics have found a relatively low number of complications and no recurrences. Other data suggests that they are of no comparative benefit although no prospective randomized trials have been performed. Nonetheless, biologic mesh minimizes the risk of complications such as adhesions and enterocutaneous fistulae which can have devastating consequences. Autologous reinforcement of the abdominal wall has also been employed with the use of autologous tensor fascia lata grafts. This is of added morbidity and has not been shown to be of additional benefit with recurrence rates of up to 29%.

Bridging of the abdominal wall defect may be necessary when release of the rectus abdominis does not allow for muscular opposition. As stated previously, this can be accomplished with an open book repair or with mesh. When bridging with mesh is decided upon, the repair should begin in the standard component separation technique. The general consensus is that the biologic mesh or "neodermis" is placed in the retrorectus plane with 3 to 5 cm of overlap with the muscle. This is incorporated with U stitches placed through the rectus muscle. Care should be employed as to not strangulate the epigastric vessels rendering the muscle ischemic. Unfortunately, the intercostal nerves may be incorporated in this closure technique and impair the innervations to the muscle.

There exists no consensus on the utility of mesh used in conjunction with the standard repair. Intuitively, posterior or deep placement wound allow for buttressing of the mesh against the anterior surface of the coelomic cavity which would hold this intimately against the abdominal wall facilitating its incorporation and neovascularization. Other sources demonstrate significant decrease in recurrence when placed as an overlay with small studies boasting zero recurrences.

# POSTOPERATIVE MANAGEMENT

Patients are kept *non per os* until return of bowel function is appreciated. Gastric decompression is achieved with a nasal gastric tube to minimize abdominal distention during the immediate postoperative period as ileus will often result. Of equal importance, this helps to minimize wrenching and emesis, which can damage the reconstruction.

A urinary catheter is usually placed intraoperatively and continued postoperatively. This allows for accurate assessment of urine output and volume resuscitation status. Secondly, this can provide important data in bladder pressures and thus intraabdominal pressures to assess for potential abdominal compartment syndrome. Drains have not been demonstrated to prevent seroma formation, although they should be considered in patients especially with large flaps and those with exposed biologic mesh as this is known accumulate periprosthetic fluid.

External abdominal support is achieved by an abdominal binder to provide abdominal wall support while the repair is approaching a plateau in the healing process at approximately 6 weeks. This can be left longer in patients who are of higher suspected risk of recurrence such as obese individuals or smokers. Again, there is no prospective evidence demonstrating decreased rate of seroma formation with binder usage. From an intuitive stance, a binder should assist in minimization of dead space and shifting or shearing of the tissues during the healing process.

## COMPLICATIONS

There is no data to suggest which co-morbidities or combination of co-morbidities carry the greatest risk of perioperative complications. Complications associated with component separation can be classified into major and minor subdivisions and commonly include recurrence, infection, seroma, necrosis, and wound dehiscence fistulae formation. De Vries Reilingh has compiled the results of over 460 patients who underwent component separation at several institutions and including various modifications of the originally described technique. Wound complications were found in 23.8% of patients. These are further broken down into wound infection that was found in 18.9% of patients. Analysis of the National Surgical Quality Improvement Program (NYSQIP) sites smoking, chronic obstructive pulmonary disease, coronary artery disease, low serum albumin levels indicative of poor nutrition, prolonged operative time, corticosteroid use, and the use of mesh to be independently directly related to the increased risk of wound infection. Seroma was noted in 2.4% of patients and hematoma in 2.4%. Skin necrosis was only noted in 1.5%. Although wound complications are high, this can be accounted for on several levels. Often these patients are undergoing repair of massive ventral hernias. This entails extensive dissection and undermining of the skin. This compromises the vascularity to the skin itself which can result in skin edge necrosis and healing problems along the midline. The potential space under the skin or fasciocutaneous flaps is expansive and allows a large area for both hematoma and seroma to form, especially in patients with onlay biologic mesh. This is not necessarily the incidence in more conventional forms of herniorrhaphy with open techniques and laparoscopic approaches. There is likely a bias in comparing the complication rates of herniorrhaphy versus the component separation techniques as these patients have large hernias that have often failed other forms of repair. The patients undergoing component separations are sometimes not amendable to any other forms of repair as there is loss of the skin overlying the visceral contents in the case of trauma laparotomies and grafting of the enteric contents. An important point of consideration is that in the elective setting, the mortality of this reconstructive technique is extremely low.

Hernia recurrence is a major consideration of this technique and has been scrutinized over the past two decades (Table 29.1). Ewart evaluated the results of abdominal wall reconstruction in 60 consecutive patients utilizing standard component separation technique, mesh repair, tensor fascia lata flaps, or latissimus dorsi flaps. Only one (9%) of the patients in the component separation group had a recurrence and those with primary repair or mesh repair had recurrences of 14% and 27%, respectively. Recurrence rates for the distant flaps were greater than 50%. He found that the most common factors influencing recurrence were patient factors such as poor tissue integrity and increased intraabdominal pressure and technical errors. Significant risk factors for

**TABLE 29.1**

| Author | N | Recurrence | F/U (months) | Complications |
|---|---|---|---|---|
| Cohen | 24 | 1 (4%) | 12–36 | 2 (8%) |
| Ewart | 11 | 1 (9%) | 1–60 | 3 (27%) |
| De Vries Reilingh | 43 | 13 (30%) | 12–30 | 14 (33%) |
| Ennis | 10 | 1 (10% | 1–53 | 1 (10%) |
| Lowe | 30 | 1 (3%) | 1–26 | 6 (20%) |
| Girotto | 96 | 21 (22%) | — | 25 (26%) |
| Vargo | 27 | 2 (7%) | 6–27 | 10 (37%) |
| Shestak | 22 | 1 (5%) | 44–84 | 3 (14%) |

hernia recurrence have additionally been found to be BMI >30 and evidence of wound infection or breakdown. Increased risk of recurrence was found in patients who had colostomy or fistula takedown at the time of herniorrhaphy. Significant risk factors for developing a complication were smoking. Obesity is associated with these complications, but was not found to be statistically significant.

## RESULTS

The anticipated result of abdominal wall reconstruction is to first and foremost repair the hernia and minimize the risks and complications in doing so. This repair technique as opposed to mesh repair alone provides relatively uniform dynamic support to the abdomen and thus minimizes areas of intrinsic weakness of the abdominal wall and reduces recurrence (Fig. 29.6). This has been found to

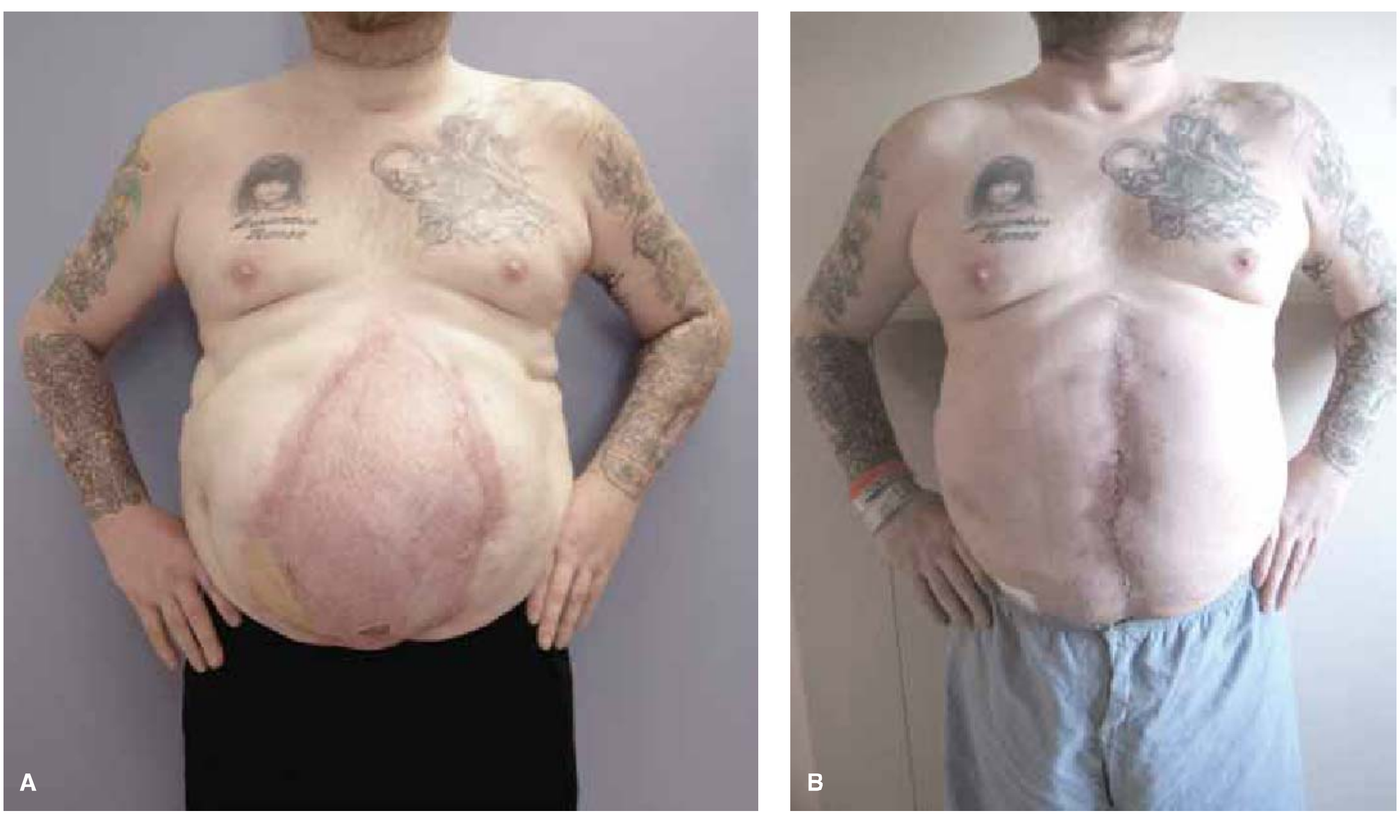


**Figure 29.6** Patient before (**A**) and after (**B**) component separation.

improve a patient's overall emotional state, and perform activities of daily living such as rise from a chair, lift objects, and exercise. The release of the rectus abdominis via the conventional component separation technique and various modifications allows for a tension-free closure of the abdomen and has been found to endure over time.

# CONCLUSION

The component separation technique of abdominal wall reconstruction was first introduces just two decades ago. This has opened a new chapter in how surgeons think about reconstructing the abdominal wall and is becoming the standard of care for reconstructing the massive ventral hernia. Ramirez's original technique allowed for medialization of the rectus abdominis up to 18 cm at the midline and thus closes rather massive ventral abdominal defects. Many variations of this original technique have resulted to allow for closure of larger defects. The beauty of component separation is that this provides autologous dynamic support to the abdominal wall and thus optimizes its original integrity and minimizes the risk and complications and necessity of mesh repair. This has been proven to be a safe and effective technique for abdominal wall reconstruction.

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# 30 Musculofascial Flap Reconstruction for Massive Abdominal Wall Hernias

**Samuel J. Lin and Charles E. Butler**

## INDICATIONS AND CONTRAINDICATIONS

In the vast majority of cases, there is ample local skin and subcutaneous tissue to close an abdominal wound following various sizes of ventral hernia repair. Rarely, however, there is a need for more complex reconstructive options which are described in this chapter. In these specific cases, a locoregional or free flap reconstruction may be required. A significant evolution of the treatment of large abdominal wall hernias and composite oncologic resection defects has occurred over the last two decades. Although the causes of the abdominal wall defects have largely remained the same (i.e., prior surgery, failure of musculofascial healing, perioperative conditions leading to an open abdominal wound, and tumor extirpation), treatment paradigm has evolved. With the increase in gastric bypass procedures the patient profile of recurrent hernia patients has also evolved over time with more hernia patients who have underwent previous open gastric bypass surgery. The basic principle of abdominal wall reconstruction is to achieve a secure musculofascial repair with stable overlying skin closure. Ideally, the reconstruction of abdominal wall defects occurs in a sterile environment. Unfortunately this is not always the case, particularly in patients with open cutaneous wounds, ostomies, transection of the gastrointestinal tract, mesh infections, or fistulas. The most abdominal defects have sufficient skin for primary advantage and closure, however, some defects require skin to be recruited from remote locations. The use of the fascial component of a tissue flap for musculofascial reconstruction has several disadvantages including the risk of hernia/bulge, paucity of good-quality durable fascia and potential compromised vascularity on the skin portion of the flap with the fascial inset. We believe that reconstitution of the musculofascial and overlying skin defect (when necessary) is optimally performed with two separate techniques.

## PREOPERATIVE PLANNING AND OVERVIEW

Full-thickness reconstruction of the abdominal wall is required when the multiply recurrent hernia or ablative abdominal procedure has rendered a significant area of the musculofascial and cutaneous abdominal wall skin untenable for primary closure. These specific cases occur when there is skin graft directly adherent to the bowel, the abdominal skin/subcutaneous layer is of poor quality secondary to previous incisions or prior radiation, or there exists a large scarred area that has healed secondarily from a prior open abdomen situation. The operative plan should consist of two primary anatomic considerations; those elements that will comprise the musculofascial repair and those components that will comprise the skin reconstruction.

Most often, the musculofascial repair is achieved by the use of synthetic or biologic mesh depending on the patient and defect characteristics. Prior to the development of new implantable materials and advanced surgical techniques, routine use of uncoated synthetic mesh in primary and recurrent hernia repair was the mainstay of treatment. This technique employed in placement of mesh as an underlay, overlay, or interpositional repair. Alternatively, defects were closed with component separation originally popularized by Ramirez et al. However, the success and longevity of this repair relates to the ability of the patient's wound-healing capacity to resist infection, the native state of the remaining surrounding musculofascial anatomy, and underlying medical status of the patient. Leber et al. reported that in a case series of 200 patients, the use of a large macroporous mesh incurred a high incidence of recurrent hernias (16%), infection cutaneous extension (16%) or fistula eventual explantation (16%) of the mesh. Few other studies report long-term complications after prosthetic incisional hernia repair. Following removal of infected mesh, patients are frequently left with granulating open abdominal wounds that often underwent temporary closure with resorbable mesh, dressing changes, and subsequent skin graft placement. Delayed permanent reconstruction 6 to 12 months later was challenging owing to continued loss of musculofascial domain, relative skin deficiency, and the need to remove the skin graft without causing an enterotomy.

Treatment of large recurrent abdominal wall hernias with poor-quality overlying skin may be analogous to a large composite wall resection defect. In particular, primary skin close may not be possible in a previously skin-grafted abdominal wall with a large surface area. In these cases, well-vascularized tissue from regional flap tissue is often required for reconstruction.

The skin reconstruction is achieved by transposition of skin and subcutaneous flap tissue from a regional or distant donor site. Thigh-based myocutaneous or fasciocutaneous flaps are excellent options for this purpose owing to a relatively large surface area of skin available and acceptable donor site morbidity. The musculofascial repair is generally performed with surgical mesh and/or without component separation.

For elective, recurrent hernia repair, and planned regional flap reconstruction of the abdominal wall, patients will have had a preoperative medical evaluation and optimized for their nutritional status. Dunne et al. have reviewed independent factors for hernia repair and found chronic obstructive pulmonary disease (COPD) and low preoperative albumin to be independent predictors of wound infection. Additional preoperative considerations include a patient's preoperative pulmonary function, history of tobacco use, and general medical condition.

## SURGERY

When primary closure of the skin and subcutaneous tissue is not an option following musculofascial repair of the abdominal wall, several other options are available. Tissue expansion of the abdominal wall skin is an option when planning for elective hernia repair with skin deficiency. In this technique, tissue expanders are placed lateral to the location of the hernia to expand the skin/subcutaneous layer. These devices are generally placed above the musculofascial layer to directly expand the skin and subcutaneous layer over several weeks to months prior to definitive hernia repair. Tissue expansion is used in many locations around the body; however, there is a risk of wound infection, contamination of tissue expanders, and wound separation leading to the loss of expanded skin, particularly if there is an adjacent open wound or ostomy. In addition, the successful completion of tissue expanded skin often requires several months prior to hernia repair and preoperative planning time with the requirement of multiple procedures. Lastly, the efficiency of tissue expansion with abdominal tissue expanders is not high since the musculofascia is not rigid and some of the device expansion is transmitted toward the peritoneal cavity rather than expanding the overlying skin.

# Musculofascial Reconstruction

When component separation is not enough to close the abdominal wall primarily, mesh is usually employed. The choice of synthetic versus bioprosthetic mesh is an important consideration. Macroporous synthetic mesh, such as polypropylene mesh, is frequently used for musculofascial repair in hernia repair. In general, synthetic mesh should only be used in defects without bacterial contamination. Any open abdominal wound, regardless how small, has an increased risk for mesh infections. In the setting of current or recent infection, a synthetic mesh is often considered to be contraindicated. There are several bioprosthetic mesh options available which are decellularized tissue matrices derived from human or animal tissues, most commonly from dermis. Human acellular dermal matrix (HADM) has been used for hernia repair for over a decade but when used in a bridging technique may cause laxity or bulge of the mesh as it remodels. Newer porcine materials have demonstrated good results in animal and human studies. These materials can be differentiated by the presence or absence of chemical cross-linking during their processing. Non–cross-linked porcine acellular dermal materials have been shown to have better biologic regenerative properties than those that undergo chemical cross-linking. Regardless of the operating surgeon's preference of bioprosthetic mesh, most have some resistance to bacterial infection and limitation of visceral adhesions to the repair site compared to synthetic macroporous mesh. Different materials may have varied cellular incorporation for the surrounding tissues, risk of seroma formation, and tensile strength over time. However, high-level evidence comparative data has not elucidated each of these properties in long-term human studies for the bioprosthetic meshes. Bioprosthetic mesh may tolerate hostile wound environments and conditions. In fact, in a prospective trial repair of infected and contaminated hernias (RICHs) non–cross-linked porcine acellular dermal matrix tolerated bacterial contamination and cutaneous exposure relatively well and none of the 80 patients involved required explantation of the bioprosthetic at 1 year follow-up.

Musculofascial reconstruction followed by flap reconstruction is utilized for settings when there is skin and subcutaneous deficit. Biologic mesh has characteristics of being able to be successfully used in the setting of bacterial contamination and tolerates cutaneous exposure well generally without need for explantation as it becomes revascularized and remodeling by the surrounding tissues. In conjunction with flap reconstruction, human acellular dermal matrix (HADM) is useful for complex abdominal wall fascial reconstruction because of its low visceral adhesion rate, low infection rate, and ability to provide a healed wound through revascularization and cellular infiltration even in the setting of cutaneous exposure. In conjunction with flap reconstruction, using biologic mesh for musculofascial reconstruction prior to flap reconstruction of the skin and soft tissue defect has potential advantages over using the fascia from the flap for the same purpose. It provides a separate, independent musculofascial repair that bears the biaxial load of musculofascial tension thus reducing the surface area and flap inset tension of the skin defect. The limitations of HADM are that it can undergo surface area expansion during the remodeling phases in some patients and result in abdominal wall laxity or bulge, particularly if biologic mesh is used to span the fascial defect (bridged repair) rather than providing complete fascial close over the biologic mesh (reinforced repair). For this reason, non–cross-linked porcine acellular dermal matrices (ncl-PADM) may be more commonly used for abdominal wall reconstructions.

Biologic mesh is useful for musculofascial reconstruction when synthetic mesh is contraindicated or unfavorable (direct unavoidable placement over bowel, bacterial contamination, unreliable overlying skin coverage and high risk for wound-healing complications). Biologic mesh is initially avascular and can bear a substantial load without concern about devascularization or necrosis. In addition, biologic mesh tolerates cutaneous exposure in the face of wound dehiscence generally without the need to be removed, and the resulting wound can often heal spontaneously by secondary intention and re-epithelialization In addition, biologic mesh has been shown to decrease visceral adhesions to abdominal wall repair sites in animal studies and has a relatively low infection rate; biologic mesh is able to revascularize and become infiltrated with host cells.

Prior reports have outlined the risk of recurrent hernia and bulge in patients with HADM repair. Whenever a bridged fascial repair is performed with HADM (rather than primary fascial closure with HADM inlay reinforcement), there is a risk of laxity and bulge with ongoing remodeling of the implant material. However, neither the minor laxity in the reconstructed musculofascial defect nor the hernia in the described small series were symptomatic, progressed in size, or required surgical correction at the last follow-up. Though there are risks associated with recurrent hernia and bulge with HADM mesh repair, the benefits of HADM mesh includes the ability of HADM to resist visceral adhesions, to be placed into a contaminated surgical wound without high risk for subsequent removal, and to become remodeled into the host tissue with cellular and vascular infiltration are useful properties of bioprosthetic mesh in this setting. Due to the potential for laxity we have been using non–cross-linked porcine acellular dermal matrix for musculofascial reconstruction with limited laxity.

# Biologic Mesh Inset

When bridging a fascial defect bioprosthetic mesh is inset with #1 polypropylene sutures using a "dual-circumferential" inlay method as previously described. Briefly, this includes full-thickness musculofascial sutures place 3 to 5 cm from the true musculofascial edge, each placed on hemostats to assure that all sutures are inset correctly before tying them. Generally, in these cases the musculofascial defect is too large to close primarily even with bilateral component separation and a bridged repair is performed. After securing the peripheral suture line the true musculofascial edge is secured to the bioprosthetic mesh with interpreted or running monofilament sutures. The biologic mesh is inset into the musculofascial defect under physiologic tension, which reduces repair site musculofascial laxity and minimizes both the musculofascial and cutaneous defect size. With defects extending to bone, the bioprosthetic mesh is anchored with #1 polypropylene sutures through drill holes in ribs, lumbosacral spine, and/or pelvis.

# Flap Options

Flap options differ for cutaneous defects in varied locations of the abdomen. For certain vertical midline defects, patients with a relatively supple skin/subcutaneous layer may be amenable to having a bipedicled skin flap performed bilaterally. This flap is a random flap that is supplied by vascular inflow from the superior and inferior bases of the flap; the central portion of the flap is undermined and advanced to the midline from both sides. The donor sites are usually closed with a skin graft and can be cosmetology disfiguring.

Other local flaps of the abdomen include a bipedicled flap, a V–Y flap (Fig. 30.1), a rhomboid flap, a bilobed flap, and a rotational flap. These flaps are based on a random blood supply and require broadly based flaps for vascularity and a tension-free closure. The objective of cutaneous flap coverage of abdominal defects following hernia repair is to have no tension over a newly repaired abdominal wall. All of these local flaps have limited ability to close large cutaneous defects and have donor site scars.

Regardless of the defect size, repair of large, composite abdominal wall defects using bioprosthetic mesh for musculofascial reconstruction and free or pedicled musculofascial lower extremity flaps for replacement of skin and subcutaneous tissue is an option for various settings including contaminated wounds. The inclusion of the rectus femoris (RF), tensor fasciae latae (TFL), and vastus lateralis (VL) may increase vascularity by providing additional myocutaneous perforating vessels. In addition, pliable vascularized

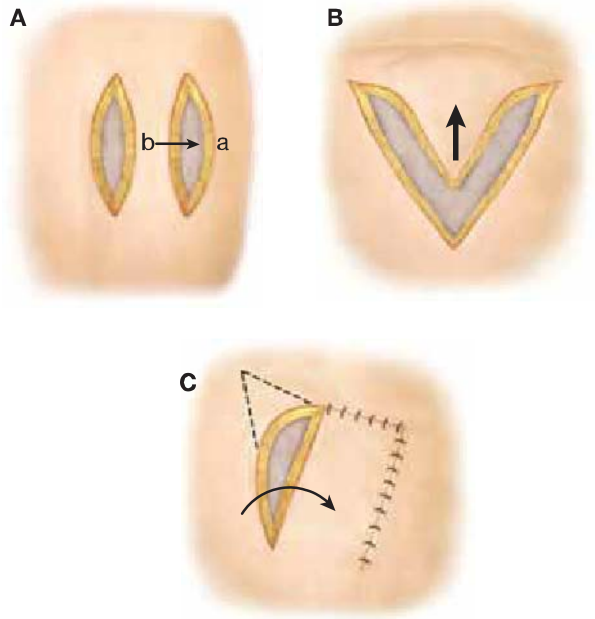


**Figure 30.1** Various types of arrangement of local tissue. (**A**) depicts bipedicled flap reconstruction; (**B**) depicts a V to Y flap reconstruction; (**C**) depicts a transposition flap.

muscle can be used to obliterate areas of potential dead space in the defect. An extension of the skin paddle to the upper border of the patella allows complete dissection of the lateral circumflex femoral (LCF) vessels to their origin, and a pedicled subtotal musculofascial lower extremity flap has the ability to reach the umbilicus and various maneuvers may get them higher. It has been reported that the flap can reach the costal margin in certain patients.

As mentioned, other thigh flaps described for the repair of large abdominal musculofascial defects include fascial extensions of rectus fascia flaps, tensor fascia lata grafts, and anterolateral thigh (ALT) flaps. Nonetheless, the utility of described thigh flaps in abdominal wall reconstruction is limited by a paucity of reliable thigh fascia available. The strongest thigh fascia is the iliotibial band; lateral and medial to this area, the iliotibial fascia becomes thin. Moreover, insetting the fascial component of a musculofascial flap in abdominal wall reconstruction may place tension on the skin paddle, potentially compromising its vascularity. Thus, we strongly believe that musculofascial reconstruction with bioprosthetic mesh prior to inset of a thigh-based flap or other myocutaneous flap is optimal and eliminates these concerns.

# Regional Flaps

The latissimus dorsi musculofascial flap is a muscle flap supplied by the thoracodorsal artery and vein pedicle. This broad muscle flap may be elevated from the posterior trunk, with a skin paddle or skin graft over the muscle and used to reconstruct lateral/superior abdominal wall defects. For instance, skin defects occurring in the upper flank are optimal areas for latissimus dorsi flap reconstruction when cutaneous reconstruction is required.

The serratus anterior myofascial flap is a muscle flap option used for smaller defects of the abdominal wall in the lateral and superior portion of the abdomen. The lower three or four muscle slips of the serratus anterior are harvested without risk of significant scapular winging. The vascular pedicle is potentially long (approximately 15 cm) if the subscapular vessels are included with the serratus anterior branch and thoracodorsal blood vessels. The surface area of the serratus anterior flap is usually limited to approximately $10 \times 12$ cm with respect to utilizing the muscle with a skin graft.

For reconstruction skin defects in the abdominal wall the major decision is which to use flap tissue from the abdominal wall, back or thigh. Certainly, each reconstruction is patient-based, and those patients who have had multiple abdominal operations with multiple incisions across the abdomen are likely not ideal candidates for flaps from the abdominal wall. Tissue vascularity does cross prior incisions well, and attempting to elevate a local flap that is inclusive of a prior incision may be prone to flap ischemia and loss. However, patients who have multiple operations through the same incision with remaining supple abdominal skin may be candidates for abdominal-based flaps.

With a supero-lateral abdominal wall defect, patients who are not candidates for abdominal-based local flap reconstruction may be suitable for posteriorly based truncal flap reconstruction such as the serratus or latissimus dorsi muscle flap. Patients have smaller defects may be candidates for these flaps as the distance available for flap advancement is limited. One disadvantage of harvesting these flaps is that the dissection often requires position changes of the patient during the operation.

Patients with lower-abdominal wall defects who are not candidates for abdominal-based local flap reconstruction may be suited for thigh-based flap reconstruction. These flaps are based on the deep femoral system and include the RF, ALT/VL, tensor fascia lata, and subtotal thigh flap. Generally, these flaps are reserved for patients with the largest abdominal defects that local abdominal flaps cannot close. These flaps are elevated and the vascular pedicle is transposed through a subcutaneous tunnel above or below the inguinal ligament.

# Regional Lower Extremity–based Flaps

Transposition of well-vascularized flap tissue with or without implantable mesh is often required to repair full-thickness, composite abdominal wall defects particularly when the existing abdominal wall soft tissue is destroyed or absent. Various thigh-based muscle, fasciocutaneous and myocutaneous flaps have been successfully used to repair abdominal wall defects. These include the tensor fasciae latae (TFL) myocutaneous flap, RF muscle or myocutaneous flap, anterolateral thigh (ALT) fasciocutaneous flap, and sartorius muscle or myocutaneous flap.

# Tensor Fascia Latae Flap

The tensor fasciae latae (TFL) flap is located on the lateral surface of the lower extremity and may be used as a pedicled regional flap for reconstruction. Its blood supply is the ascending branch of the LCF artery. The TFL extends from the anterior superior iliac spine (ASIS) to the iliotibial tract. It has a significant distal fascial component that is useful for musculofascial reconstruction. Originally, it was once believed that the tensor fascia latae fascia was useful for musculofascial reconstruction in hernia repair. Currently, however, the indications for using TFL fascia for musculofascial repair in recurrent herniorrhaphy is limited owing to donor site morbidity and other good bioprosthetic mesh options. However, with careful planning, there remain settings such as salvage cases where pedicled TFL flaps may be successful. It has a relatively small muscular component as a reconstructive flap. The viability of the distal aspect of the flap is not routinely reliable due to the lack of an axial blood supply along the length of the flap. In addition, the pivot point for the vascular paddle is in the lateral thigh; this limits the reach of the flap beyond the midline and/or above the umbilicus.

# Rectus Femoris Flap

The rectus femoris (RF) muscle (Fig. 30.2) is located directly anterior on the upper portion of the lower extremity and functions as a hip flexor and knee extender. The regional blood supply of the muscle is the LCF artery. This muscle extends from the ilium to the patella. This flap can be used as a muscle or a myocutaneous flap with good success. The main advantage of using this muscle is its vascular territory and central location on the upper portion of the lower extremity. This muscle may be transposed under a subcutaneous tunnel to reach the low- and mid-abdominal wall for reconstruction.

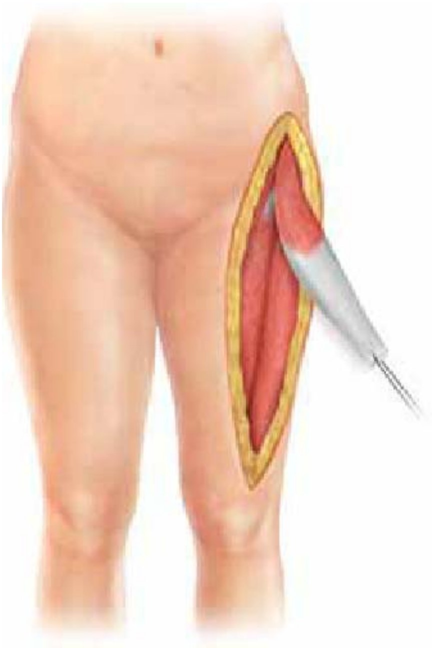

Figure 30.2 Rectus muscle dissection.

## Vastus Lateralis Flap

The vastus lateralis (VL) flap is located on the anterolateral surface of the lower extremity. Its regional vascular supply is the LCF artery. Often, a skin paddle may be dissected along with the muscle itself to allow for a musculocutaneous flap to be transferred to the abdominal region. The available skin paddle can vary in size and may be quite substantial. In addition, this flap may be transferred as a free flap by using microvascular free tissue transfer techniques, which allow the flap to be placed virtually anywhere on the body for reconstruction.

## Gracilis Flap

The gracilis muscle flap is based on the gracilis muscle which extends between the pubis and medial portion of the knee. This muscle is by the ascending branch of the medial circumflex femoral artery. This muscle may also be transferred as a free flap. It was originally used in individual cases for inguinal hernia repair. This muscle is, in most patients, thin, and there are limited indications for using a gracilis muscle flap for abdominal wall coverage.

## Sartorius Flap

The sartorius muscle is most ideally transposed locally as a muscle flap (Fig. 30.3) for coverage of the femoral vessels, which are adjacent to the origin and insertion of the sartorius. The sartorius muscle extends from the ASIS to the medial tibial condyle. The vascular supply of the sartorius are segmental branches from the superficial femoral artery. Its use for abdominal wall reconstruction is very limited.

## Anterolateral Thigh Flap

When the abdominal defect is too large the aforementioned flaps, alternatives must be considered to provide reliable reconstruction in a single stage. Primary advantages of the ALT flap (Fig. 30.4) relate to its wide vascular territory and ability to be pedicled

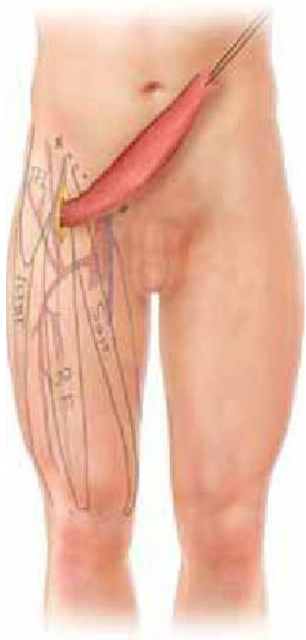

**Figure 30.3** Dissection of the sartorius muscle.

to reach several areas of the abdominal wall. Disadvantages of the ALT flap relate to its ability to be inset in various dimensions; authors have noted that a notably large skin paddle is required when attempting to the use the ALT flap with a horizontally oriented skin paddle. This commonly used flap in the repair of abdominal soft tissue/cutaneous defects, the ALT flap, can be extended to include vascularized TFL fascia for musculofascial reinforcement. However, the thigh fascia lateral and medial to the iliotibial band is weaker and less reliable.

# Subtotal Thigh Flap

One alternative for large, composite abdominal wall defects is thigh flaps based on the LCF vascular supply. The LCF vessels supply the RF, VL, and TFL muscles and the overlying skin (Fig. 30.5); all these structures may be used for abdominal wall reconstruction

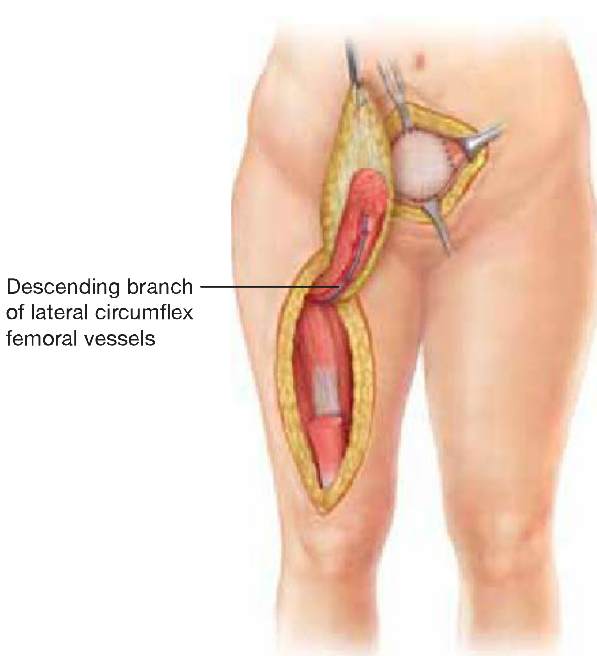


**Figure 30.4** Muscle flap with skin paddle is used for reconstruction of the abdominal wall when there is a need for skin/subcutaneous reconstruction.

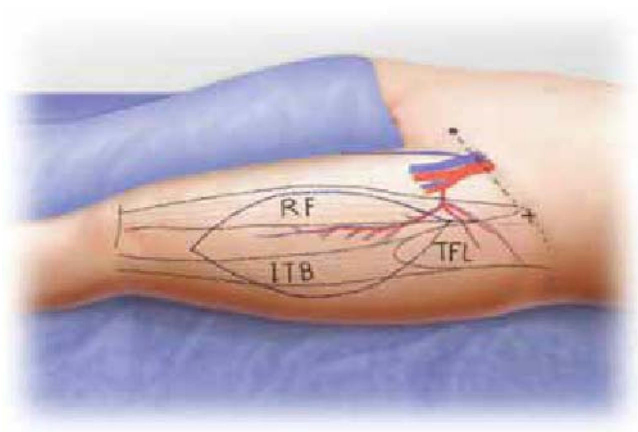


Figure 30.5 Examples of muscles of the lower extremity that are used for reconstruction: Rectus femoris (RF) and tensor fascia latae (TFL).

if needed. The authors have termed "subtotal thigh flap" for chimeric flaps that includes muscles supplied by the LCF vessels in the initial published description. The subtotal musculofasciocutaneous thigh flap is based on one or more major branches of the LCF axis and includes one or more associated muscle components, with at least a 400 $cm^2$ thigh skin paddle.

Reconstruction for large, complex, and/or full-thickness defects or recurrent hernias of the abdominal wall requires careful planning. Often, in patients with recurrent hernias, significant portions of the anterior abdominal wall have stretched and have become completely attenuated. Using this tissue to attempt cutaneous closure and reconstruction may be futile. It is often essential to use remote, well-vascularized tissue for the reconstruction. In the setting of irradiated wounds with enterocutaneous fistulae and exposed bowel, the wound environment may be especially hostile to successful, lasting reconstruction and use of a synthetic, permanent mesh is usually contraindicated. It is desirable to have a secure musculofascial repair; however, the fascia from the thigh is often insufficient or less reliable in such large, complex defects.

The anatomic landmarks of the upper thigh are identified below and marked on the overlying skin. The anterosuperior iliac spine and upper lateral border of the patella were first identified; the intersecting line was considered the axis of the thigh (Fig. 30.6). The skin paddle design was determined by the cutaneous abdominal defect size and location after musculofascial repair with inlay HADM (Fig. 30.7). The flap design is extended to the patella for maximum pedicle reach (Fig. 30.8).

When a pedicled subtotal thigh flap is used (Figs. 30.9–30.12), the pedicled flap is transposed below the sartorius muscle (and RF muscle if not included in the flap). Transposing the flap below the sartorius adds approximately 5 cm of additional flap reach. When a free tissue transfer was used for abdominal wall reconstruction, a



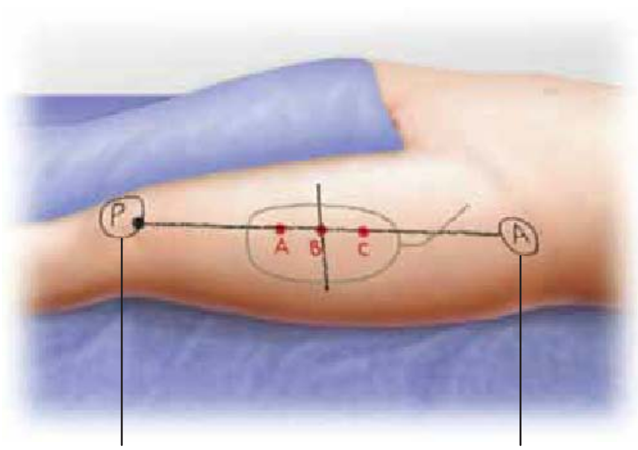


Figure 30.6 Landmarks of the ALT flap. 'B' is the midpoint between the anterior superior iliac spine (ASIS) and the supero-lateral point of the patella.

**Figure 30.7** Patient with planned ventral skin/subcutaneous defect and ventral hernia requiring muscle/skin paddle reconstruction.


**Figure 30.8** Skin paddle planned for abdominal wall reconstruction with a muscle flap.

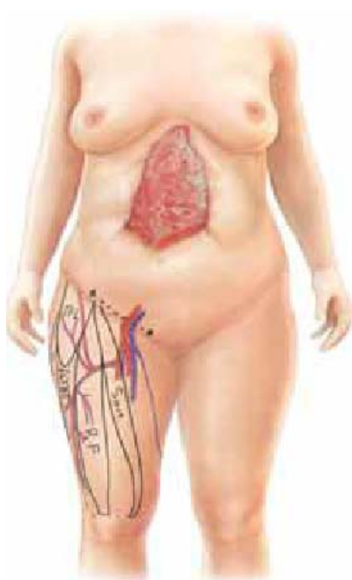

**Figure 30.9** Patient with prior hernia repair and open abdominal wound that has granulated with a recurrent hernia and skin/subcutaneous defect.

**Figure 30.10** Bioprosthetic mesh inset with planned skin paddle/muscle flap reconstruction of the abdominal wall.

saphenous arteriovenous loop is first created by anatomizing the distal saphenous vein (end-to-side) to the superficial femoral artery.

When the RF muscle is included with a flap a distal tenorrhaphy of the vastus medialis and VL is performed with #1 polypropylene interrupted sutures for 10 cm above the patellar tendon. Centralization and apposition of the vastus medialis and VL muscles provided a stable wound bed for skin graft adherence and potentially improved terminal knee extension.

Donor sites are repaired with split-thickness skin grafts that are secured in place with resorbable quilting 4-0 chromic sutures and a negative-pressure wound therapy device. Postoperatively, knee immobilization for 1 week is accomplished with a soft knee immobilizer.

**Figure 30.11** Inset of the muscle flap with skin paddle in place.

**Figure 30.12** Closure of donor defect and abdominal wall defect.

## Distant Flaps

Several of the previously described flaps may be used as microvascular free flaps. Intraoperative decision-making whether to perform these flaps as pedicled flaps or microvascular free flaps depends on factors such as vascular pedicle length, skin paddle size, donor site morbidity, and intraoperative positioning of the patient. Patients with large ventral defects may require flap reconstruction from a distant donor site and microvascular free tissue transfer. In these patients, the sheer size of the ventral defect may preclude any local abdominally based flap. In addition, lower extremity–based regional flaps and posterior truncal flaps may not reach the defect for pedicled flap reconstruction. One main consideration in these patients is the location of the defect; with an abdominal defect in the xiphoid region, the lower ribcage preserves the upper abdominal domain and essentially decreases flap transposition distance. For instance, component separation hernia repair is more effective in the relatively lax abdominal region below the subcostal area as compared with abdominal defects immediately below the xiphoid area secondary to resiliency of the lower 4 ribs. In this area flap reconstruction for large defects generally requires tissue from a distant donor site used as a free flap. For microvascular free tissue reconstruction of the abdominal wall, potential recipient vessels are located in the groin (i.e., femoral vessels), axilla (i.e., thoracodorsal pedicle), or chest (internal mammary). For additional pedicle length, vein grafts may be required for the arterial and the venous vessel length. Potential donor sites for free tissue transfer include many of the same sites for regionally based reconstruction such as the latissimus dorsi, serratus, ALT, and RF flaps. The latissimus dorsi myocutaneous flap has also been used as free tissue transfer and provides a broad-based muscle with potential innervation.

# POSTOPERATIVE MANAGEMENT

The postoperative management of recurrent herniorrhaphy patients in the setting of regional flap reconstruction includes perioperative flap management in addition to routine postoperative herniorrhaphy management. Usually, these patients will have thromboembolic prophylaxis in the postoperative period. Regional flaps and cutaneous reconstruction require routine flap checks every 4 hours initially for color, capillary refill, and temperature. The use of free tissue transfer in the setting of full-thickness abdominal wall reconstruction requires hourly flap checks and Doppler evaluation of a flap vessel to ensure vascular patency. Any change in flap vascular status generally requires an operative intervention. Physical therapy may be required for patients in the recovery period from the utilization of lower extremities as donor sites for flap reconstruction. Similar to other ventral hernia repairs, patients have a period of activity restriction in the postoperative period. Complex wound management may be necessary in the setting of a contaminated wound with abdominal wound separation. These patients often have numerous drains in order to eliminate potential space which are managed postoperatively.

## COMPLICATIONS

Complications from combination recurrent herniorrhaphy in the setting of flap reconstruction for the abdominal wall include bleeding, infection, sepsis, flap/graft loss, delayed healing, reoperation, recurrent hernia, bulge, visceral injury, deep vein thrombosis, pulmonary embolism, persistent pain, numbness of the incision site, and enterocutaneous fistula. Additional specific complications include potential seroma formation between the bioprosthetic mesh and flap and potential increased donor site morbidity of harvesting muscle with the lower extremity–based pedicled flap. Abdominal wound dehiscence in the setting of a biologic mesh may be managed conservatively initially in the majority of cases. Unlike a macroporous mesh, a biologic mesh has an ability to re-epithelialize when exposed. Initially, dressing changes and then negative pressure wound therapy have a significant ability to contract an abdominal wound. Once a wound is clean, flap re-advancement of the abdominal skin may suffice to close the wound. In more extreme cases, a second flap may be required to close the wound.

# Case Series

We reviewed a series of patients from the senior author (Charles E. Butler) with abdominal wall defects that required a combination of a subtotal thigh musculofascial flaps and an inlay of bioprosthetic mesh (HADM) to enable a reliable, single-stage reconstruction for large, composite abdominal wall defects that had at least 8 months' follow-up. Data collected included demographic data, co-morbidities, and indications for reconstruction, defect size, bioprosthetic mesh size, flap type, complications, and outcome. The mean musculofascial defect size was 536.4 $cm^2$ (range: 300 to 1,050 $cm^2$). The mean subtotal thigh flap skin paddle size was 514 $cm^2$ (range: 400 to 720 $cm^2$).

Recipient site complications included partial flap necrosis (<2% of flap area) requiring debridement and flap re-advancement in one patient; no HADM infections, wound dehiscences, bowel obstructions, or seromas occurred in any patient during follow-up. One patient developed a 6 cm hernia at the HADM–musculofascial interface 18 months postoperatively; the hernia remained constant, was asymptomatic, and did not require repair during the follow-up period. Other complications included a focal laxity/bulge in the HADM musculofascial reconstruction at 18 months without evidence of hernia by physical examination or CT in another patient.

## CONCLUSIONS

Large, composite abdominal wall defects either from hernia repair or tumor ablation can be successfully repaired using a combination of bioprosthetic mesh and skin/musculofascial flaps from various locations.

# Acknowledgment

The authors would like to thank Dr. Ahmed Ibrahim for expertise in editing and formatting this chapter.

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# 31 Parastomal Hernia Repair

**William S. Cobb**

## Introduction

Parastomal hernias are unavoidable following the creation of intestinal conduits to the skin. By definition, all ostomies are hernias because there is a fascial defect to allow passage of the bowel. When additional intraabdominal contents protrude around the fascia at the stoma site, patients may become symptomatic and warrant surgical intervention. The two types of parastomal hernias are the sliding enterostomal defect, which is herniation of the same segment of intestine that forms the ostomy, and the paraenterostomal defect, where a different organ other than the bowel that forms the stoma is involved (Fig. 31.1).

The incidence of true parastomal hernias varies greatly and depends on how aggressively the surgeon investigates its presence. The incidence of parastomal hernia is quoted as 30% to 35% on physical examination and increases to a rate greater than 60% when computed tomography of the abdomen is included. Factors that increase the incidence of parastomal hernia formation include placement of the ostomy lateral to the rectus sheath, ostomy aperture greater than 2.5 cm, and advancement in age.

## INDICATIONS/CONTRAINDICATIONS

The majority of patients with parastomal defects are asymptomatic at presentation. The hernia presents itself as fullness or pain at the ostomy site. Frequently, the defects are found incidentally on computed tomography imaging of the abdomen for other pathology. Most asymptomatic parastomal hernias can be treated with “watchful waiting.” Patients should be given the warning signs of a symptomatic hernia and especially cautioned regarding the possibility of incarceration or strangulation of the hernia.

The most common indication for repair of parastomal hernias is pain at the ostomy site. Obstructive symptoms, particularly nausea and vomiting, diminished ostomy output, and admissions for partial small obstruction, should be elucidated from the patient. Frequently, patients seek surgical intervention as a result of problems with the ostomy appliance consisting of either poor fit or leakage of enteric contents at the site.

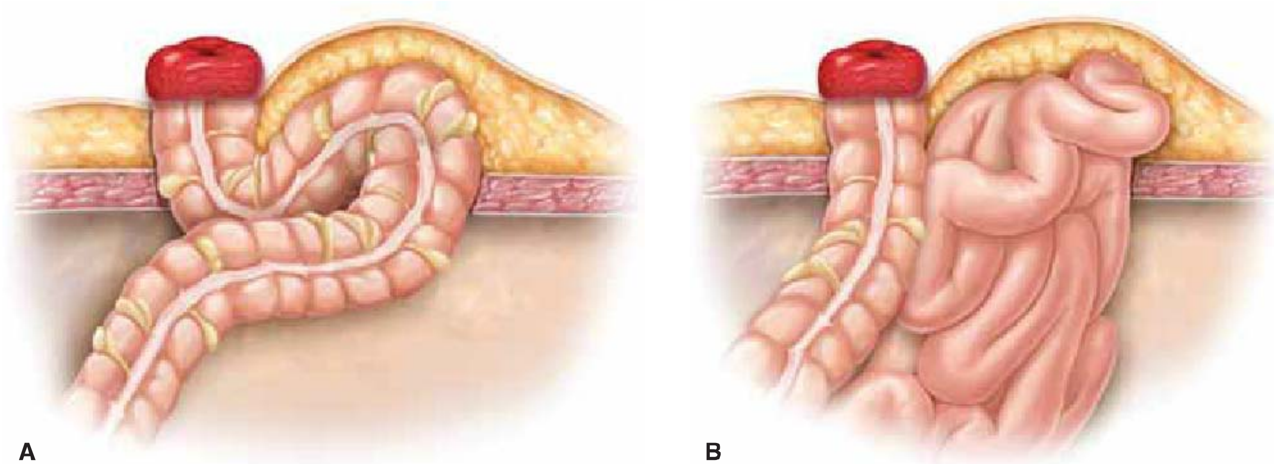


**Figure 31.1** Two types of parastomal hernia; (**A**) sliding enterostomal and (**B**) paraenterostomal.

Contraindications for repair would include patients that are poor candidates for general anesthesia either from a cardiac or pulmonary standpoint. The inability to tolerate general anesthesia will typically preclude a laparoscopic repair. Any decision regarding repair of parastomal hernias should consist of an appraisal of the risks versus benefits unique to each patient.

## PREOPERATIVE PLANNING

The best way to manage a parastomal hernia is to convert it to an incisional hernia by reversing the ostomy. Many times, patients have not been properly considered for ostomy reversal. This possibility needs to be addressed prior to embarking on a mesh-based repair of any parastomal defect. It may be necessary to locate previous operative or outpatient notes to identify this possibility.

Many patients presenting for repair of parastomal hernias have additional comorbidities that may complicate their perioperative course. Achieving a durable repair of parastomal defects is difficult enough to warrant medically maximizing the patient as best as possible.

Patients who use tobacco should be made to stop. Tobacco use has been demonstrated in several studies to increase the risk of wound and mesh infections. A urine nicotine level on the preoperative visit or the day of surgery may be drawn to exclude patients that continue to smoke.

Morbid obesity frequently accompanies parastomal hernias. Frank discussion with patients regarding weight loss and potentially bariatric surgery should be had. This conversation takes on added importance in situations of multiply recurrent parastomal defects.

The preoperative conversation with the patient should include expected postoperative outcomes related to the hernia repair. The possibility of mesh infection and damage to the ostomy are real and should be discussed. The long-term recurrence rate is higher than for ventral hernia repairs and approaches 30% for all comers according to the literature.

Imaging of the abdomen should be considered in patients with parastomal hernia, particularly if it is a recurrent defect with previously placed intraabdominal mesh. With laterally displaced defects, the landing zone for mesh may be compromised by the iliac crest. In this situation, bone anchors may be required to fixate the mesh laterally.

Preoperative mechanical bowel preparation is not necessary. Many times bowel cleansing may complicate the repair as a result of drainage of intestinal contents from the ostomy during the repair.

# SURGERY

The surgical repair of parastomal hernias is divided into three main approaches: (1) Primary, suture-based repair of the defect, (2) relocation of the ostomy, and 3) mesh-based repair of the defect. A straightforward, suture repair of the parastomal defect does not provide a long-term solution, but may be the preferred approach in a symptomatic patient who is a poor surgical candidate. Synthetic mesh or a biologic graft may be used as an onlay to reinforce a suture-based repair of a parastomal defect. Relocation of the ostomy is a viable option, particularly for large defects, but the concern is for creating two hernia prone sites on the abdominal wall. The technique portion will focus on the mesh-based repairs of parastomal hernias.

## Preparation and Positioning

Preparation of the parastomal hernia patient requires management of the ostomy prior to cleansing the abdominal wall of the patient. The ostomy site is closed with a purse-string suture of 2-0 silk. For ileal conduits, a catheter is used to cannulate the ostomy. The abdomen is prepped with povidone-iodine or silver chlorhexidine scrub. A sterile clear adhesive dressing (Tegaderm) is placed over the ostomy site. The entire abdomen is then covered with an adhesive iodine-impregnated drape (Ioban).

Systemic antibiotics are given preoperatively just as with a mesh-based incisional hernia repair and consist of a first-generation cephalosporin given 1 hour prior to incision. The dose is adjusted for weight and re-dosed at 4 hours. Prophylaxis for deep vein thrombosis should be instituted with sequential compression hose and subcutaneous heparin for high-risk patients.

## Open Repair

Mesh can be placed either in the retro-rectus or intraabdominal position in the repair of parastomal defects. A midline approach is preferred given that most cases have a midline incisional defect as well. The patient is positioned with the arms out and padded. A urinary catheter is placed for decompression. The previous midline cicatrix is excised. The abdominal cavity is entered and adhesiolysis is undertaken. The contents of the hernia sac are reduced and the fascial edges are delineated. Excision of the hernia sac is not necessary.

The posterior sheath of the rectus is identified and carefully dissected free of the rectus muscle. The retro-rectus space is developed on both sides out laterally to the insertion of the oblique muscles. On the side of the ostomy, the posterior sheath is dissected off the edges of the parastomal defect.

If the parastomal defect is in the midbody of the rectus muscle, there should be enough overlap for placement of mesh. If the ostomy defect is outside of the rectus sheath or adjacent to the lateral edge of the rectus sheath, the posterior sheath can be carefully incised at the lateral edge of the rectus to enter the preperitoneal space and allow for lateral placement of mesh (Fig. 31.2).

The posterior rectus sheath is re-approximated in the midline utilizing a long-acting absorbable monofilamented suture. This maneuver effectively walls off the visceral sac and allows for placement of uncoated synthetic mesh. The defect in the posterior fascia at the ostomy site is closed snug around the intestine. A flat, uncoated synthetic mesh is placed in the retro-rectus space. We prefer a macroporous, partially absorbable, polypropylene mesh in this situation. An effort is made to achieve at least 5 cm of mesh overlap to defect. A keyhole is cut in the mesh to position it around the bowel constructing the ostomy (Fig. 31.3).

The mesh is secured in a transabdominal fashion utilizing a non-absorbable, monofilament suture. A suture passer is used to pass sutures through stab incisions in the skin (Fig. 31.4). Stitches are placed superiorly and inferiorly in the midline, as well as a single suture laterally at the midpoint of the mesh. The anterior rectus sheath is then

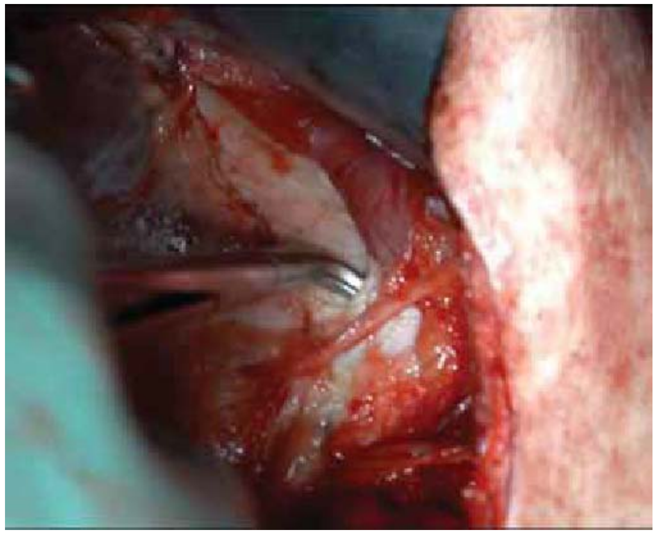

**Figure 31.2** A lateral release allows for placement of mesh beyond the boundary of the rectus sheath.

closed over the top of the mesh to provide vascularized coverage of the synthetic. The subcutaneous fat and skin is loosely closed with skin staples.

The repair of parastomal defects can be achieved with the intraabdominal placement of mesh as well. The technique of an intraperitoneal placement of mesh (IPOM), for the repair of parastomal hernias, was first described by Dr. Paul Sugarbaker in 1985. It effectively allows for appropriate overlap of the hernia defect while providing a conduit for the bowel to course from the skin to the intraabdominal cavity. It also avoids slitting the mesh as described in the "keyhole" repair.

The approach for the Sugarbaker repair is similar to the open keyhole described earlier. The principle difference arises at the time of mesh placement. After reducing the hernia contents and identifying the bowel forming the ostomy, the bowel is lateralized along the side wall by placing a pexy suture. An appropriate sized mesh ensuring 4 to 5 cm of overlap is then chosen to cover the defect. The mesh effectively forms a sling, or hammock, for the suspended bowel (Fig. 31.5). The defect may or may not be suture closed around the bowel depending on its size.

The mesh is secured in a transabdominal manner in at least five points. The periphery can be sutured or tacked to ensure that intraabdominal contents do not herniated around the edges of the mesh.

## Laparoscopic Repair

The laparoscopic technique provides benefit by reducing the incidence of wound and mesh-related infectious complications. The two techniques of mesh placement are the keyhole and modified Sugarbaker. The latter is preferred.

**Figure 31.3** The mesh is key-holed to allow for positioning around the ostomy.

**Figure 31.4** Transabdominal sutures are placed to secure the mesh.

The patient is positioned similar to a laparoscopic ventral herniorrhaphy. A urinary catheter is placed. The patient's arms are tucked and generously padded. Initial access is achieved according to surgeon comfort. We prefer an optical trocar in the subcostal space on the side opposite the ostomy. Additional trocars are placed laterally to assist with adhesiolysis and mesh placement (Fig. 31.6).

Meticulous adhesiolysis is then performed. Energy sources should be used sparingly and judiciously during this portion of the case. It is important to clear the midline to identify potential incisional defects. The contents of the hernia sac are reduced; however, special care must be taken to identify the bowel forming the ostomy. The bowel is mobilized for an adequate distance to allow for lateralization of the bowel segment for mesh coverage.

The edges of the fascial defects are delineated with spinal needles. An internal metric ruler measures the dimensions of the fascial defect. An appropriate sized mesh is chosen to provide 4 to 5 cm of overlap. The mesh is prepared for implantation by placing sutures at the midpoints of the sides except on the lateral aspect of the mesh. Here, sutures are placed approximately 6 to 8 cm apart to allow for the passage of the bowel. The superior and inferior sutures are brought out in a transabdominal fashion, ensuring the appropriate overlap. The medial most suture is then brought out. The mesh should be relatively taut. The three sutures are secured. The lateral edge of the mesh is placed in a manner to create a sling for the lateralized bowel of the ostomy (Fig. 31.7). As with the open intraabdominal mesh repair, the bowel may be sutured to the lateral side wall to assist with mesh placement. The final two sutures are brought out just above and below the course of the bowel to secure the lateral edges of the mesh. The mesh is then circumferentially secured with a tacking device at the periphery. Tacks



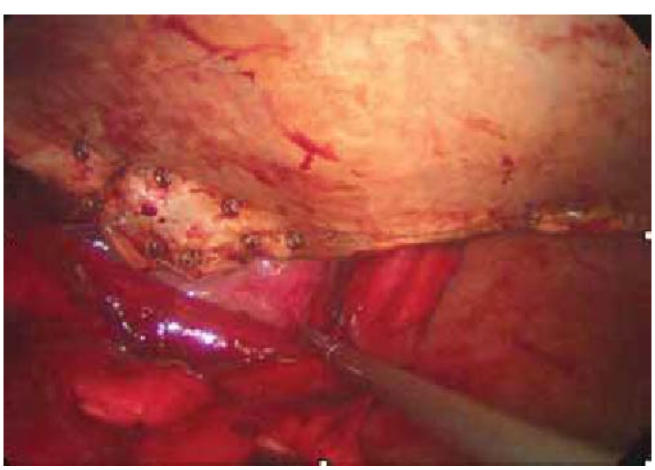

**Figure 31.5** Intraperitoneal placement of mesh (IPOM) creates a sling of the bowel forming the ostomy.

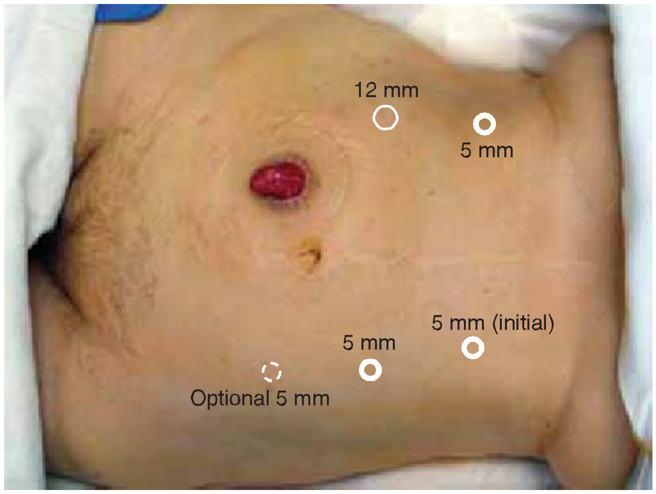


**Figure 31.6** Trocar placement for laparoscopic repair of parastomal hernia.

can be placed along the course of the lateralized bowel with care not to injure the intestine (Fig. 31.8).

Additional transabdominal sutures are placed at each quadrant. Sutures are placed approximately 5 to 7 cm apart. It is more important to fixate the mesh laterally where the bowel courses around the mesh. A monofilament suture of either non-absorbable or slow-absorbing polymer should be chosen.

## Mesh Choices

The mesh choices for parastomal hernia repair are numerous and should be tailored to the patient. The choice of mesh polymer will depend on a variety of factors such as the surgical approach (open or laparoscopic), the location of the mesh (onlay, retro-rectus, or intraperitoneal), and type of repair (bridging or reinforcing). A synthetic mesh that resists intense in-growth into the adjacent viscera is ideal for parastomal herniorrhaphy. Expanded polytetraflouroethylene (ePTFE) works very well especially for laparoscopic repairs. In open repairs, ePTFE may be used, or a polypropylene- or polyester-based mesh with an absorbable coating. There is always a theoretical concern with polypropylene or polyester mesh resting against the bowel once the absorbable barrier is gone. Biologic and bioresorbable meshes have been used for this very reason. These "absorbable" materials should preferably be used in a reinforced case so as to minimize recurrence.

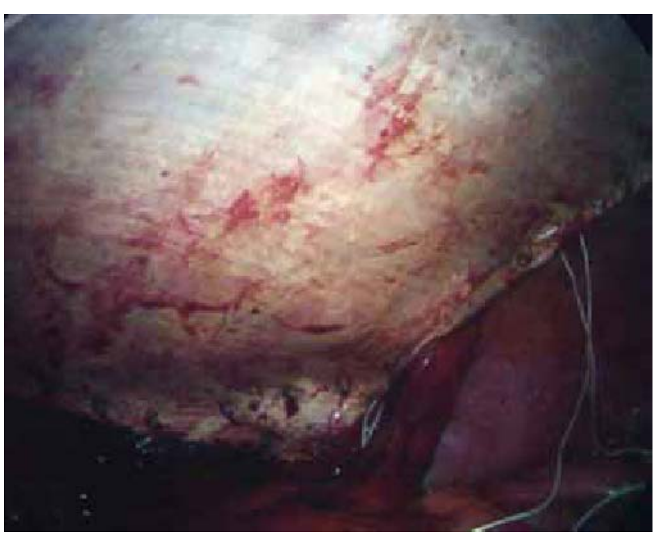

**Figure 31.7** The lateral sutures are placed last in the laparoscopic repair.

**Figure 31.8** Tacks are placed along the conduit where the intestine exits the mesh.

Macroporous, light-weight synthetics perform much differently from the heavy-weight polypropylene materials of the past. A partially absorbable, macroporous polypropylene mesh is preferred for open retro-rectus repair of parastomal defects. It is also the mesh used preferentially for reinforcing ostomy sites in a prophylactic effort.

## POSTOPERATIVE MANAGEMENT

The postoperative care of the parastomal hernia patient is very similar to that of a ventral hernia patient. Pain control is the most important initial concern. Patient-controlled intravenous analgesia with either morphine or hydromorphone is instituted. An epidural pain catheter may be placed preoperatively particularly for open cases. If the patient's renal function tolerates it, intravenous ketorolac can supplement the analgesic regimen. Diazepam can be used to treat muscle spasms of the abdominal wall. Once bowel function returns, oral analgesics are instituted. A stool softener is given starting on postoperative day 1.

Daily monitoring of vital signs is important, just as with any postoperative ventral hernia patient. Elevations in temperature curves or unexplained tachycardia should raise the suspicion of potential bowel injury. These findings should be correlated to the physical examination. Early recognition of bowel injury is critical with any hernia patient. Special attention should be given to the ostomy on a daily basis. The viability of the ostomy should be assessed by visual inspection.

Early ambulation is encouraged to avoid the potential deep venous thrombosis. Subcutaneous heparin and sequential compression hose are continued during the hospitalization.

The urinary catheter is removed on postoperative day one. Drain output is recorded for each 24-hour period. For synthetic mesh, drains are typically removed at 48 to 72 hours regardless of drain output. For biologic or bioresorbable grafts, drains are left in place until the daily output is less than 30 mL.

Patient discharge goals are the ability to tolerate a diet with resolution of bowel function, ambulation, and pain control with oral analgesics. Most patients are discharged between hospital day 4 and 5.

## COMPLICATIONS

Wound infection is not insignificant especially following an open repair. Even though the repair of parastomal hernias is technically a clean-contaminated case, the incidence of wound complications is not necessarily higher when compared to ventral herniorrhaphy. Erythema of the wound or purulent discharge should be treated by opening of the wound with wide drainage.

Seroma formation is common especially after a laparoscopic repair. Seromas are largely ignored unless they cause excessive pain or ischemia of the overlying skin due to pressure. Percutaneous aspiration can be performed under sterile conditions with concern given for potential mesh contamination.

Ileus frequently results after the repair of parastomal hernias regardless of the approach used. Rarely, gastric decompression is required, but we do not routinely place nasogastric tubes following hernia repair. With a prolonged return of bowel function, investigation into a potential bowel obstruction should be undertaken. There should always be concern for potential obstruction at the site where the bowel courses around the mesh. Computed tomography of the abdomen is the best way to evaluate this possibility and should be considered if bowel function has not returned by postoperative day 5.

Persistent pain can be seen beyond 6 weeks following mesh repair of parastomal hernias. The pain almost always occurs at suture sites. Patients describe a burning or pulling sensation with movement. These suture sites can be injected with 30 mL of a mixture of lidocaine and bupivacaine; however, this treatment is rarely required.

Mesh infection is always a concern following any type of hernia repair. Fortunately, the incidence is low; however, the consequences are grave. The management of mesh contamination is extensive and many times requires mesh removal. In patients who present with erythema of the abdominal wall or delayed abdominal pain over the mesh, CT imaging of the abdomen should be obtained. Fluid collection above or deep to the prosthetic that contains air is a mesh infection and treated as such. The fluid may be aspirated and sent for gram stain and culture. The mesh should be removed if it has a component of expanded PTFE. Attempts to salvage the prosthetic should involve open drainage of the fluid collection with negative pressure vacuum therapy. This maneuver may be successful with light-weight polypropylene materials, but less so with polyester-based materials.

## RESULTS

Recurrence rate is the ultimate outcome metric following any hernia repair. The incidence of recurrence following any hernia repair directly depends on the rate of follow-up. Ideally, all hernia patients should be seen at a minimum of 1 year postoperatively before any assessment of recurrence is made.

The literature reports a variety of techniques for repair of parastomal hernias. Most series are small in number and combine techniques or involve multiple centers. Many reports have fewer than 10 patients and emphasize novel techniques of repair as opposed to stressing a consistent repair with acceptable recurrence rates.

The review of the published literature in regards to recurrence rate is a lesson in humility. Not surprisingly, the primary suture repair of parastomal hernia exhibits an unacceptable rate of recurrence ranging from 53% to 76%. The results after resiting the stoma are slightly better with regard to recurrence. The incidence of recurrent parastomal hernia ranges from 24% to 33%; however, morbidity is higher and there is an increased risk of incisional hernia formation at the old ostomy site.

Mesh-based repairs are touted as having superior recurrence rates. The use of synthetic mesh in the repair has recurrence rates ranging from 0% to 46%. The difficulty in interpreting this literature, however, is the wide variation in technique and the small number of patients in the studies. The higher recurrence rates are reported with the slit or keyhole technique of placing the mesh around the stoma site.

The concern for placing synthetic mesh in close proximity to the bowel in the repair of parastomal hernias is the theoretical possibility of mesh infection and mesh erosion. Most studies in the literature have very few, if any, mesh-related complications. Nevertheless, some authors have advocated the use of biologic grafts to ameliorate some of the potential complications with synthetic mesh. A systematic review of the use of biologics demonstrates a recurrence rate of 15.7% and wound-related complications in 26.2% of patients. These results are not much better than synthetics with increased cost of material.

No data exists to tout the superiority of any particular technique for parastomal hernia repair. In spite of the lack of support, the laparoscopic approach utilizing the modified Sugarbaker technique seems to be the preferable technique. The recurrence rates with this technique are reported at less than 10%. Morbidity is not insignificant and the length of follow-up is relatively short.

## CONCLUSIONS

Parastomal hernias are one of the most challenging abdominal wall defects to fix with durable results. Much like the repair of paraesophageal hernias, recurrence rates approach 30% when efforts are made to repair a defect at a site where an enteric structure must continue to pass. The numerous methods of repair of parastomal hernias speak to the uncertainty in the preferred technique to approach this difficult problem.

There are a multitude of techniques both laparoscopic and open that have been described over the years. Given their problematic nature, a preventive approach toward parastomal hernias has been taken and may be the future answer. Some advocate mesh reinforcement of the ostomy site at the time of creation, and there is growing, prospective data to support this technique.

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# 32 Laparoscopic Incisional and Ventral Hernia Repair

Karl A. LeBlanc

## INDICATIONS/CONTRAINDICATIONS

In general, a laparoscopic repair of an incisional or ventral hernia (LIVH) can be considered for any individual who is stable enough to undergo a general anesthetic. The majority of these patients will have developed a hernia following an open intraabdominal procedure or will have had one or more failed hernia repairs by either the open or laparoscopic method. The indications most commonly used are as follows:

- Fascial defect size >3 to 4 cm in a non-obese patient
- Fascial defect ≥2 cm in obese patients
- Recurrent hernias with or without multiple defects

Most patients will fit into one of the above categories, however, there are circumstances that need to be considered wherein an open procedure might be the better option such as:

- Infected or exposed mesh
- Thin skin with direct adherence to the underlying intestine
- Hernias larger than 15 cm in transverse dimension
- Unusual locations such as a "denervation" flank hernia (although a combined approach can be used)
- Extremely extensive intraabdominal adhesions

Exposed or infected mesh will need excision and other therapy to close the defect that cannot be effectively dealt with by the laparoscopic approach. The second situation may have resulted in vascular supply to the overlying skin by the intestine (as prior open abdomen with skin graft) resulting in skin necrosis with dissection of the underlying adherent intestine for the repair. Very large hernias will require component separation. The hernias that commonly develop after nephrectomy result from transection of the innervation to the abdominal wall muscles. This will not provide an acceptable cosmetic result in most patients (but a combination of open and laparoscopic approach can be applied successfully). The last consideration is based upon time factors. If the laparoscopic adhesiolysis will incur operative times of 3 to 4 hours alone, then an open approach will likely be quicker; however, here again, a hybrid approach could be applied.

## PREOPERATIVE PLANNING

In most patients, routine laboratory testing as per their age and co-morbidities will be sufficient. Elderly patients or those with significant heart or lung disease may be at risk for an inability to tolerate the required insufflation pressures. They may require preoperative cardiac and pulmonary assessments. It is preferable for the morbidly obese patient to lose 10% to 15% of their weight preoperatively. This will aid in the repair and significantly improve the available intraabdominal space with which to perform the repair. In patients with prior abdominal procedures, especially if these were hernia repairs with mesh, it is beneficial to obtain the operative reports from the prior surgical procedures (when possible).

A CT scan is helpful in most cases but is not always necessary. It is especially useful for large, multiple or unusually located hernias. In some cases, a previously placed mesh and/or tacks used for fixation may be seen. This will assist in planning the procedure. If performed, this should be done with oral contrast to identify any intestinal contents within the hernia.

All patients should not be nutritionally depleted. All patients who smoke should cease for at least 3 to 4 weeks prior to the operation to diminish complications such as wound infection. If there has been a prior mesh infection, it is desirable to delay the repair for 3 to 6 months to ensure adequate clearance of any bacteria. Additionally, one should then use prophylactic antibiotics specifically used for the prior bacterial infection as these pose a particularly high risk. The use of purgatives is not necessary unless the colon is located within the hernia contents.

## SURGERY

LIVH procedures will begin the introduction of general anesthesia. Nasogastric suction is used selectively. If the procedure is felt to be relatively uncomplicated and short in duration, a urinary drainage catheter is unnecessary. If the location of the hernia is in the lower portions of the abdomen, a three-way catheter should be used. The bladder can be filled with saline to ease its identification for dissection and placement of transfascial sutures. Sequential compression devices should be used because of the nature of these operations. Prophylactic anticoagulation should be considered as well.

### Positioning

The supine position will be used in the majority of these cases. However, if the hernia is located in the flank, lumbar, or other areas the patient will require positioning on their side at least to some extent. A "bean-bag" for this purpose is very supportive. If the hernia is the upper abdomen, the arms do not need to be tucked. It is preferable (if the habitus of the patient allows) to tuck them for hernias in the lower abdomen for technical maneuvers related to the procedure. After widely draping the patient, an iodine impregnated plastic drape should be used over the skin.

The monitors that are used for any laparoscopic operation should be placed so that the surgeon is looking directly into them with no strain on the neck of the operator. This is an ergonomic consideration that is frequently forgotten. There should be one on either side of the table for all of the participants of the procedure to visualize (Fig. 32.1). The operating table should be able to assume Trendelenberg (and reverse) positions as well as roll side to side (airplane maneuver).

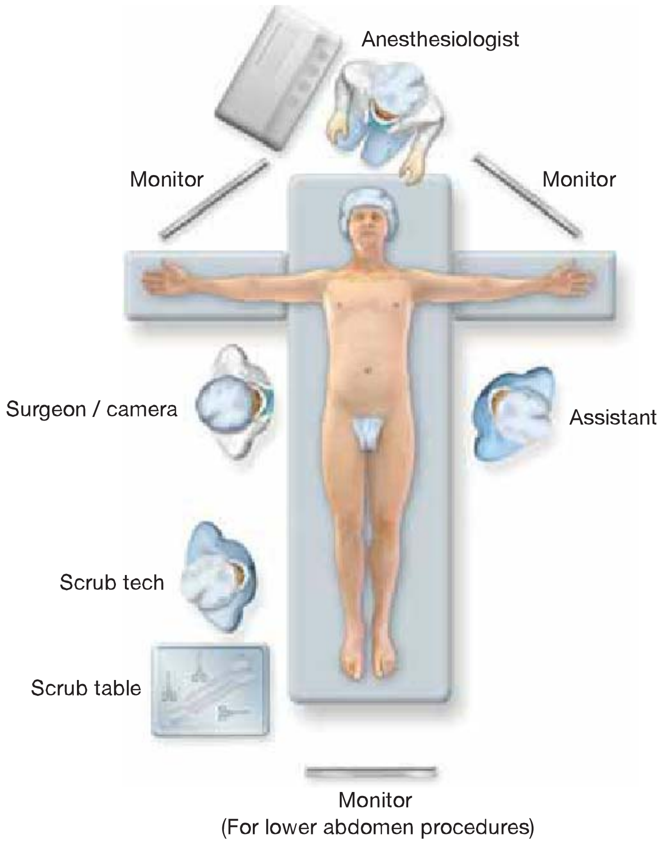


**Figure 32.1** Typical operating table and room set-up.

# Technique

There are several steps to the operation:

- Access to the abdominal cavity
- Laparoscopic selection
- Methods and instruments of adhesiolysis
- Identification and measurement of the defect(s)
- Potential of defect closure
- Choice and introduction of the prosthetic material to repair the hernia
- Fixation of the product

The initial consideration with all laparoscopic procedures should be the method and location of the entry into the abdominal cavity. All methods are applicable to LIVH. Most surgeons prefer the subcostal regions for the initial entry regardless of technique. If there is a hernia in these regions or if the trocar placement in that location is not appropriate, other sites will be used. Generally, three to four trocars will be used. I believe it best to place at least one trocar on the opposite side of the abdomen to adequately visualize the contents of the abdomen during dissection and fixation (Fig. 32.2). After the introduction of each successive trocar, the laparoscope should be inserted to view the areas from that perspective to assure the locations of the intestine and the adhesions.

Currently, the use of 5 mm laparoscopes is most common. However, if the optics are not best, the 10 m scopes would be needed. The latter scopes are able to withstand more torque than their smaller counterparts. Most surgeons will use the 30° scopes but many prefer the 0° while the 45° can occasionally be useful.

Without question, the lysis of the adhesions of these individuals can be the most challenging portion of the operation and constitutes the largest segment of time involved (Fig. 32.3). The options include blunt dissection, cold or hot scissor dissection, bipolar cautery, or ultrasonic dissection. Blunt dissection is better suited with filmy adhesions. Cold scissor dissection should be used in close proximity of the intestine. The latter

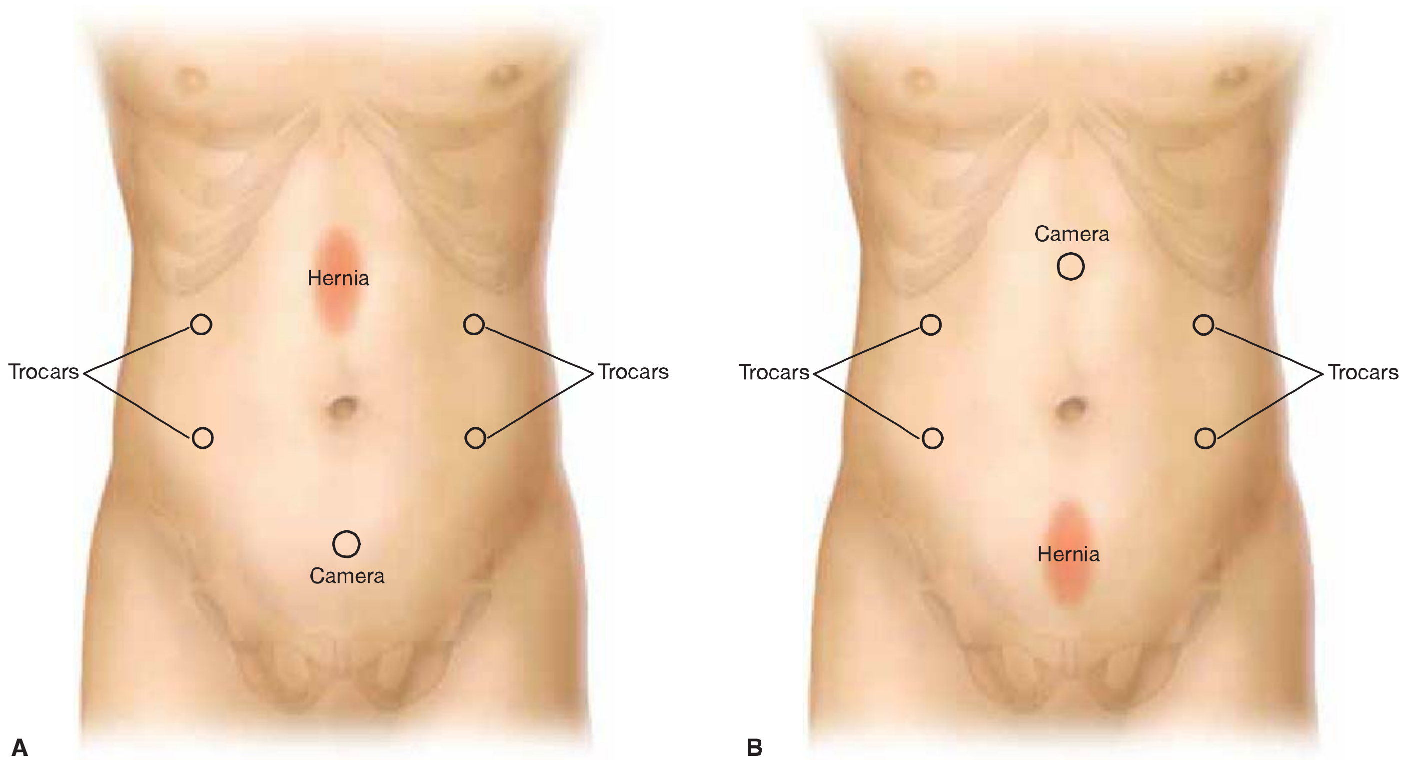


**Figure 32.2** Typical trocar placement for upper (**A**) and lower (**B**) hernias.

three options are very helpful when omental or vascularized adhesions require lysis. In all cases, one should be as certain as feasible that there is no bowel adjacent to the areas where these are used to avoid injury.

Once all of the adhesiolysis has been completed, all of the fascial defects should be identified (Fig. 32.4). It is important to perform wide dissection including the preperitoneal fat that will prevent the prosthesis from contacting the fascia into which it must attach. It is especially important in the upper abdomen to dissect the falciform ligament away from the fascia such that there can be a 5 to 8 cm overlap of the mesh in this area if there is a subxyphoid hernia (Fig. 32.5). Similarly, in the pelvis, the bladder must be brought down to expose Cooper's ligament so that the mesh can be fixed to that structure if the hernia is suprapubic (Fig. 32.6). There are a multitude of options of measurement of the defect(s). Sizing can be difficult in a fully insufflated abdomen; therefore, in most instances all of the carbon dioxide should be released for measurement. I prefer to place marks at the four cardinal points of the defect(s) with the fully inflated abdomen (Fig. 32.7), then measuring once all of the $CO_2$ is released

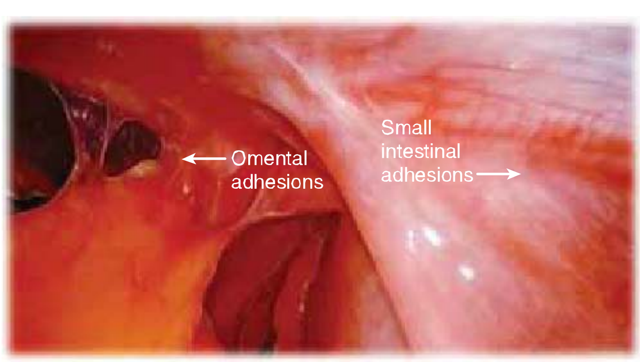


**Figure 32.3** Extensive small bowel adhesions to anterior abdominal wall.

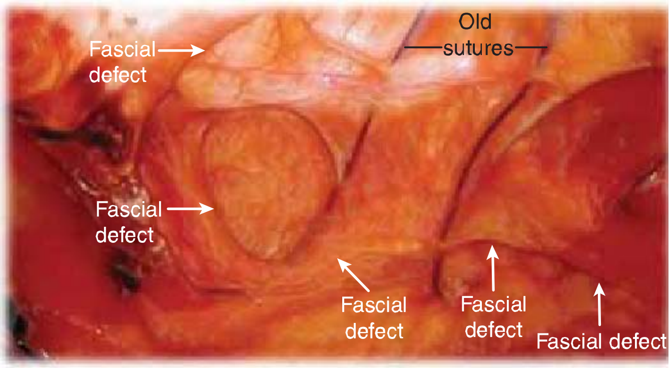


**Figure 32.4** A few hernia defects visualized laparoscopically.


**Figure 32.5** Fully dissected falciform ligament.

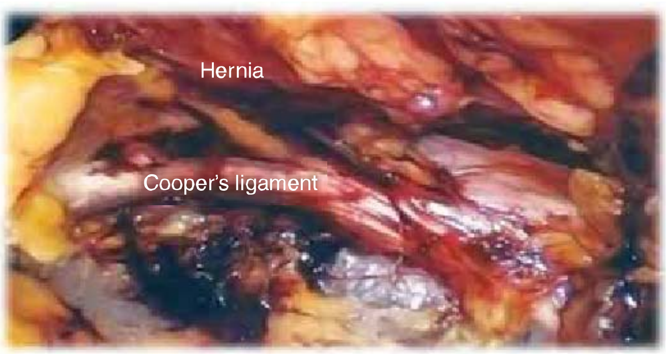


**Figure 32.6** Suprapubic hernia with dissection of Cooper's ligament.

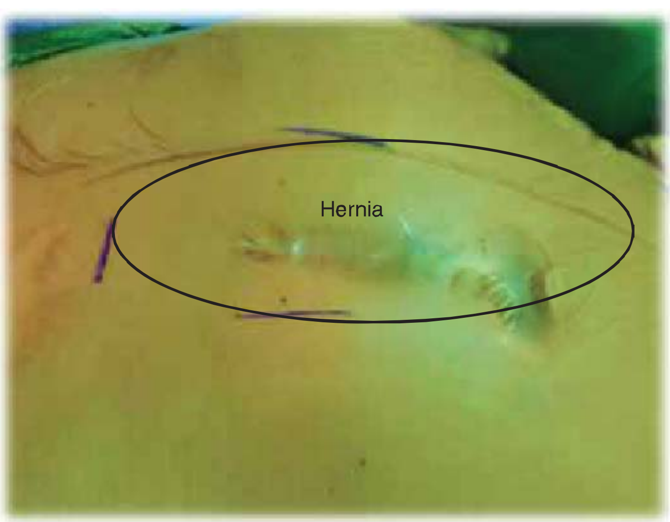


**Figure 32.7** Fully insufflated abdomen with marks outlining the hernia defect.

Figure 32.8 Measurement of the defect using these marks after desufflation.

(Fig. 32.8). If multiple defects are present, one should measure from the farthest apart margins in all directions. Additionally, one should provide mesh coverage under all of the existing incision to mitigate future development of hernias at a site not covered by the prosthesis.

There has been a developing opinion that, when feasible, the fascial defects should be closed prior to mesh placement. It is felt that this might prevent re-herniation, improve the cosmetic result, and restore the respiratory function of the abdominal muscles. This can only be done with hernias that measure less than 5 to 6 cm, in most cases. Transfascial sutures are passed after the insufflation pressure has been reduced as much as possible (typically 8 mm Hg) (Figs. 32.9, 32.10). There are many products available for the repair of these hernias. All of these materials are designed to inhibit the potential for adhesion development to the product on the visceral surface while encouraging tissue ingrowth into the opposite parietal surface. These "tissue-separating" meshes accomplish this with either an absorbable layer (Table 32.1) or a nonabsorbable material (Table 32.2). It is beyond the scope of this chapter to discuss the characteristics of these materials but there are sources that detail these products. The choice should be based upon the available literature and science but surgeon experience and preferences will dictate the choice in most cases. It is important, however, to provide an overlap of all fascial defects by at least 5 cm unless it is not possible to do so. This prosthesis chosen may also impact the choice of fixation methods.

The mesh will be rolled into a tubular shape with or without pre-placement of sutures. It can be introduced either directly through the trocar or with the trocar removed. In the latter instance the product is pulled into the abdominal cavity

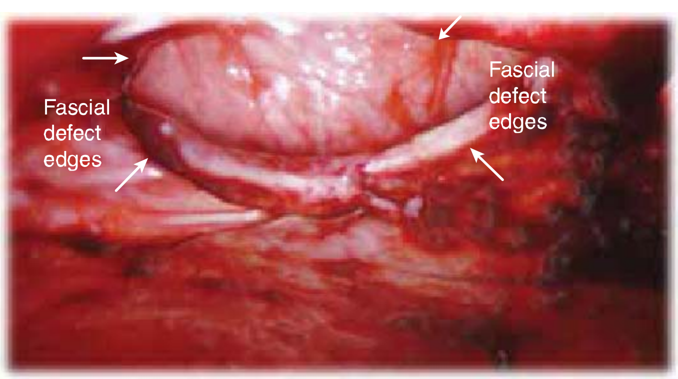


Figure 32.9 Typical hernia defect before closure with transfascial sutures.

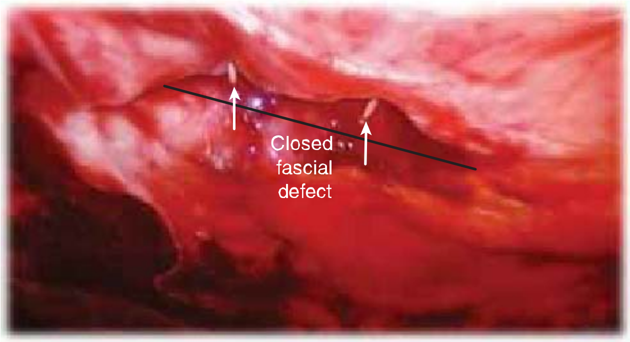


**Figure 32.10** The same hernia defect after closure with transfascial sutures.

**TABLE 32.1 Permanent Herniaplasty Materials with an Absorbable Component**

| |
|---|
| *Adhesix,* Cousin Biotech, Wervicq-Sud, France |
| *Biomerix Composite Surgical Mesh,* Biomerix Corporation, Fremont, CA |
| *CA.B.S. 'Air SR,* Cousin Biotech, Wervicq-Sud, France |
| *C-QUR,* Atrium Medical Corp., Hudson, NH, USA |
| *C-QUR **EDGE**,* Atrium Medical Corp., Hudson, NH, USA |
| *C-QUR Lite,* Atrium Medical Corp., Hudson, NH, USA |
| *C-QUR OVT Mesh,* Atrium Medical Corp., Hudson, NH, USA |
| *C-QUR V-Patch,* Atrium Medical Corp., Hudson, NH, USA |
| *Easy Prosthesis (PPM/Collagen),* TransEasy Medical Tech.Co.Ltd, Beijing, China |
| *Parietene Composite (PPC),* Covidien plc, Dublin, Ireland |
| *Parietex Composite (PCO),* Covidien plc, Dublin, Ireland |
| *Parietex Composite (PCO) Skirted Mesh,* Covidien plc, Dublin, Ireland |
| *Parietene ProGrip,* Covidien plc, Dublin, Ireland |
| *Parietex ProGrip,* Covidien plc, Dublin, Ireland |
| *PHYSIOMESH,* Ethicon, Inc., Somerville, NJ, USA |
| *Proceed,* Ethicon, Inc., Somerville, NJ, USA |
| *PVP,* Ethicon, Inc., Somerville, NJ, USA |
| *SepraMesh IP,* Davol, Inc., Warwick, RI, USA |
| *Ventralex ST,* Davol, Inc., Warwick, RI, USA |
| *Ventrio ST,* Davol, Inc., Warwick, RI, USA |

**TABLE 32.2 Herniaplasty Materials Solely of Permanent Material**

| |
|---|
| *CA.B.S 'Air,* Cousin Biotech, Wervicq-Sud, France |
| *ClearMesh Composite (CMC),* Di.pro Medical Devices, Torino, Italy |
| *Combi Mesh,* Angiologica, S. Martino Sicc., Italy |
| *Composix E/X Mesh,* Davol, Inc., Warwick, RI, USA |
| *Composix Kugel (CK) Patch,* Davol, Inc., Warwick, RI, USA |
| *Composix L/P Mesh,* Davol, Inc., Warwick, RI, USA |
| *DynaMesh IPOM,* FEG Textiltechnik mbH, Aachen, Germany |
| *IntraMesh T1,* Cousin Biotech, Wervicq-Sud, France |
| *IntraMesh W3,* Cousin Biotech, Wervicq-Sud, France |
| *Intramesh PROT1,* Cousin Biotech, Wervicq |
| *Omyra Mesh,* B. Braun Melsungen AG, Melsungen, Germany |
| *MotifMESH,* Proxy Biomedical Ltd, Galway, Ireland |
| *Rebound HRD V,* Minnesota Medical Development, Plymouth, MN, USA |
| *Relimesh,* HerniaMesh, Torino, Italy |
| *SurgiMesh XB,* Aspide Medical, St. Etienne, France |
| *SurgiMesh TintraP,* Aspide Medical, St. Etienne, France |
| *TiMesh,* GfE Medizintechnik, Nuremburg, Germany |
| *Ventralex,* Davol, Inc., Warwick, RI, USA |
| *Ventrio Hernia Patch,* Davol, Inc., Warwick, RI, USA |

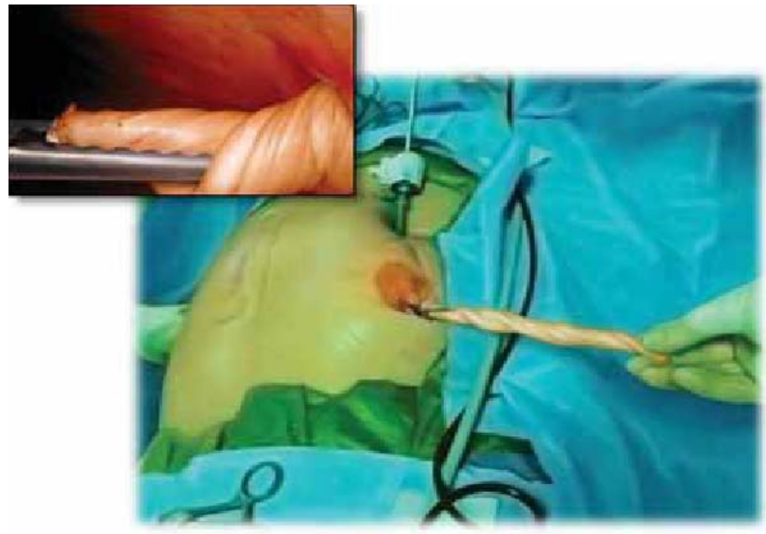

Figure 32.11 Mesh with initial two sutures in place, exterior. Inset: Rolled mesh grasped by an instrument with the trocar removed; the mesh as it is pulled into the abdominal cavity.

(Fig. 32.11). It will be unrolled and manipulated into place with the hernia defects centered on the mesh. Fixation will then commence.

Fixation is an area of controversy. While most surgeons include the placement of transfascial sutures to fixate all prosthetic products, many do not. Evidence exists that the smaller hernia defects may not require transfascial sutures but the defects larger than 5 cm should include them. If 2 to 4 sutures have been pre-placed, they will be pulled through the abdominal wall assuring that that the defect(s) are adequately covered by one of several devices designed for that purpose (Fig. 32.12). If no sutures have been placed, the prosthesis will be held up to the abdominal wall and fixed with fasteners of some type. Historically, permanent devices were used exclusively (Table 32.3). Recent availability of absorbable fasteners have allowed fixation with products that will not remain after 12 to 18 months (Table 32.4). Most commonly, transfascial sutures are placed 5 to 6 cm apart followed by one or two rows of the fasteners 1 to 2 cm apart (Figs. 32.13–32.18).

Once the procedure itself has been completed, a final inspection of the intraabdominal structures to assure that there is no excessive bleeding and the intestine should be examined to the extent possible to assure that no injury has occurred. It is virtually impossible to “run the bowel” completely in these patients due to adhesions but an attempt should be made. At this point all instruments and trocars are removed. Larger cutting trocar fascial incision sites should be closed. Skin closure follows by whatever method is preferred.

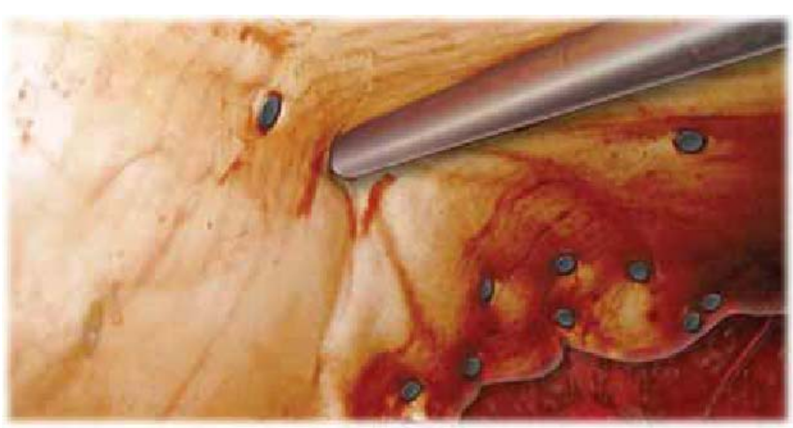

Figure 32.12 Use of the SorbaFix fastener device.

**TABLE 32.3 Permanent Fixation Fasteners**

| |
|---|
| *Endo Universal Stapler,* Covidien plc, Dublin, Ireland |
| *Multifire Endo Hernia Stapler,* Covidien plc, Dublin, Ireland |
| *PermaFix,* Davol, Inc., Warwick, RI, USA |
| *ProTack,* Covidien plc, Dublin, Ireland |
| *Tacker,* Covidien plc, Dublin, Ireland |

**TABLE 32.4 Absorbable Fixation Fasteners**

| |
|---|
| *AbsorbaTack,* Covidien plc, Dublin, Ireland |
| *PermaSorb,* Davol, Inc., Warwick, RI, USA |
| *SecureStrap,* Ethicon Inc., Somerville, NJ, USA |
| *SorbaFix,* Davol, Inc., Warwick, RI, USA |

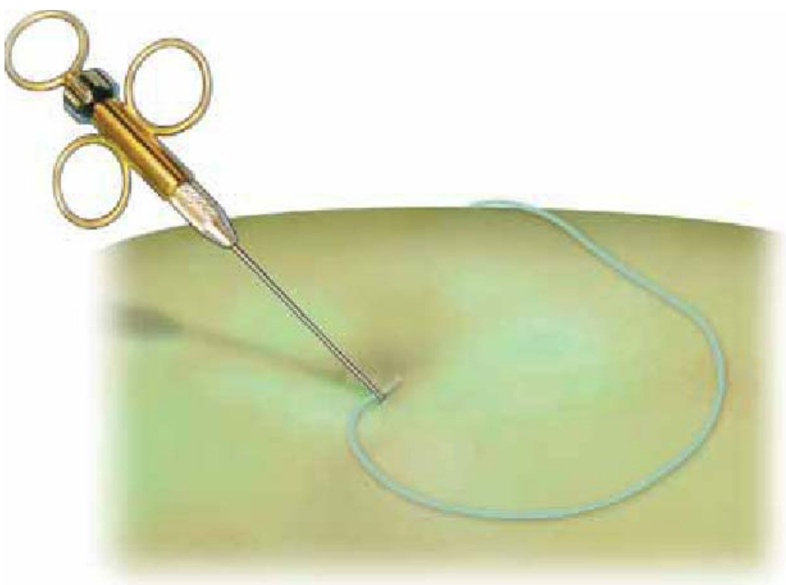

**Figure 32.13** Use of the suture passing device placing a transfascial suture.

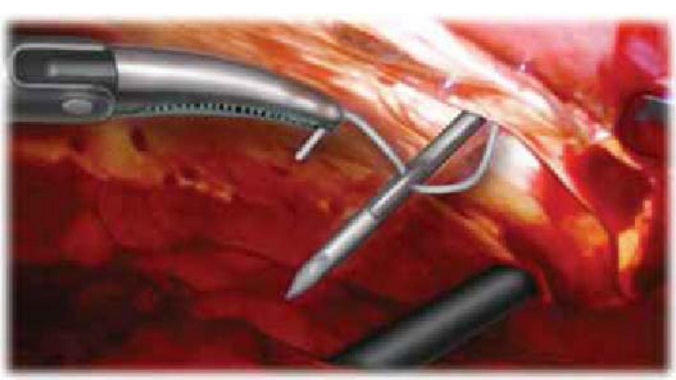

**Figure 32.14** Laparoscopic view grasping of the transfascial suture.

Figure 32.15 Empty suture passer with suture being placed onto it prior to introduction of the additional transfascial sutures.

Figure 32.16 Final view of properly placed sutures and Sorbafix fasteners.

Figure 32.17 View of uncut transfascial sutures.

Figure 32.18 Completed procedure.

## POSTOPERATIVE MANAGEMENT

All patients have an abdominal binder placed in the operating room. This assists with pain relief and minimized the development of a postoperative seroma. Intravenous fluids are only continued if the patient is to be admitted. The urinary drainage catheter and nasogastric tube are removed in the operating or recovery room unless deemed necessary.

Approximately 30% to 50% of these patients can be sent home immediately after the procedure. Another 25% will be kept within the hospital with only an overnight stay. The choices of admission versus a limited stay will be determined by the co-morbidities of the patient, the amount of pain experienced postoperatively, and if there are concerns regarding complications such as intestinal injury. The larger hernias that require extensive adhesiolysis will frequently develop an ileus and may become dehydrated. These will also be more likely to have significant postoperative pain resulting in an admission.

Early ambulation is encouraged, as is aggressive pulmonary toilet efforts. Diet is progressed as tolerated. Activities of daily living and employment are allowed according to the pain of the patient. It is preferred that the abdominal binder be worn for 1 to 2 weeks if possible.

## COMPLICATIONS

The more common adverse issues following these procedures can be categorized into the minor (and more frequent) events and the problematic major complications.

- Minor
  - Seroma
  - Ileus
  - Pain
- Major
  - Hemorrhage
  - Intestinal injury
  - Mesh infection
  - Recurrence

Virtually all patients will develop a postoperative seroma after this operation. This is due to the fluid that is secreted by the peritoneum within the hernia sac. Not surprisingly, the larger the hernia sac, the larger the seromatous collection that may be seen. The use of the abdominal binder will greatly aid in the prevention or diminution of this fluid. Like a seroma, an ileus is a very frequent occurrence. In fact, these are so common that many do not consider these complications but rather a consequence of the procedure itself. An ileus that requires treatment occurs in approximately 8% of the cases. It is usually short-lived and easily treated with nasogastric suction. The real concern when an ileus develops is that this may mask the more ominous problem of an enterotomy. Pain following these procedures very commonly exceeds that of the original open laparotomy. It is said to be especially seen when transfascial sutures are used. However, recent data suggests otherwise. It should be treated with appropriate analgesics. It, too, can make the diagnosis of an inadvertent enterotomy more difficult.

Fortunately, major complications are uncommon. Major hemorrhage is rarely seen but can result from penetration of the inferior epigastric vessels with one of the fixation methods. Transfascial sutures above and below the puncture site can control it. Omental or mesenteric hemorrhage is uncommon and is usually avoided by the use of one of the devices designed for control such as the ultrasonic shears.

Intestinal injury can occur despite the most judicious use of any instrument whether it includes an energy source such as cautery or ultrasonic dissection. This will occur in approximately 1.78% of these procedures. The potential sources of injury include:

- Instrument exchange
- Traction
- Scissor (cold)
- Energy source burn

Instrument exchange injuries occur by the introduction of them into the abdominal cavity. This can occur at the start of the procedure with introduction of a trocar whether a Veress needle, Hassoon technique, or an optical trocar is used. This is uncommon but underscores the fact that at the introduction of every trocar, the laparoscope should be inserted into it to inspect the area near it and to locate the placement site of the next trocar.

Traction injury can occur from the grasping of the intestine to reduce the hernia contents, to aid in dissection, or simply during manipulation of the bowel. This can result in a simple serosal tear that may or may not require repair. It can result in exposure of the mucosa or even penetration into the lumen of the intestine. When recognized these should be oversewn either laparoscopically or open depending upon the surgeon's comfort level. One should observe the patient closely postoperatively for potential leakage from these repairs.

Scissor dissection is an integral part of all hernia repairs. One can injure the bowel by merely rubbing the tips of the scissors against them to dissect them away from the abdominal wall. This should be treated similarly to the traction injury described above. Frank laceration into the intestine or bladder can occur despite utmost care. When the injury is severe and exposes a large portion of the mucosa, the surgeon should base the ability to close this intra- or extracorporeally by the size of the defect and his or her comfort with laparoscopic suturing. If it is elected to close extracorporeally, a small laparotomy can be made or a trocar site can be enlarged to exteriorize the bowel to repair or resect it.

When in close proximity to the intestine, the use of any energy source should be avoided. This energy can be transmitted some distance laterally and result in a burn that may not be apparent to the surgeon at that time and result in a burn that may not necessarily result in a full thickness perforation at that time. Instead, this may become manifest 2 to 4 days later. The largest risk of this lateral burn, in increasing order, occurs with the bipolar cautery, the ultrasonic dissection, and monopolar cautery devices. The obvious signs of potential injury such as blanching, charring or an obvious perforation will alert the surgeon to treat these as a full thickness injury.

Once an injury is recognized, a decision must be made as to how to manage not only it but also the hernia repair. The primary goal at that point is to repair the potential or real perforation. This should be handled in the same fashion as that described above for a scissor injury. In general, if there is a lack of or minimal contamination, the hernia repair could proceed as planned. If there is a colonic injury, a moderate or great amount of spillage, the injury should be treated and the hernia repair delayed for at least a few days. However, in the era of available biologic products, consideration could be made to proceed with a biologic mesh repair rather than the use of a synthetic one. A primary repair is, of course, an option but this would be the least preferable option. Antibiotics should be continued for the appropriate length of time after such an event.

Mesh infection is an uncommon event (1% to 2%). If this is a small and contained area, an attempt to treat this with incision, drainage, and application of a vacuum assisted system is justifiable. If this fails, local or complete removal of the product will be necessary. Following that, continued treatment with vacuum assistance or repair with a biologic mesh can be performed.

Recurrence is the standard by which these procedures are judged with low rates are reported (5% to 6%). These patients can be once again treated with an LIVH (or open if deemed necessary). Complete dissection of the hernia defect(s) should be performed again. If the prior prosthetic material was, all or in part, based upon expanded polytetrafluoroethylene (ePTFE), this portion should either be fenestrated or removed to allow for adequate tissue ingrowth from the newer prosthesis. Additionally, the use of more than the normal number of transfascial sutures would be highly recommended.

# RESULTS

The outcomes following this procedure are excellent, with the lowest recurrence rates of most of the available techniques. Ultimately, the abdominal contour of the patient will be very near that of the pre-hernia condition in the majority of cases. The ability of the patient to return to productive employment without restriction is excellent.

# CONCLUSIONS

This very effective technique is one that most surgeons can perform. Important details to adhere to include:

- Patient selection
- Adequate preoperative evaluation and preparation
- Safe adhesiolysis
- Identification and measurement of all fascial defects
- Use of an appropriate prosthetic material with a 5 cm overlap of the fascial defect
- Fixation that is firm and sure

Future improvements in laparoscopic instruments, mesh technology, mesh introduction products, and fixation methods will provide for broader adoption and application of this valuable technique.

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# 33 Endoscopic Separation of Components

**Ashley H. Vernon and Ryan R. Gerry**

## INDICATIONS/CONTRAINDICATIONS

- Ramirez published his experience with the "separation of components" procedure in 1990 for the closure of complex abdominal wall hernias, and since this time the use of component separation has become widespread for this indication. His original paper describes complete mobilization of the external oblique muscle and its aponeurosis from the rectus and internal oblique which resulted in the ligation of perforators of the deep inferior epigastric artery and deep circumflex iliac artery to the overlying skin. The Achilles heel of this procedure is that it creates skin flaps that are relatively ischemic, which makes these flaps prone to wound problems, including superficial wound infection and necrosis. Modifications of the original procedure that preserve the perforating vessels to the overlying flaps have been adopted in attempt to preserve the perfusion to the overlying flaps and reduce these complications.
- Endoscopic release of the external oblique aponeurosis and component separation, otherwise known as bilateral endoscopic component separation (BECS), incorporates several improvements in technique which reduce complications inherent to the open procedure. The most significant improvement is that the perforating vessels are not disrupted and there is no soft tissue undermining.
- Additionally, the incisions used to create the release are separated from the midline wound which ensures that any wound complications created by the release will not undermine the primary repair.
- The durability of the open component separation is well documented with wound healing rates approaching 100%, even in contaminated wounds. The longevity of the repair, however, is less certain and may depend upon augmentation with permanent mesh. The endoscopic component separation draws on the strengths of the open version as it has been demonstrated to have similar physiologic and anatomical characteristics.
- BECS is gaining popularity because of lower wound complication rates compared with the open technique. The past decade has been notable for an increased availability of bioprostheses that can be used in contaminated wounds. Experience with these products has highlighted the need to restore the muscular function of the

abdominal wall. Combining BECS and underlay mesh to reinforce a primary closure at the midline achieves the best functional outcome with the lowest perioperative complications.

- Indications for BECS with ventral hernia repair, include but are not limited to (1) contaminated hernias in which permanent mesh is contraindicated, (2) moderate to large-sized ventral hernias, and (3) hernia-associated symptoms due to large abdominal wall deformity, for which primary closure of the abdominal wall in the midline will restore normal abdominal contour.
- Prior surgery of the lateral abdominal wall may pose difficulty with dissection due to adhesions. It is impossible to develop the plane between the oblique muscle layers when they are fused at an old wound. The most commonly encountered lateral deformities which prohibit BECS are open appendectomy scars and stoma sites.

# PREOPERATIVE PLANNING

- In the elective setting, nutrition is maximized with enteral or parenteral feeding; infection should be adequately treated; and obese patients have lost weight under the guidance of a dietitian and surgeon.
- Preoperative abdominal CT assists in determining the size of the abdominal wall defect and in identifying the lateral border of the rectus abdominis muscles.

# SURGICAL PROCEDURE

## Positioning

- The patient should be in the supine position with a wide surgical field, including the costal margins and the lateral abdominal wall.
- Tucking both arms at the patient's side is helpful since both the surgeon and assistant may be more comfortable standing on the same side.

## Anesthesia

- General anesthesia is routine when repairing hernias of sufficient size to require separation of components.
- Prophylactic antibiotics to cover gram-positive organisms should be administered within 60 minutes of incision and re-dosed according to hospital antibiotic guidelines throughout the case.

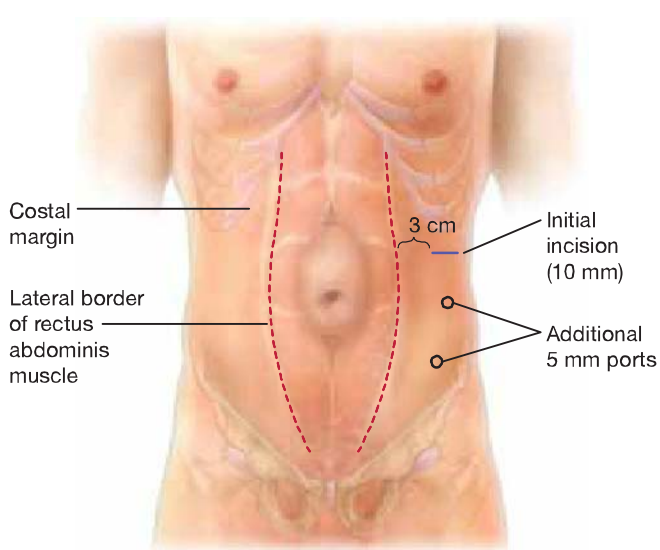


**Figure 33.1** Port Placement.

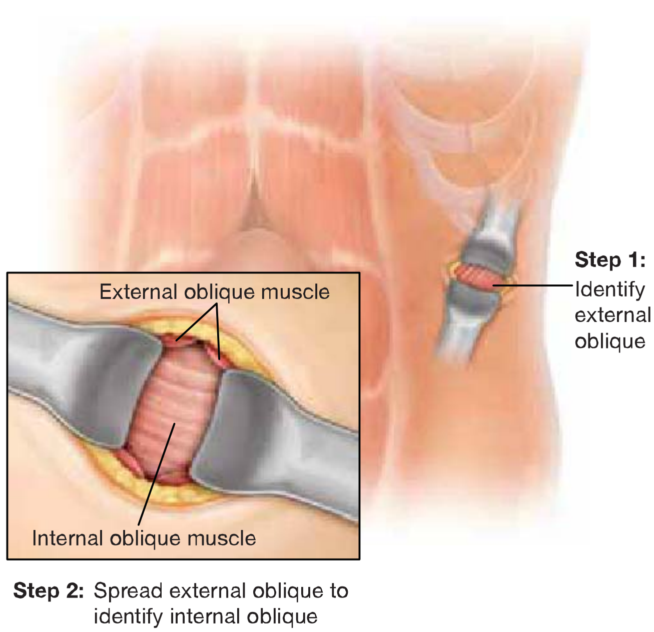


**Figure 33.2** Dissection of the abdominal wall.

- A urinary catheter is useful to decompress the bladder and helps avoid injury to the bladder when dissecting in the pelvis.

## Technique

*Port placement and development of the dissection plane:*

- A preoperative CT scan will aid in identifying the lateral border of the rectus. The lateral border is marked in the operating room by measurements acquired from CT scan and physical examination. A 2 cm transverse incision is made inferior to the costal margin, approximately 3 cm lateral to the lateral border of the rectus abdominis muscle (Fig. 33.1).
- The Bovie electrocautery is used to dissect through the subcutaneous fat while utilizing S-retractors for exposure. Once the thin anterior fascia overlying the external oblique muscle body is identified, it is incised to expose the orientation of the muscle fibers. The correct orientation of the external oblique muscle fibers allows definitive identification of the level of dissection (Fig. 33.2).
- The muscle fibers are bluntly separated until the plane between the oblique muscles is confirmed. The internal oblique aponeurosis is smooth and whitish in color and care should be taken not to go too deep into or through the internal oblique.
- While elevating and holding the external oblique muscle fibers apart with a small retractor, the balloon dissector is introduced into the plane between the oblique muscles. The tip is pushed inferiorly to the inguinal ligament. The balloon dissector is serially inflated and deflated, each sequence pulling the balloon more cephalad. Two to three sequences are usually adequate to fully separate the muscles.
- Superiorly and medially, the pocket is manually created with the surgeon's finger. Palpation of the costal margin also confirms the correct plane of dissection in this area.
- The balloon dissector is replaced with a port with a balloon at the distal end. There is limited space between the muscles and this port can be pulled all the way back to allow the best view without inadvertent removal of the port.
- The space between the oblique muscles is insufflated with carbon dioxide. If the correct plane has been dissected, the initial inspection will reveal a cavity with external oblique above and the internal oblique below (Fig. 33.3). These muscle layers are identified by the orientation of their fibers. The medial and lateral aspects of the cavity will be fused together, and flimsy fibroareolar connective tissue is seen

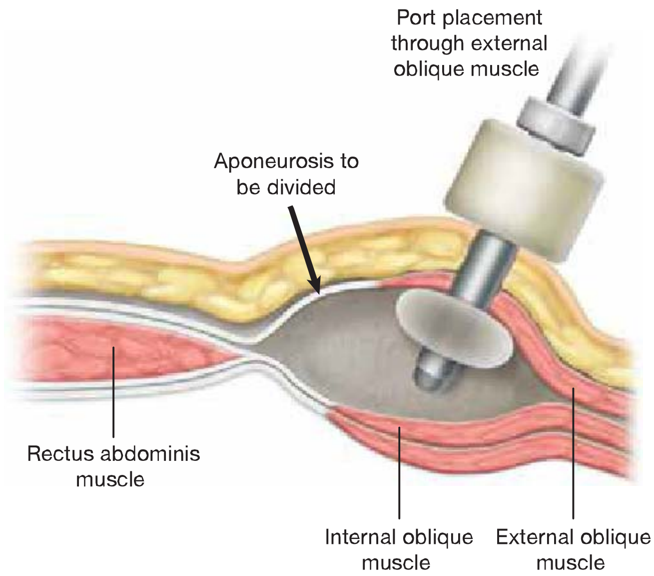


**Figure 33.3** Abdominal wall in cross-section after creation of the space between the oblique muscles.

along these attachments. The medial boundary represents the lateral border of the rectus sheath.

- Two 5 mm transverse incisions are then made inferior to the initial access site. These should be evenly spaced in the craniocaudad direction. The additional port sites should be lateral enough to allow for instrument and scope manipulation.

*Release of External Oblique Aponeurosis:*

- The division of the external oblique aponeurosis is usually associated with minimal bleeding as the plane is avascular. Laparoscopic Metzenbaum scissors are adequate in most circumstances except when nearby subcutaneous and muscular blood vessels are injured. We encourage the use of monopolar cautery to supplement the shears or a 5 mm energy source such as an ultrasonic coagulator if needed (Fig. 33.4).
- The instrument used to divide the aponeurosis will be placed through the middle port, and the scope will be placed through the ports in the upper and lower quadrants (Fig. 33.1).
- The aponeurotic division should begin almost directly medial to the middle port, approximately 5 to 10 mm lateral to the rectus-external oblique junction. The incision is continued vertically and parallel to this junction all the way to the inguinal ligament inferiorly and superior to the costal margin at the superior border of the dissection (Fig. 33.1). It is common to view and divide muscle fibers above the costal margin. The internal oblique/transversus abdominis/rectus abdominis unit will visibly “release” medially as the aponeurosis is divided. You should immediately see subcutaneous fat above the fascia.
- Once the aponeurosis is divided, gentle dissection of the connective tissue in the subcutaneous space should be performed to gain significant additional mobility.
- The ports are then removed under direct vision, the carbon dioxide is allowed to escape, and the skin incisions are closed.

*Hernia Repair:*

- BECS improves options for hernia repair, especially in complex abdominal wall reconstructions. This is best employed when midline tissue is missing, when there is loss of domain, or when the midline tissue needs to be excised, as in cases with infected mesh or an enterocutaneous fistula.
- The order of repair and BECS is variable. The hernia repair can be the first step with plans to proceed with the component separation if the midline cannot be brought together. Once adequate release is achieved, then finish with closure of abdominal wall. This is how the open component separation is typically performed.

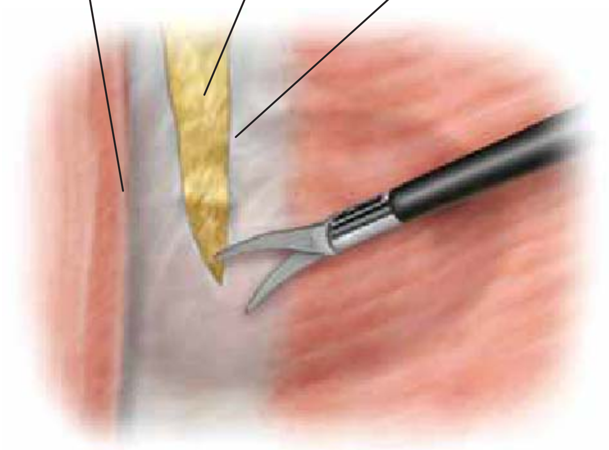


**Figure 33.4** Dividing the external oblique aponerosis (laparoscopic view).

- To minimize the amount of time that the midline wound is open, the better approach is to perform the component separation first and follow with the open hernia repair. The only disadvantage to this approach is in the circumstance when less mobilization would have been adequate. Fortunately, preoperative CT scanning can help to determine this accurately.

## POSTOPERATIVE MANAGEMENT

- Standard postoperative instructions after ventral hernia repair should be given to the patient, including avoidance of strenuous activity and heavy lifting for a significant period of time to allow the repair to heal.
- Binders are often utilized, but if too tight they can create ischemic edges of skin flaps.

## COMPLICATIONS

- If the wrong plane is accessed, the surgeon has likely dissected too deeply and has traversed the internal oblique or transversalis muscle. One should try repeating the access incision more laterally and spread through the external oblique with a blunt instrument or S-retractors to identify the shiny white aponeurosis of the internal oblique. Inability to determine the potential space between the internal and the external oblique can be exacerbated by prior surgical adhesions.
- Restoring abdominal wall integrity may increase intraabdominal pressure significantly and cause abdominal compartment syndrome in rare cases. If there are any signs of intraabdominal hypertension, confirm with the anesthesia team that peak inspiratory pressures or plateau pressures have not increased significantly. Also be aware of additional signs of abdominal compartment syndrome, such as oliguria and hypotension.

## RESULTS

- Rosen demonstrated in a porcine model that BECS results in approximately 86% of the total length of mobilization when compared to the open component separation.

Although these results fall short of the open release, numerous studies show dramatic reduction in wound complications, usually reducing the risk by half.

- In a study of single stage treatment of infected abdominal wall prosthetic graft removal, there were low wound complication rates and short lengths of stay. In this small retrospective review, laparoscopic component separation mean operating time was 52 minutes. Total operative time, including complete open excision of infected mesh was 185 minutes. Additionally, the average size of the defect after mesh excision was 338 $cm^2$. Out of 7 patients, there was one midline wound infection that did not spread into the lateral laparoscopic compartments and one hematoma at the site of the lateral component separation. No bulges or hernias at the midline or site of component separation at an average 4.5 months follow-up.

## CONCLUSIONS

- The original "separation of components" as described by Ramirez has become the standard of care for the treatment of complex abdominal wall hernias despite its limitations. Recent studies suggest that BECS can match its open counterpart physiologically, with similar recurrence rates, and anatomically, with the ability to repair similarly sized hernias; albeit, with reduced local wound complications. This novel approach is technically challenging yet familiar for the laparoscopic surgeon with a set of instruments, ports and balloons common to other laparoscopic cases. Described step-by-step in this text is one systematic approach to performing endoscopic component separation.

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# 34 Suprapubic Hernia

**John T. Paige**

## INDICATIONS/CONTRAINDICATIONS

The term "suprapubic" hernia was first defined by el Mairy and refers to an abdominal wall defect arising within 4 cm of the symphysis pubis. Also known as "parapubic" hernias, the repair of suprapubic hernias are a technical challenge due to their close proximity to bone, nerves, and blood vessels in the pelvis. Suprapubic hernias are a subset of incisional hernias, often developing after gynecologic, urologic, and general surgical procedures in which division of the lower abdominal wall fascia near the symphysis pubis is required for adequate exposure. Fortunately, they are relatively infrequent. The incisional hernia rate in patients undergoing a low transverse Pfannenstiel incision only ranges from 0.04% to 2.1%. Even among centers specializing in the laparoscopic repair of suprapubic hernias, their rates range from 11.6% to 32.8% of the total number of incisional hernias encountered. Such facts, however, emphasize the difficulty in treating enough of these hernias to develop expertise in their repair.

Suprapubic hernias develop as a result of disruption of the musculotendinous insertion of the abdominal oblique aponeurosis, rectus abdominis musculature, and rectus sheath into the symphysis pubis (Figs. 34.1 and 34.2). Typically, these defects form secondary to inadequate purchase of tissue during closure of a low midline incision near the symphysis pubis. The resultant midline deformity can then extend laterally along the pubis. Thus, repair is indicated in the presence of a defect, especially if the patient is symptomatic (see Preoperative Planning).

Minimally invasive repair is the preferred therapy for suprapubic hernias. First described by Hirasa et al. in 2001, it has been refined over the decade. Contraindications to suprapubic hernia, therefore, are the same as those for any laparoscopic incisional hernia. Severe chronic obstructive pulmonary disease, uncorrectable bleeding dyscrasia or coagulopathy, and frozen abdomen are some examples of conditions that might preclude a successful laparoscopic approach.

## PREOPERATIVE PLANNING

The first step in preoperative planning is to obtain a thorough history and physical examination. Patients presenting with suprapubic hernias can complain of symptoms similar to those found in the presence of inguinal hernias. Pain, heaviness, or a dragging sensation may be present in the suprapubic region with or without abdominal wall

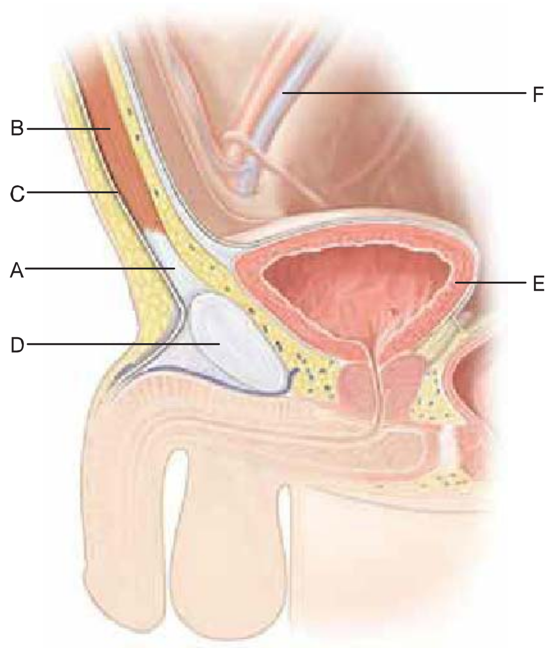


**Figure 34.1** Anatomy. Suprapubic hernias develop at the level of the musculotendinous insertion of the abdominal oblique aponeurosis **(A)**, rectus abdominis musculature **(B)**, and rectus sheath **(C)** to the symphysis pubis **(D)**. In this region (i.e., within 4 cm of the symphysis pubis), they are in close proximity to important structures within the pelvis such as the bladder **(E)**, external iliac vessels **(F)**, and nerves of the lower extremity.

bulging. An antecedent history of prior lower abdominal surgery is invariably present and can be confirmed on physical examination by the presence of low midline, Pfannenstiel, Maylard, or Cherney incisions (Tables 34.1 and 34.2). Often, patients have had multiple abdominopelvic procedures, and, hence, a careful determination of prior operations is essential. Additionally, review of operative notes related to prior incisional hernia repairs is recommended in order to determine the presence, location, and type of any mesh used. Review of co-morbid conditions, especially those that might preclude a minimally invasive approach (see Indications/Contraindications), is also important.

Physical examination should emphasize delineation of the size, extent, and borders of the hernia defect. In certain patients, such as those who are obese, such determination can be a challenge. Computed tomography (CT) of the abdomen and pelvis is useful in such circumstances, since it can give information related to the relation of the inferior edge of the hernia to the symphysis pubis. Additionally, it can lend insight into hernia size and its exact contents. CT is also recommended in patients who have mesh present from a prior incisional hernia repair, since it helps identify its location in

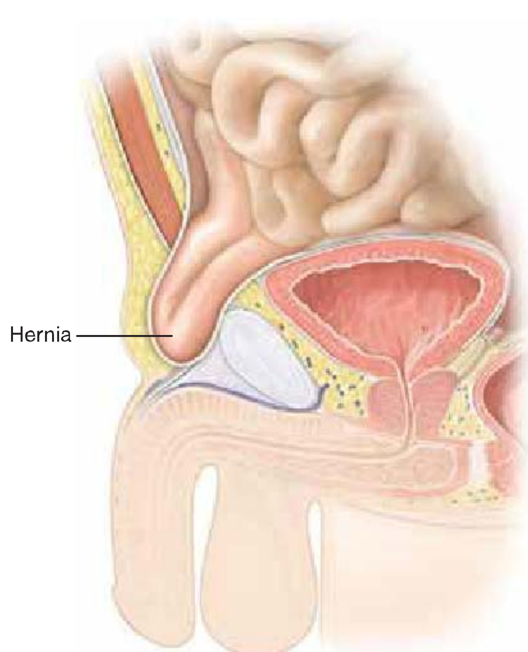


**Figure 34.2** Pathophysiology. With disruption of the musculotendinous insertion of the lower abdominal wall muscles near the symphysis pubis, herniation of intraabdominal and pelvic contents occurs.

**TABLE 34.1 Type of Previous Surgery in Patients Presenting with Suprapubic Hernia**

| Type of Surgery | Sharma et al. ($n = 72$) | Varnell et al. ($n = 47$) |
|---|---|---|
| Gynecologic | 40 Patients (55.6%) | 42 Procedures[a] |
| Gastrointestinal | 24 Patients (33.3%) | 53 Procedures[a] |
| Urologic | 3 Patients (4.2 %) | 8 Procedures[a] |
| Herniorrhaphy | 5 patients (6.9%) | 27 Patients (57%) |

[a]Total number of procedures among 47 patients.

relation to the current defect. Ultrasonography has been employed as well to help determine the size of suprapubic defects. Finally, appropriate preoperative laboratory analysis and medical/cardiac clearance is undertaken based on patient condition, risk factors, and co-morbidities.

## SURGERY

Although open tension-free repair using mesh coverage has been described, current therapy for suprapubic hernias involve a minimally invasive approach similar to that used for other anterior abdominal wall incisional hernia repairs. This approach is based on the principles of the open retro-rectus tension-free repairs using wide mesh coverage developed by both Rives and Stoppa. Key components include adequate circumferential dissection of the hernia defect with proper underlay mesh placement and fixation to ensure a 4 to 5 cm overlap of the hernia defect in all directions. A step-by-step description of the laparoscopic technique follows.

### Patient Positioning and Preparation

The patient is placed in the supine position on the operative table (Fig. 34.3). Sequential compression devices are placed on the bilateral lower extremities. Following induction of general anesthesia and secure placement of an endotracheal tube, an orogastric tube is placed. In addition, a triple lumen Foley catheter is inserted into the bladder to assist with dissection in the suprapubic region (see Dissection). Both arms are tucked and padded unless precluded by the patient's body habitus. In obese patients, additional padding is required to elevate the tucked arm to avoid traction on the brachial plexus. Monitors are positioned at the foot of the bed. Often, a single one is sufficient. With arms tucked, the assistant can position him/herself opposite or alongside the surgeon for the procedure. On the basis of port placement, the surgeon can position him/herself on either side of the operating room table (see Port Placement). The pubis hair is clipped to assist with access to this region, and surgical preparation is undertaken from the nipples to the mid-thighs and lateral to the table on both sides using chlorhexidine except for the genitalia for which a betadine scrub is used. An iodine-impregnated drape can also be applied to the abdomen for added antimicrobial effect. Prophylactic antibiotics are administered prior to incision.

### Access

Abdominal access is typically obtained above the umbilicus in a location away from prior incisions. A Veress needle is placed in the left hypochondrium. with creation

**TABLE 34.2 Scar Location in Patients Presenting with Suprapubic Hernia**

| Scar Location | Palanivelu et al. ($n = 17$) | Sharma et al. ($n = 72$) | Ferrari et al. ($n = 18$) |
|---|---|---|---|
| Lower midline | 12 (70.6%) | 16 (22.2%) | 13 (72.2%) |
| Pfannenstiel | 5 (29.4%) | 41 (56.9%) | 5 (27.8%) |
| Paramedian | N/A | 7 (9.7%) | N/A |
| Multiple | N/A | 8 (11.1%) | N/A |

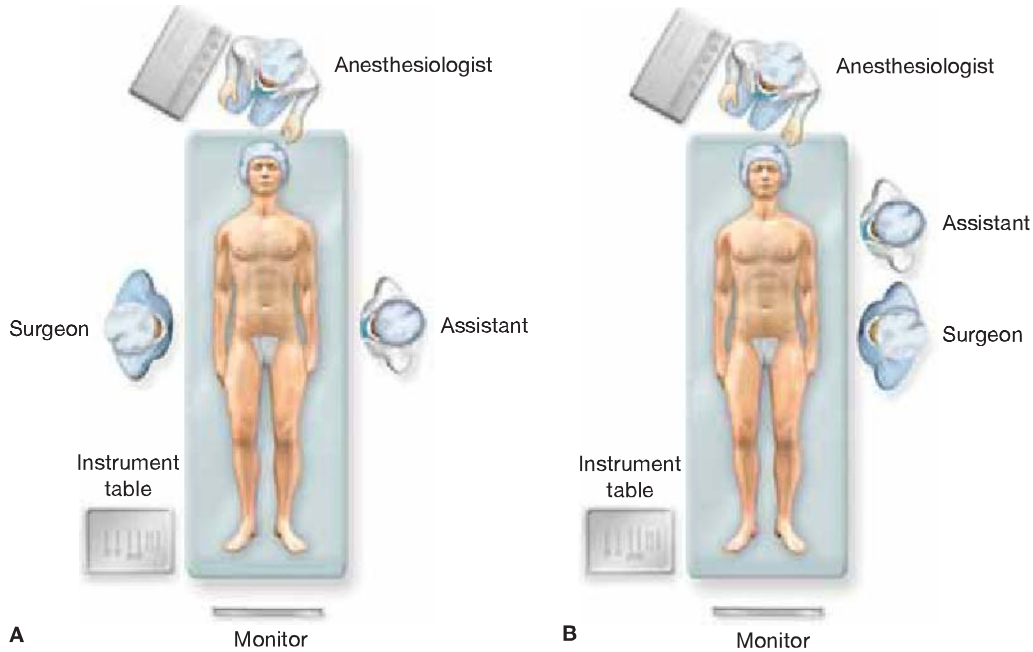


**Figure 34.3** Patient Positioning. The patient is placed in the supine with arms tucked. In this manner, the operative surgeon can position him or herself on either the right (A) or left (B) side of the table with the assistant opposite (A) or alongside (B) him or her.

of pneumoperitoneum after verification of its location with syringe aspiration and gravity testing using a column of saline. Pneumoperitoneum is established to approximately 15 mm Hg pressure. Next, a 5 or 12 mm bladeless trocar is introduced into the abdominal cavity using a zero-degree laparoscope for direct visualization. Alternatively, the abdomen can be entered via an open cutdown technique with direct placement of a 10 or 12 mm trocar. It should be placed away from prior incision sites if possible.

## Port Placement

Port placement is determined based on defect size, scar location, and extent of adhesions. In principle, each port should be placed as far as possible from the defect and should be at least a hand breadth apart from other port locations. In addition, triangulation of the hand ports with the camera port should be sought in order to assist with ease of operation. For example, in the case of a midline incision, ports can be shifted to the left lateral abdominal wall. The surgeon would then operate from the left side of the table. All ports should be placed under direct visualization with care being taken to avoid intraabdominal injury. A minimum of three ports is required of which two can be 5 mm in size. At least one should be 10 to 12 mm in size to assist with the introduction of mesh into the abdomen (see Mesh Placement). Fig. 34.4 demonstrates several examples of port placement.

## Dissection

Following port placement, adhesiolysis is performed. Care should be taken to avoid hollow viscus injury, and sharp dissection is preferred to prevent inadvertent thermal injury to structures. The contents of the hernia sac should be completely reduced in order to determine the size and extent of the defect. Often, the bladder can be among the herniated contents. Consequently, care must be taken when dissecting the inferior portion of the defect to avoid its injury. Its visualization may be assisted with inflation of the bladder at this point. Adhesiolysis is aided through the use of an angled laparoscope. Additionally, placement of the patient in Trendelenburg position can assist with

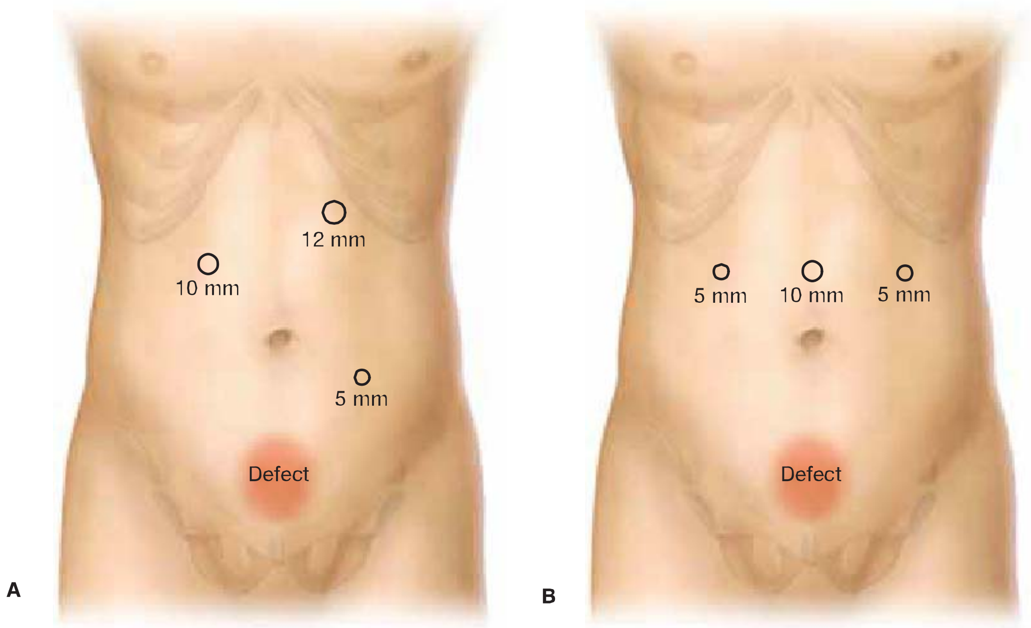


**Figure 34.4** Trocar placement. Trocars should be placed as far from the defect as possible, keeping triangulation, and should be at least one hand breadth apart from one another. A and B demonstrate two possible trocar placement arrangements for a suprapubic hernia repair.

visualization of the defect in the pelvis. Upon reduction of sac contents, the distance of the inferior defect to the symphysis pubis should be measured to determine if it is within 4 cm. If this is the case, the presence of a suprapubic hernia is confirmed, and dissection of the space of Retzius is required.

To dissect the space of Retzius, the bladder is inflated with 300 to 400 mL of saline in order to assist with identification of the plane between it and adherent structures. A peritoneal flap is raised by grasping the median umbilical ligament just superior to the level of the hernia defect and dividing the peritoneum. This division is extended laterally on either side using cautery to allow adequate placement of mesh with a 4 to 5 cm overlap. The flap is then dissected inferiorly using blunt dissection to expose the symphysis pubis, Cooper's ligament, and the iliac vessels bilaterally in a manner similar to a transabdominal preperitoneal (TAPP) approach for laparoscopic inguinal hernia repair. In this manner, the bladder is mobilized away from the pubic bones (Fig. 34.5).

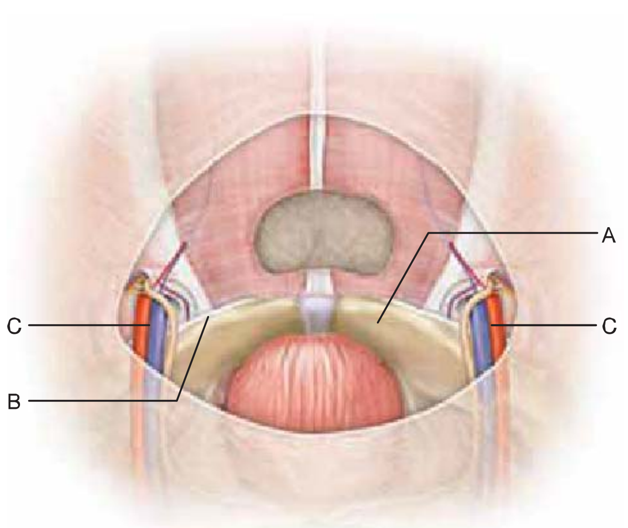


**Figure 34.5** Dissection of space of Retzius. A preperitoneal flap is created just above the level of the bladder and the space of Retzius is dissected, mobilizing the bladder inferiorly and exposing the pubic bone (A), Cooper's ligaments (B), and the Iliac vessels (C).

Once the space of Retzius has been dissected, circumferential dissection of the defect is completed. The defect is then measured intracorporeally at its greatest longitudinal and transverse locations using two 3.5 inch, 20 G needles and a tape measure. Extracorporeal measurement can also be undertaken by reducing the pneumoperitoneum to 6 mm Hg to confirm internal measurements. Once the defect size has been determined, any additional dissection is undertaken to ensure at least a 4 cm overlap of mesh from the edge of the defect circumferentially.

## Mesh Placement

Following measurement of the hernia defect and completion of dissection, mesh is obtained and trimmed to size in order to ensure at least a 4 cm overlap from the edge of the defect circumferentially. The mesh should consist of a dual layer of expanded polytetrafluoroethylene (ePTFE) (e.g. DualMesh, W.L. Gore and Associates Inc, Newark, Delaware) or a composite compound using polypropylene (e.g., Proceed, Johnson & Johnson, Cincinnati, Ohio) or polyester (e.g., Parietex, Covidien, Dublin, Ireland). In this manner, adhesiogenesis with intraabdominal contents is reduced. When placed, the adhesiogenic component of the mesh (e.g., the polypropylene/polyester) should be in contact with the anterior abdominal wall.

The mesh is oriented with markings and four cardinal sutures are placed using ePTFE or monofilament permanent suture (Fig. 34.6). The superior and lateral sutures should consist of a 1 cm bite and should be located approximately 1 cm from the edge of the mesh. The inferior suture should be at least 2 cm from the edge of the mesh, since the mesh will cover the pubic bone in this direction. Hence, the suture should be placed to allow for its placement at the superior level of the symphysis pubis.

Once the cardinal sutures are placed, the mesh is rolled and placed through the largest port into the abdomen. This maneuver is often assisted by placing a 5 mm port opposite the port through which the mesh is to be introduced and threading a grasper through the mesh introduction port across the abdomen. The mesh is then grasped and brought into the abdomen in a twisting motion to ease with its transfer into the abdomen. Once the mesh is in the abdomen, it is unrolled and oriented appropriately.

At this point, the fascial edges of the defect can be closed if so desired using either intracorporeal sutures or transabdominal sutures via a suture passer. Such closure is thought to help with restoring abdominal domain, to aid in muscle function, and to decrease seroma formation. It is not, however, a required step.

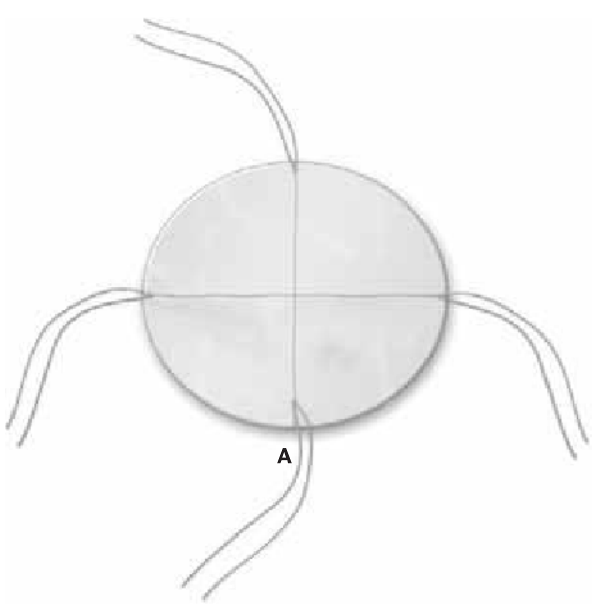


**Figure 34.6** Mesh preparation prior to insertion. The mesh is oriented and then four cardinal sutures are placed. Bites should be 1 cm in size and 1 cm from the edge of the mesh except for the inferior edge (A). The bite here should be placed far enough from the edge of the mesh (i.e., at least 2 cm) to ensure that it is at the superior level of symphysis pubis for transabdominal fixation.

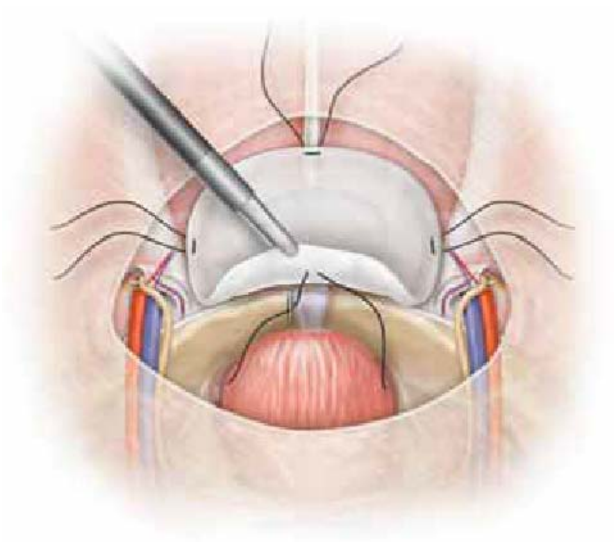

Figure 34.7 Initial positioning of mesh. Once the mesh is properly oriented within the abdomen, the most inferior transabdominal suture it placed, making sure that each limb of suture pierces the periosteum of the symphysis pubis.

## Mesh Fixation

Mesh fixation begins by bringing out the most inferior transabdominal suture to ensure adequate overlap over the pubic bone (Fig. 34.7). A suture passer is placed into the abdomen in such a manner that the periosteum of the pubic bone is punctured. One suture end is then grasped and brought out through the abdominal wall. A second pass is made with the suture passer through the periosteum of the pubic bone into the abdomen near the first pass and the other end of the suture is brought out. The suture limbs are then secured with a hemostat. The remaining three sutures are then brought out through the abdominal wall using the suture passer and secured in place when the mesh lies flat against the anterior abdominal wall (Fig. 34.8). The mesh is then fixated superiorly and laterally using spiral tacks at 1 to 2 cm intervals and placing transabdominal sutures at 4 to 6 cm intervals (Fig. 34.9).

Once the superolateral fixation is completed, attention is directed toward inferior fixation of the mesh. Further fixation to the pubic bone is obtained by placing additional transabdominal U-stitches that puncture the periosteum. These sutures are placed 2 cm from the initial midline suture. The inferior edge of the mesh is lifted to aid with placement of these sutures (Fig. 34.10). This placement is continued along the pubic bone as needed. A minimum of three sutures should be placed. The inferior sutures are then tied down, and spiral tacks are placed along the pubic bone and at Cooper's ligament

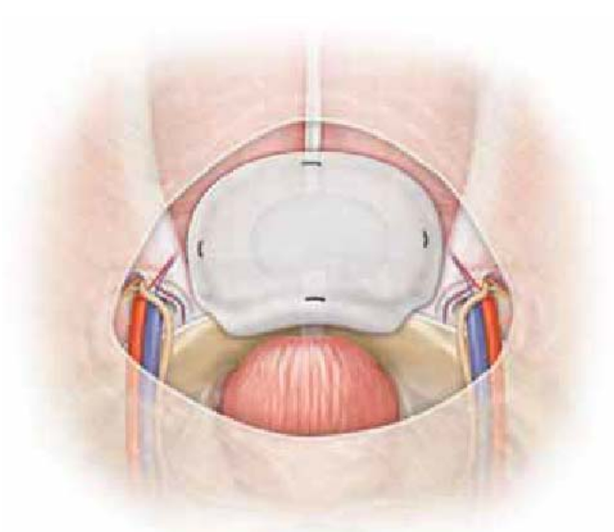

Figure 34.8 Initial positioning of mesh. The remaining three transabdominal sutures are brought out and secured to position the mesh flat against the abdominal wall.

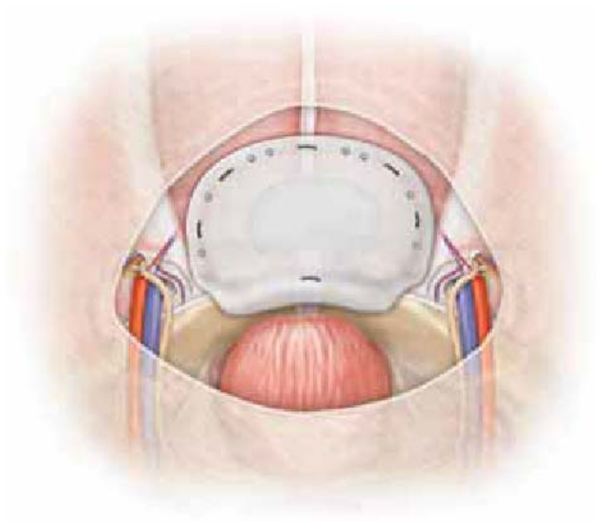

**Figure 34.9** Superolateral mesh fixation. The mesh is then fixed in the superior and lateral directions by placing spiral tacks at 1 to 2 cm intervals and transabdominal sutures at 4 to 6 cm intervals.

bilaterally (Fig. 34.11). Care must be taken to avoid injury to neurovascular structures during tacking of Cooper's ligament. An inner circumferential row of spiral tacks can then be placed to complete fixation. Inferiorly, this row should be above the pubic bone if space exists. Otherwise, it can be omitted.

Alternative fixation techniques exist. For example, only two sutures can be placed laterally before introducing the mesh into the abdomen. They are then brought through the abdominal wall and secured. Following this, spiral tacks are used to secure the mesh circumferentially to the abdominal wall. Inferiorly, they are used to secure the mesh to Cooper's ligaments. Transabdominal sutures are then placed through Hesselbach's triangle for further fixation of the inferior part of the mesh. Transabdominal sutures are then spaced every 4 to 6 cm around the mesh along the anterior abdominal wall.

Another alternative is to use bone fixators to secure the mesh to the pubic bone. Pneumoperitoneum is released after initial fixation of the mesh using transabdominal sutures and spiral tacks. An incision is made over the pubic bone and it is exposed. Titanium bone anchors are then placed after drilling holes into the bone using a 2.4 mm drill bit. Pneumoperitoneum is then re-established, and the suture passer is used to bring the suture ends attached to the anchor through the mesh as a U-stitch. The inferior edge is then secured to the pubic bone with spiral tacks.

The mesh can be properly centered by placing an initial suture in the center of the mesh and bringing this out through the center of the defect once the mesh is oriented in the abdomen. The center of the defect can be marked by transecting the halfway

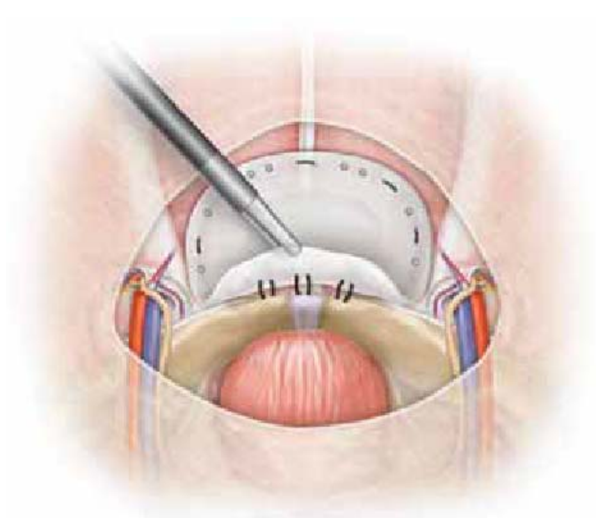

**Figure 34.10** Inferior mesh fixation. Transabdominal U-stitches are placed at the superior edge of the pubic bone piercing the periosteum. They are placed 2 cm from the initial inferior transabdominal suture on either side. Additional stitches are placed as needed in a similar fashion.

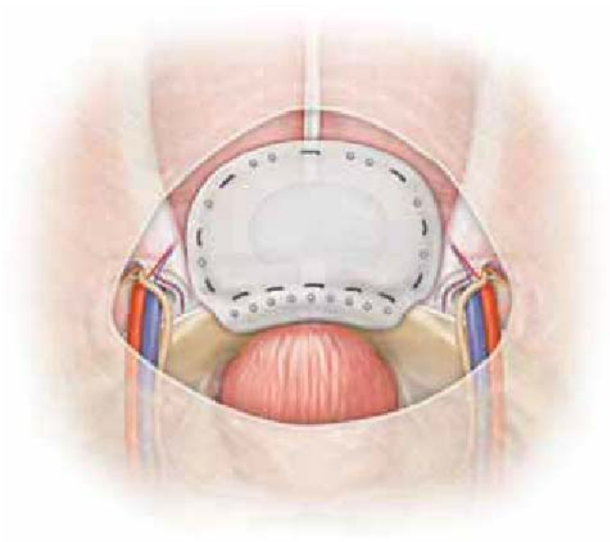

**Figure 34.11** Completion of mesh fixation. After the inferior transabdominal sutures have been placed and secured, the inferior edge of the mesh is fixed to the pubic bone and Cooper's ligaments bilaterally with spiral tacks. A second inner row of tacks can be placed at this time if desired.

point of the greatest longitudinal and transverse defect distances with a line. The center point of the defect is where these lines cross.

Finally, in the presence of very large defects, two overlapping meshes have been placed. They should overlap by 5 cm and be secured to one another. In these cases, a non-composite mesh can be placed inferiorly as long as the preperitoneal flap can be tacked over it completely at the end of the case.

### Closure

Upon completion of mesh fixation, the abdomen is inspected and hemostasis is confirmed. In the event of concern regarding a bladder injury, methylene blue dye can be instilled into the bladder to inspect for leak. Transfascial closure of all ports greater than 10 mm is performed using a suture passer and suture. Ports are then removed under direct visualization and the sites inspected for bleeding. Pneumoperitoneum is then released. The ports are irrigated and closed as well as the transabdominal suture stab incisions. Steristrips are then placed. Alternatively, a liquid skin adhesive can be used.

## POSTOPERATIVE MANAGEMENT

Upon completion of the case, the orogastric tube and Foley catheter are removed in the operating room, and the patient is extubated following emergence from anesthesia.

Alternatively, the Foley can be kept in place overnight if extensive dissection was needed or if the patient is at risk for retention. After recovery in the post anesthesia care unit, the patient can be transferred to the floor. Clear liquids are begun, and the diet is advanced as tolerated. The patient is encouraged to ambulate as soon as possible. Pain control with oral and intravenous agents is initiated. Patient controlled analgesia can be used, especially in more extensive cases. An abdominal binder is provided for comfort.

The patient can be discharged once tolerating a regular diet, urinating, passing flatus, ambulating, and afebrile. He/she should follow up within 2 weeks for an initial postoperative check. After this first visit, another within 2 months should occur. The patient can start resuming regular activity approximately 4 weeks postoperatively.

## COMPLICATIONS

Common intra-operative complications include bleeding, bladder injury, and bowel injury. The omentum, accessory obturator artery, and inferior epigastric artery have all been reported as sources of significant intra-operative bleeding. As mentioned above,

**TABLE 34.3 Patient Demographics, Defect Size, Mesh Size, Operative Time, and Length of Stay for Selected Series of Laparoscopic Suprapubic Hernia Repairs**

| Category | Carbonell et al. ($n = 36$) | Varnell et al. ($n = 47$) | Palanivelu et al. ($n = 17$) | Sharma et al. ($n = 72$) |
|---|---|---|---|---|
| Male/female (*n*) | 10/26 | 18/29 | 5/12 | 18/54 |
| Mean age, y | 55.9 | 54 | 55.9 | 48.8 |
| (range) | (33–76) | (28–84) | (23–76) | (27–69) |
| Mean BMI, kg/m$^2$ | 31 | 35.1 | 30 | 31.3 |
| (range) | (22–67) | (SD = 7.5) | (25–35) | (20.2–41.5) |
| Mean defect size, cm$^2$ | 191.4 | 139.8 | 87.5 | 5.2 cm[a] |
| (range) | (20–768) | (SD = 126) | (6–169) | (3.1–7.3 cm)[a] |
| Mean mesh size, cm$^2$ | 481.4 | 453.8 | 234 | 328.8 |
| (range) | (193–1,428) | (SD = 329) | (144–324) | (225–506) |
| Mean operative time, min (range) | 178.7<br>(95–290) | 130<br>(50–270) | 95<br>(65–125) | 116<br>(64–170) |
| Conversion rate, *n* (percentage) | 1<br>(2.8%) | 1<br>(2.1%) | 1<br>(5.9%) | 0<br>(0%) |
| Mean length of stay, days (range) | 2.4<br>(1–7) | 3[b]<br>(1–20) | 1.5<br>(1–2) | 2.2<br>(1–6) |

[a]Mean largest hernial diameter measured intraperitoneally.
[b]Median value.

bladder herniation within the sac is common, and care must be taken to avoid injury when dissecting the inferior aspect of the defect. If an enterotomy occurs, repair of the injury should be undertaken. The procedure should then be aborted, since mesh placement at that time is precluded. Delayed/staged repair can then be undertaken.

Reported early postoperative complications include deep vein thrombosis, pulmonary embolism, pneumonia, ileus, urinary retention, urinary tract infection, trocar site cellulitis, skin necrosis, C. difficile colitis, thigh numbness, renal insufficiency, cardiac arrhythmia, and delayed recognition of enterotomy. Other potential early complications include postoperative hemorrhage, mesh migration/failure, and osteitis.

Commonly reported late complications of laparoscopic suprapubic hernia repair include chronic seroma and chronic pain (i.e., pain lasting longer than 6 weeks). Seromas lasting longer than 6 weeks may require aspiration for resolution. Pain often is associated with the transabdominal sutures, and local anesthetic injection of bothersome sites can be effective at stopping it. Additionally, small bowel obstruction, port site herniation, and tack erosion into the bladder have all been reported. Finally, hernia recurrence can also occur.

## RESULTS

Table 34.3 lists results related to published data for laparoscopic repair of suprapubic hernias. In general, patients presenting with suprapubic hernias in these series tended to be female, older, and obese. Mean mesh length ranged from 15.3 cm to 21.9 cm, based on square root of the reported mean mesh area required to cover defects. Mean operative times remained under 3 hours and conversion rates were less than 6%. Finally, length of stay averaged between 2 to 3 days.

Jenkins et al. have demonstrated that the presence of a suprapubic hernia does increase the difficulty of performing a laparoscopic ventral hernia repair, adding approximately a quarter hour of extra operating time (Table 34.4). The longer time for adhesiolysis

**TABLE 34.4 Estimated Increased Operative Time Caused by Presence of Suprapubic Hernia**

| Step | Mean Increased Operative time (min, s) |
|---|---|
| Adhesiolysis | 10 min, 28.4 s |
| Mesh placement | 6 min, 39.1 s |
| Total operative time | 14 min, 44.4 s |

**TABLE 34.5 Morbidity and Recurrence Rates Following Laparoscopic Suprapubic Hernia Repair**

| Author | Morbidity, *n* (%) | Recurrence, *n* (%) |
|---|---|---|
| Carbonell et al. (*n* = 36) | 6 (16.6%) | 2 (5.5%) |
| Varnell et al. (*n* = 47) | 18 (38.2%) | 3 (6.3%) |
| Palanivelu et al. (*n* = 17) | 5 (29.4%) | 1 (5.9%) |
| Sharma et al. (*n* = 72) | 20 (27.8%) | 0 (0%) |
| Hirasa et al. (*n* = 7) | N/A | 1 (14.2%) |
| Ferrari et al. (*n* = 18) | N/A | 2 (11%) |

caused by the presence of a suprapubic defect likely results from the extra attention to dissection around the bladder which is often a component of the hernia sac contents. The increased time for mesh placement during suprapubic hernia repair is likely due to the difficulty of working around structures in the pelvis.

Table 34.5 lists published results related to morbidity and recurrence rates associated with laparoscopic suprapubic hernia repairs. Although morbidity does occur and can be high, none of the listed reports had a mortality related to repair. Furthermore, recurrence rates remain low, especially if series in which repairs employing only spiral tacks for mesh fixation are excluded. In this instance (i.e., when transabdominal sutures are employed), rates remain below 7%.

## CONCLUSIONS

Suprapubic hernias are a technical challenge to repair given their proximity to bony and neurovascular structures in the pelvis. Laparoscopic mesh repair has become the primary modality for their treatment. Key components of such a repair include reduction of the hernia sac with complete delineation of the defect, dissection of the space of Retzius after bladder inflation to expose the pubic bone, Cooper's ligament, and iliac vessels, circumferential underlay mesh placement over the defect with at least 4 cm overlap, combined transabdominal suture and spiral tack mesh fixation to the anterior abdominal wall, and inferior mesh fixation to the pubic bone and Cooper's ligament using a combination of transabdominal periosteal suture and spiral tack placement. Keeping these principles, morbidity is acceptable and recurrence rates remain low.

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# 35 Spigelian Hernia

**Eric G. Sheu, Douglas S. Smink, and David C. Brooks**

## INDICATIONS/CONTRAINDICATIONS

Spigelian hernias are rare abdominal wall hernias. Approximately, 1,000 cases have been reported in the literature, and their incidence is estimated to be <2% of all abdominal wall hernias. The hernia is named after Adriaan van der Spieghel, the Belgian anatomist who first described the semilunar line in 1645. It was, however, a Flemish anatomist Josef Klinkosch who identified the hernia in 1764 as a defect in the semilunar line and named it after van der Spieghel.

These hernias occur through the spigelian aponeurosis, which is composed of the aponeurosis of the transverse abdominal muscle that lies between the lateral edge of the rectus muscle and the linea semilunaris (Fig. 35.1). The spigelian aponeurosis extends both above and below the arcuate line of Douglas. However, the vast majority of spigelian hernias occur within the 6 cm segments of the aponeurosis that lie immediately cranial to the anterior superior iliac spine. In this so-called "spigelian belt," the lack of a posterior rectus sheath and the parallel orientation of the transversus and internal oblique aponeuroses predisposes the spigelian aponeurosis to the development of a hernia.

The external oblique fascia is often intact over the hernia, so that on physical examination, an abdominal wall bulge or defect can often not be detected (Fig. 35.2). Because of the difficulty of physical examination, patients presenting with symptomatic hernias are often misdiagnosed—for example, symptoms of a left-sided spigelian hernia can be mistaken for diverticulitis. Ultrasound can identify the defect in the semilunar line or the hernia sac itself. CT is the current gold standard of imaging diagnosis and can characterize the hernia defect and contents (Fig. 35.3). However, CT is not a 100% sensitive—six false negative CT scans (out of 19) were reported in a case series using older generation CT scanners. It is generally felt that modern high resolution CT scanners have higher sensitivity, but no published data on the topic exists.

A high proportion of patients with spigelian hernias will present with incarceration. Given this fact, all diagnosed spigelian hernias should undergo operative repair. Contraindications are identical to those for any intraabdominal operation and are not specific to spigelian hernia repair: For example, recent MI, severe coagulopathy, and other medical co-morbidities prohibiting a general anesthetic.

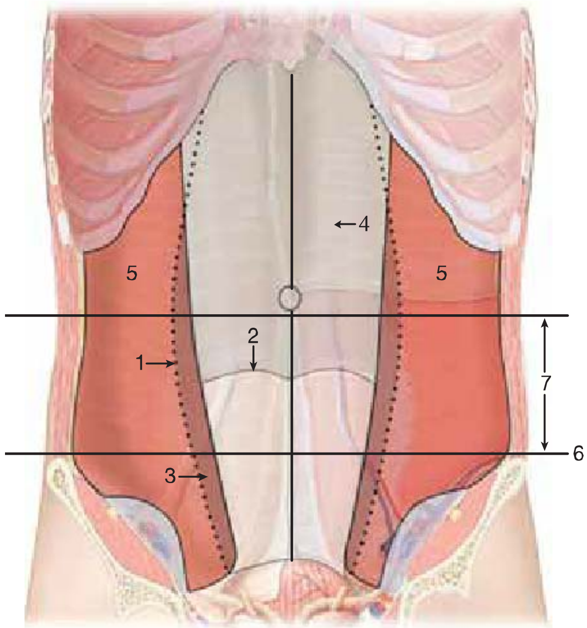



**Figure 35.1 Posterior view of the abdominal wall.** (*1*) Semilunar line of Spiegel. (*2*) Semicircular line of Douglas. (*3*) Spigelian aponeurosis. (*4*) Posterior rectus sheath. (*5*) Transversus abdominis muscle. (*6*) Interspinal line connecting the anterior superior iliac spines, forming the caudal border of the (*7*) spigelian belt, where majority of spigelian hernias occur within the spigelian aponeurosis.

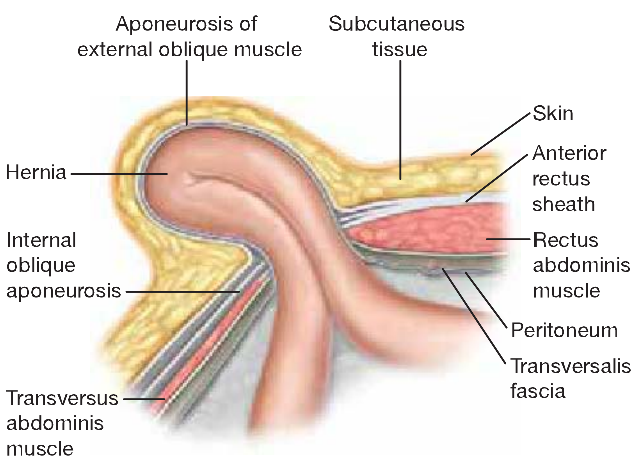



**Figure 35.2 Spigelian hernia and abdominal wall layers.** Cross-sectional representation of typical spigelian hernia, which occurs through the spigelian aponeurosis (confluence of internal oblique and transversus abdominis, as shown) at the lateral border of the rectus sheath. However, the external oblique aponeurosis is often intact over the hernia, obscuring physical examination.


**Figure 35.3 CT scan of spigelian hernia.** Representative CT scan of the abdomen demonstrating a left-sided spigelian hernia containing sigmoid colon.

## PREOPERATIVE PLANNING

Preoperative evaluation focuses on diagnosing and characterizing the hernia and determining the optimal operative approach for repair. Spigelian hernias are well suited for laparoscopic repair, either via a transabdominal intraperitoneal approach or a total extraperitoneal approach (TEP).

Limited data is available to truly support the superiority of one approach over the other. Some reports have suggested that TEP repair results in shorter hospital stays and improved pain control. The TEP approach retains the mechanical advantage of an underlay repair, where increased abdominal pressure serves to promote mesh adherence to the abdominal wall but avoids the potential complications associated with intraperitoneal mesh. We therefore recommend the total extraperitoneal laparoscopic approach for elective repair of spigelian hernias.

Laparoscopic transabdominal repair is indicated when intraperitoneal pathology requires concomitant evaluation or intervention. Open repair should be considered in the emergency setting, in the presence of cardiopulmonary disease contraindicating laparoscopy, or in the cases of large, incarcerated hernias.

## SURGERY

### Open Repair

The patient is placed in the supine position with arms extended. An incision is made overlying the hernia and carried down to the external oblique. The external oblique fascia is divided in the direction of the fibers, and the hernia sac is identified (Fig. 35.4). The hernia sac is dissected down to edges of the fascial defect, the contents are reduced, and the sac itself is either reduced or ligated and divided. Once the boundaries of the hernia are defined, an appropriate size mesh is selected and fixed within the extraperitoneal space with non-absorbable sutures. The transversus abdominis may be closed primarily over the mesh if this can be accomplished without tension. The external oblique is re-approximated, and the skin and soft tissue are closed in layers.

### Intraperitoneal Laparoscopic Repair

The patient is positioned in the supine position. The arm contralateral to the hernia is tucked. Laparoscopic screens should be positioned directly across from the surgeon (Fig. 35.5). A Veress needle is placed in the umbilicus or left upper quadrant and used to create pneumoperitoneum. One 10 to 12 mm and two 5 mm ports are placed laterally across from the hernia defect, to facility visualization and optimize triangulation (Fig. 35.5). At least one 10 mm port is required to allow introduction of the mesh. Alternatively, a midline 10 mm port may be placed using an open cut-down method, and 2 to 3 other working ports then placed laterally.

Laparoscopic exploration of the abdomen is performed, and the hernia examined. The contents of the hernia are bluntly reduced using atraumatic graspers. External pressure on the abdominal wall can facilitate reduction of contents. The hernia sac is reduced and any remaining can be excised (Fig. 35.6). A bipolar, vessel-sealing device or ultrasonic scalpel is useful for this dissection.

The edges of the defect are defined and measured externally and, if desired, internally, after reducing abdominal insufflation pressure. Marking the abdominal wall at locations for planned transfascial sutures is helpful. If the hernia defect is small, the hernia defect can be primarily suture repaired using the transfascial needle passing device. Cauterizing the edges of the fascia is thought to promote scarring and incorporation of the mesh.

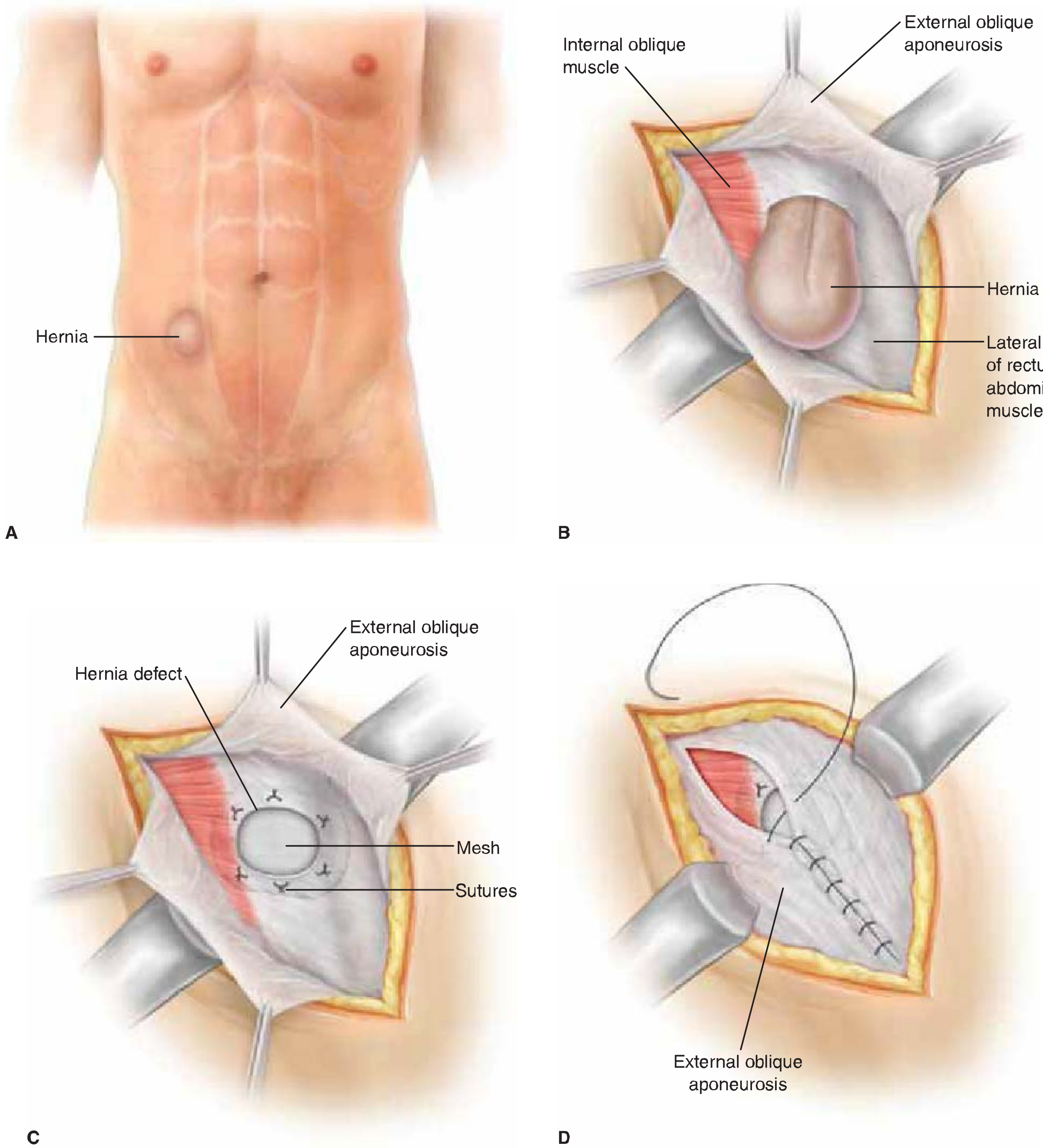



**Figure 35.4 Schematic representation of open spigelian hernia repair. A:** Typical location of spigelian hernia at the lateral border of the rectus, inferior to the umbilicus. **B:** Exposure of the hernia sac and fascial defect. The external oblique aponeurosis has been divided. **C:** After the hernia sac has been reduced and/or excised, an underlay mesh is placed to cover the hernia defect and secured in place with interrupted sutures. **D:** The external oblique aponeurosis is re-approximated to cover the hernia defect and mesh.

Next, an appropriately sized mesh is chosen to overlap the fascia edges of the hernia defect by 3 to 5 cm in all directions. For intraperitoneal placement, we prefer a composite mesh with a nonadherent or absorbable layer facing toward the visceral contents. Transfascial sutures are placed extracorporeally in the corners of the mesh and tied. The mesh is rolled and can be fixed using the "scroll technique" to facilitate intraabdominal orientation (Fig. 35.7, 35.8). The mesh is placed into the abdomen through the 10 mm port. The previously placed sutures are oriented, and the transfascial suture passing device is used to fixate the mesh at the previously marked locations,

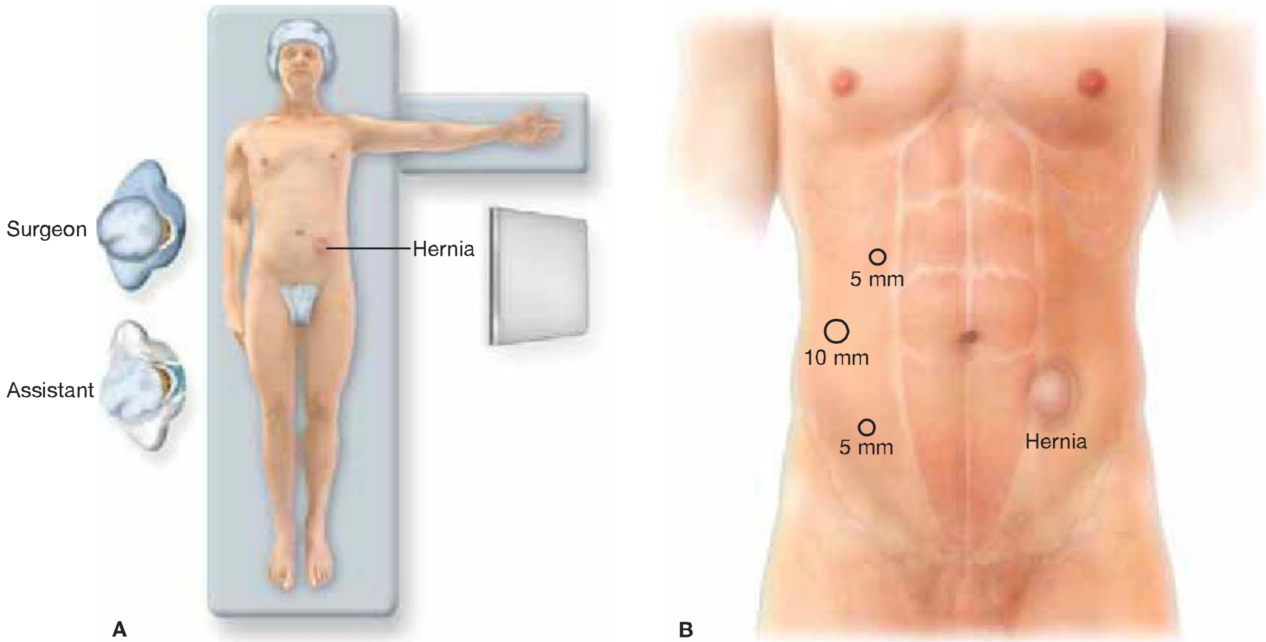



**Figure 35.5 Laparoscopic repair: Equipment and trocar placement. A:** The patient is placed in supine position. The contralateral arm is tucked to enable free movement of the surgeon and the assistant, who stand opposite to the hernia. **B:** Example of trocar placement. At least one 10 mm port is required to introduce the mesh. Placement of the working ports as far lateral facilitates securing the proximal side of the mesh.

first along the long axis of the mesh. The distal lateral scroll stitch is then cut, the mesh unfurled and fixated with the transfascial suture device, and the process repeated with the proximal mesh edge.

A laparoscopic tacking device is then used to secure the mesh to the abdominal wall at 1 cm intervals in two concentric rings ("double crown" technique). At the end of the fixation, the mesh should lie flush to the abdominal wall, with good overlap of the hernia defect. The edges of the mesh should not have any gaps through which abdominal viscera could herniate (Fig. 35.8). Pneumoperitoneum should be temporarily

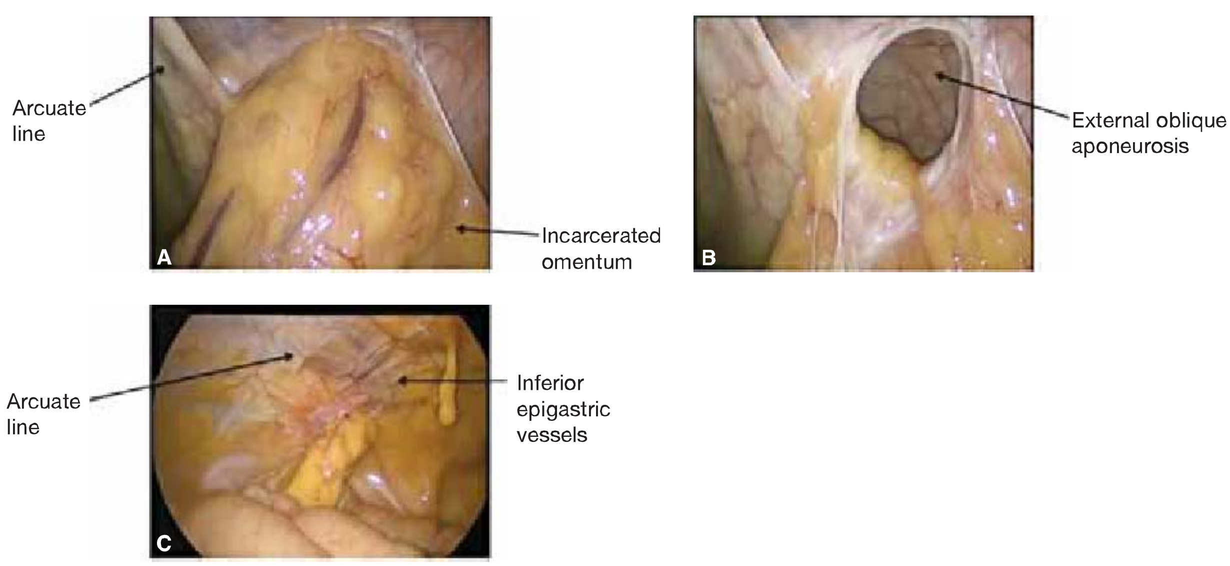



**Figure 35.6 Laparoscopic view of spigelian hernia and the anterior abdominal wall.** Intra-operative photos showing spigelian hernias from two separate patients, before (**A**) and after (**B**) reduction of incarcerated omentum. Both hernias lie inferior to the arcuate line, and the relationship of the defect to the inferior epigastric vessels (**C**) and the intact overlying external oblique aponeurosis (**B**) is clearly illustrated.

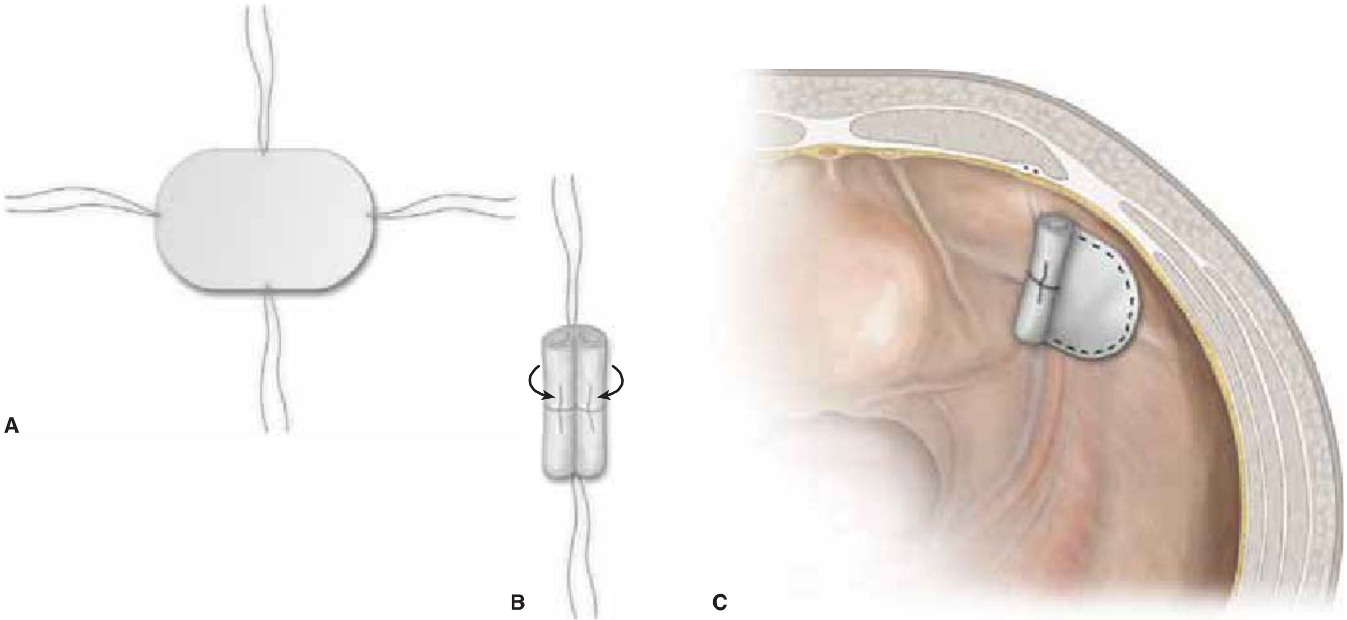


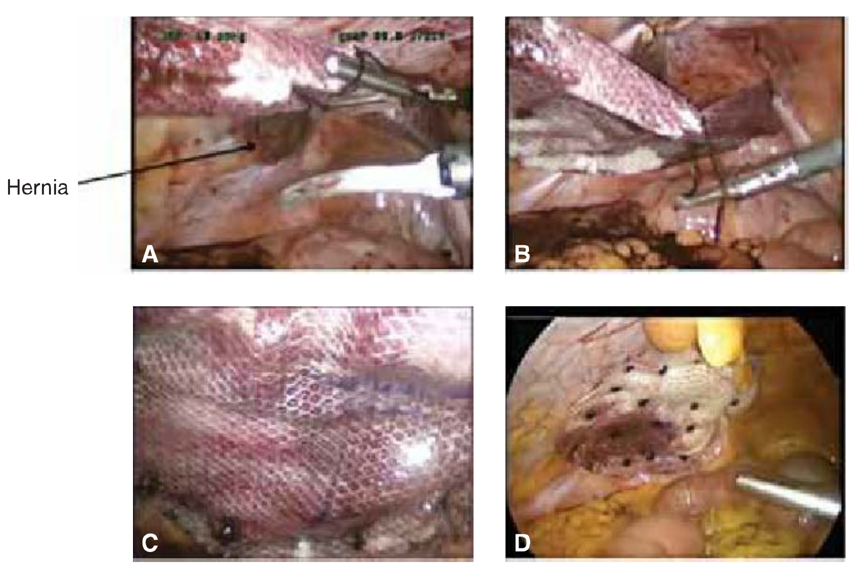

Figure 35.7 **Scroll technique for mesh placement. A**: Four sutures are placed and secured in each corner of the mesh. **B**: The mesh is scrolled in both directions, with two further sutures placed and tied loosely to hold the scroll in place. **C**: The cranial and caudal sutures are secured using the transfascial suturing device. The far scroll stitch is cut, the mesh unrolled, and the far lateral transfascial stitch is passed and tied. Finally, the near scroll is released and secured.

released to confirm adequate positioning and fixation of the mesh. Hemostasis is confirmed, and the laparoscopic trocars are removed under direct visualization.

## Extraperitoneal Laparoscopic Repair

Positioning is similar to the intraperitoneal laparoscopic approach. The patient should void preoperatively or a Foley catheter may be placed to empty the bladder. Access to the abdomen is made via a periumbilical incision, and the extraperitoneal space is accessed by dividing the anterior fascia, retracting the rectus muscle in the midline, and using the balloon dissector to develop the extraperitoneal space. Insufflation is achieved, and two further 5 mm trocars can be placed either in the midline or in the RLQ/LLQ to better facilitate triangulation toward the operative field. Further dissection

Figure 35.8 **Intra-operative photographs demonstrating stroll technique and final mesh placement.** The mesh is first secured with the cranial and caudal sutures (**A**), the far scroll stitch is cut and the mesh secured lateral to the hernia defect (**B**), and finally, the near scroll is released and secured to the abdominal wall. The mesh is further secured to the abdominal wall using laparoscopic tacking device to widely overlap the hernia defect (**C, D**).



is performed bluntly to expose the preperitoneal space, identify the hernia, and create enough space for the mesh to lie comfortably around the hernia.

The remainder of the operation proceeds as with the laparoscopic transabdominal approach. The hernia is identified and its contents reduced bluntly. Residual hernia sac can be left in place. If the defect is small, consideration is made for primarily suture closure of the hernia defect with the transfascial suture device. Alternatively, the size of the defect is measured, and a suitably sized piece of mesh to ensure overlap of the defect by 3 to 5 cm in all directions is selected.

With the extraperitoneal approach, the concern for visceral incarceration within the mesh is essentially eliminated. Therefore, we prefer to secure the mesh with a minimum of absorbable tacks, primarily to prevent migration of the mesh in the early postoperative period until mesh ingrowth and fibrosis can occur. Some surgeons do not routinely secure the mesh at all and instead confirm adequate positioning of the mesh by visualization while $CO_2$ insufflation is released.

## POSTOPERATIVE MANAGEMENT

In the absence of any significant bowel involvement or manipulation, diet can be advanced rapidly. Abdominal binders can reduce strain on the repair, improve pain control, and help prevent seroma formation. Many patients undergoing laparoscopic repair can be discharged the same day or after 24-hour observation. Patients undergoing open repair will more commonly require hospital admission for pain control. Heavy lifting or abdominal straining should be prohibited for at least 6 weeks.

## COMPLICATIONS

Significant complications following spigelian hernia repairs are uncommon. As with other hernia repairs, wound and mesh infections can occur, requiring antibiotics and uncommonly, mesh removal. Postoperative seromas are not uncommon and can usually be managed expectantly. Pain syndromes from entrapment or injury of nerves by mesh, sutures, or tacks can occur. Pain specialist consultation with local nerve blocks and analgesic injections can be helpful for management of this problem. Reoperation to remove mesh and/or tacks should be reserved for recalcitrant cases. Iatrogenic causation of a spigelian hernia due to trocar placement through the contralateral spigelian aponeurosis has been reported in the literature as a complication.

## RESULTS

Given the rarity of spigelian hernias, the majority of the literature consists of small case series or case reports. One of the larger case series of spigelian hernias comes from the Mayo clinic, which reviewed outcomes for 81 patients that underwent repair between 1976 and 1997. All but one of these patients underwent open repair, and the majority of repairs were performed using primary suture closure and no mesh (75/81). A low recurrence rate of 3.7% was found, with a mean 8-year follow-up. There were no recurrences noted in the five patients who underwent mesh repair.

One small ($n = 22$), non-blinded randomized trial comparing laparoscopic and open spigelian hernia repair has been published. This study found a significantly shorter length of stay after laparoscopic repair. Nearly all patients who underwent TEP repair were discharged the day of surgery; patients undergoing intraabdominal laparoscopic repair usually were discharged on the first postoperative day; and patients who underwent open repair stayed for an average of 5 days. They also found a significant decrease in morbidity after laparoscopic repair; although all morbidities in the open group consisted of hematomas that were managed non-operatively. Although follow-up was short, no hernia recurrences were documented in any of these patients.

Taken together, the published literature indicates that spigelian hernia repairs are durable and well-tolerated operations, both laparoscopic and open.

## CONCLUSIONS

Spigelian hernias are unusual hernias that require operative repair when detected. CT or ultrasound imaging is a useful adjunct in diagnosis as physical examination can be misleading. Spigelian hernias are well suited for laparoscopic repair, either through total extraperitoneal or intraperitoneal approach. Laparoscopic repair may offer improved pain control and shorter hospital stays. For large incarcerated hernias or emergent cases, open repair is indicated. Although published long-term data are limited, outcomes of spigelian hernia repair appear to be excellent with a low rate of recurrence.

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# 36 Update on Hiatal Hernia Repair

**Raul Rosenthal, Andre Teixeira, and Melissa Gianos**

## Introduction

### Definition

The classification of diaphragmatic hernias is distinguished by the position of the gastroesophageal junction. Type I, sliding hiatal hernia, is the most common type. The GE junction has migrated above the diaphragmatic hiatus. With a true paraesophageal hernia, Type II, the GE junction remains in anatomical position without migration. Type II constitutes a large hiatal defect, with herniation of a portion of the stomach through this defect. Type III is a combination of the sliding and paraesophageal hernia. The GE junction migrates into the mediastinum along with the paraesophageal component. The rarest of them all is Type IV, complex paraesophageal hernia, where there is intrathoracic migration of abdominal viscera in addition to the stomach.

## INDICATIONS/CONTRAINDICATIONS FOR SURGICAL REPAIR

Elective repair is based upon hernia type, symptomatology, and the potential complications caused by PEHs. Surgical repair is indicated in patients with reflux-induced damage, in those who are acutely symptomatic, and if risk of necrosis is present. Those patients who are asymptomatic at presentation should be monitored by follow-up radiographic examinations. However, younger asymptomatic patients fit for surgery may be considered surgical candidates due to their longer life expectancy and risk of future complications if left untreated. Contraindications include severe cardiopulmonary disease and risks of surgery outweighing benefits in the elderly population.

# PREOPERATIVE PLANNING

## Clinical Presentation

The majority of patients are symptomatic upon presentation. Symptom severity is not a predictor of hernia size and further workup is necessary. A minority of patients is asymptomatic upon incidental finding of the hernia.

The most common complaint is chest pain, either substernal or postprandial in nature, often suspected as cardiac in origin. Symptoms include heartburn, belching, regurgitation, dysphagia, nausea, and vomiting. Pulmonary symptoms are commonly present—dyspnea, wheezing, recurrent pneumonia, and aspiration due to chronic cough.

The symptoms experienced by patients with a PEH can be attributed to the volvulization of the stomach. The stomach has two anchoring points—the GE junction and the pylorus. As the stomach ascends into the mediastinum in the hernia sac, it rotates to the upside-down position. Compression of the distal esophagus by the distended stomach can cause dysphagia. The volvulized and distended body of the stomach can limit the lungs' capacity, causing shortness of breath. Laboratory findings of anemia are due to chronic blood loss from gastric erosions. The organoaxial (long axis of stomach) or mesenteroaxial (perpendicular to long axis) rotation of the stomach is the root cause of PEH complications (Fig. 36.1). The stomach's volvulization,

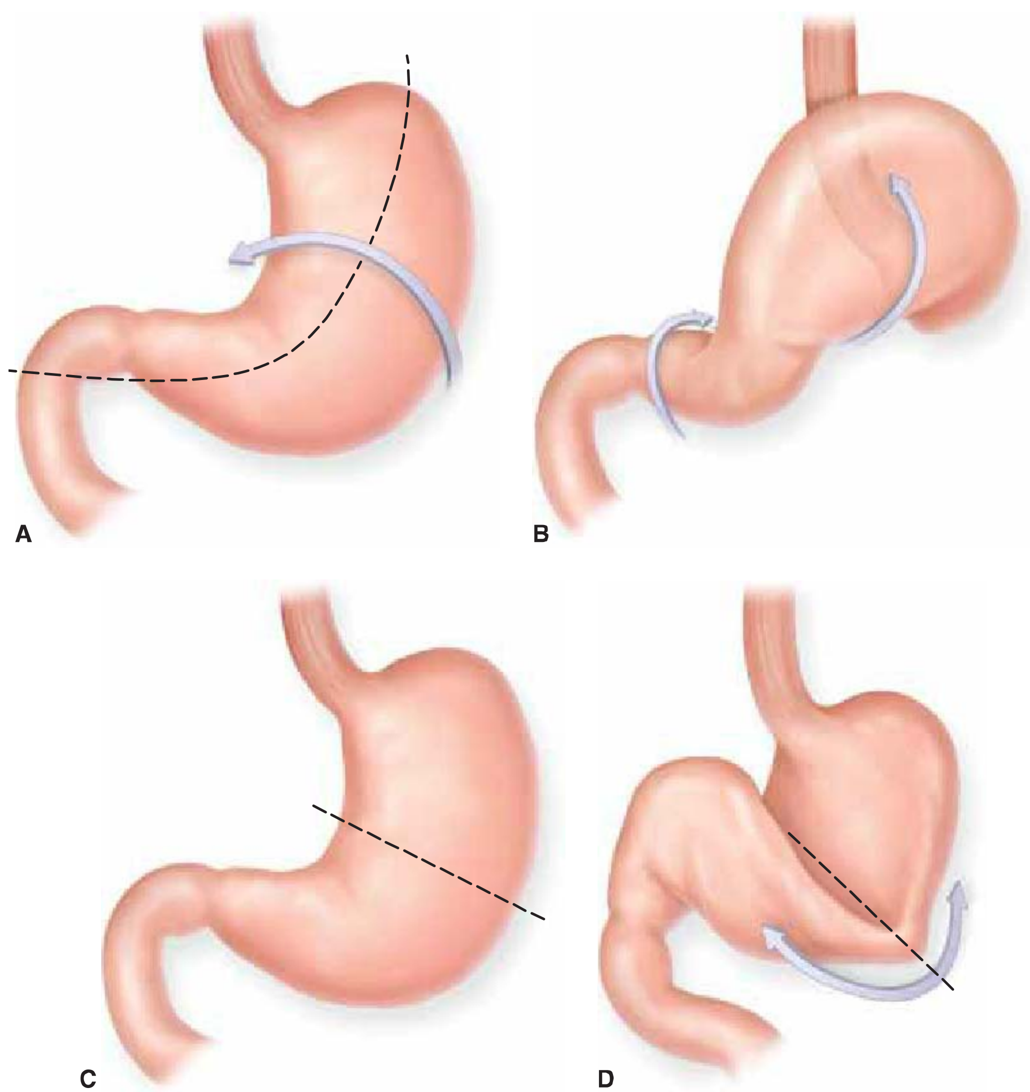


**Figure 36.1** **A:** Organoaxial plane after volvulus. **B:** Organoaxial volvulus. **C:** Mesenteroaxial plane. **D:** Mesenteroaxial volvulus.

distention, and compression precede bleeding, incarceration, and perforation. These life-threatening complications stem from the gastric blood supply being jeopardized.

## Diagnostic Evaluation

The evaluation of patients with potential PEHs begins with a chest x-ray, and an air-fluid level is seen behind the cardiac shadow if a hernia is present. A contrast esophagram is done to define esophageal anatomy and delineation of esophageal length. Upper endoscopy allows for evaluation of the esophageal lining to detect mucosal erosions as the probable culprit of gastrointestinal blood loss. Manometry is used to assess esophageal dysmotility and localization of the LES. The 24-hour pH test to verify GERD is optional.

# SURGERY

## Surgical Technique

### Positioning

The patient is placed in the supine position, both arms extended at a right angle with the patient positioned in the center of the table. The surgeon and the assistant stand on opposing sides, with the surgeon operating from the right side.

### Incision

A transverse skin-crease incision is made above the umbilicus, using the opt view through which access into the abdominal cavity is gained. Intraabdominal insufflation is initiated, and the initial pressure reading should remain relatively low. High pressures early during insufflation indicate access into the intraperitoneal space. If, however, insufflation is progressing well, the abdominal cavity should rise and be uniformly tympanic on percussion. The intraabdominal pressure should be observed to rise gradually.

### Port Placement

Five operating ports are placed to allow for all angles and access to the crural defect. A 12 mm trocar is placed in the supraumbilical area for the introduction of a 30° angled laparoscope. The main manipulating port is placed in the left upper quadrant at the midclavicular line using a 5 mm trocar. Three 5 mm accessory trocars are placed in the subxiphoid area, the right upper quadrant, and the lateral left upper quadrant (Fig. 36.2). The assistant on the left side of the patient operates the camera and the left port. The patient is placed in a steep reverse Trendelenburg position.

## Exposure and Operative Technique

### Division of Short Gastric Vessels

After accessing the abdominal cavity the liver is cranially retracted. Division of the short gastric vessels on the greater curvature side of the stomach is preformed first and the posterior attachment of the stomach to the pancreas is taken down. The posterior confluence of both branches of the crus can be better exposed from the left and the posterior side. Mobilization of the fundus facilitates the reduction of the hernia sac and ensures a loose fundoplication.

Bleeding is controlled with the Harmonic Scalpel™ (Ethicon Endo-Surgery, Cincinnati, OH) during the division of the short gastric vessels. When working near the upper pole of the spleen, caution is advised as branches of the splenic artery tend to cause an excessive amount of bleeding.

### Division of Pars Flaccida and Dissection of the Right Crus

During the division of the pars flaccida and dissection of the right crus, bleeding is common with manipulation along the lesser curvature of the stomach. The vagal nerve is usually spared. Caution is taken to avoid injury to the esophagus because of the tension

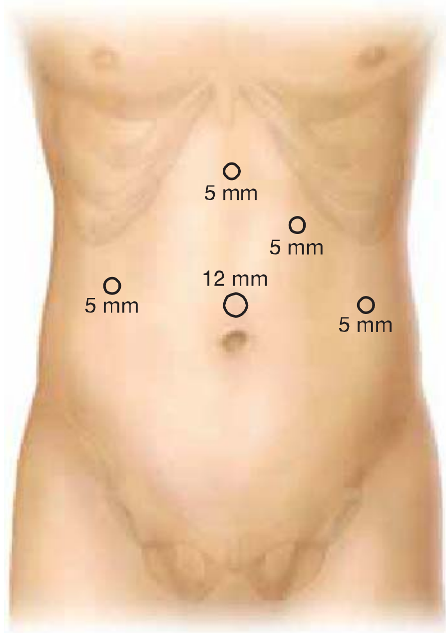


**Figure 36.2** Port placement.

along the lesser curvature and the esophagus. Identification of the anterior margin of the right crus is facilitated by referring to the left and the posterior side where the left crus is exposed by the previous step.

#### Reduction of the Hernia

Hernia type dictates the difficulty of its reduction. Type I and type II are easily reduced into the abdominal cavity. Type III and type IV hernias are more complicated due to the contents of the hernia sac. The hernia sac is divided around its opening and from its outside attachment, the sac is then retracted.

#### Removal of the Hernia

Retention of the hernia sac has been acknowledged as a significant factor in increased recurrence rates after paraesophageal hernia repair. The identification of the GE junction is made easier with the resection of the hernia sac.

#### Creation of a Tunnel Posterior to the Esophagus and Placement of a Penrose Tube

The Penrose tube allows the gastroesophageal junction to be raised giving a clearer view of the crural confluence. The crural defect is approximated. The size of the posterior space is estimated and mobilization of the fundus is evaluated. The fundus is pulled through the posterior space for fundoplication from left to right. The fundus should remain in place without retraction.

#### Closure of the Hiatal Defect

It is our preference to close the defect using a running non-absorbable suture. In our institution we use zero non-absorbable sutures in an interrupted figure of eight techniques or in a running fashion. The decision is usually made intraoperative depending on the size of the defect. A running non-absorbable suture makes possible bidirectional fixation that provides distribution of the tension across the two edges of the tissue and eliminates the need to tie knots maintaining tight tissue approximation.

#### Placement of Mesh

The placement of mesh is based upon the muscular stability of the crural fibers and hernia size (Fig. 36.3).

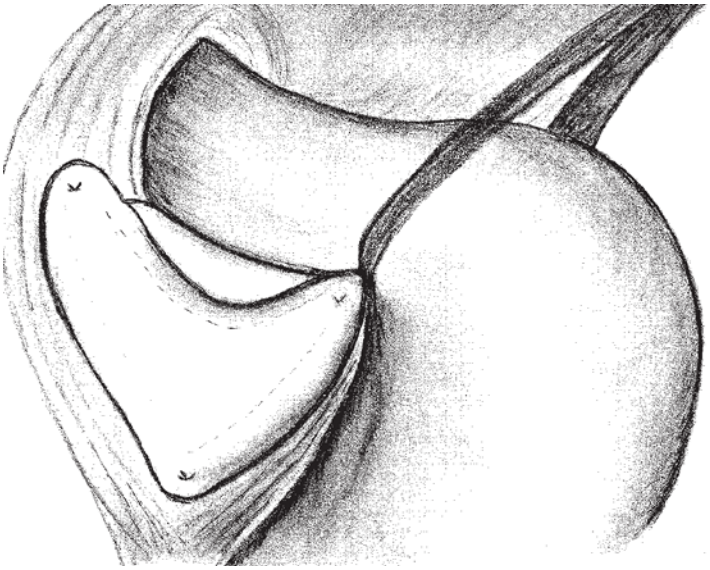

Figure 36.3 Placement of mesh.

### Fundoplication

An antireflux procedure is added to the procedure to prevent postoperative reflux after the extensive hiatal dissection. A floppy Nissen fundoplication is performed with two interrupted gastroesophageal gastric and gastrogastric 2-0 silk sutures (Fig. 36.4).

### Closure

The fascial defects at the periumbilical and infraxiphoid locations are closed with figure-of-eight sutures using 0-0 absorbable sutures. The skin is approximated with

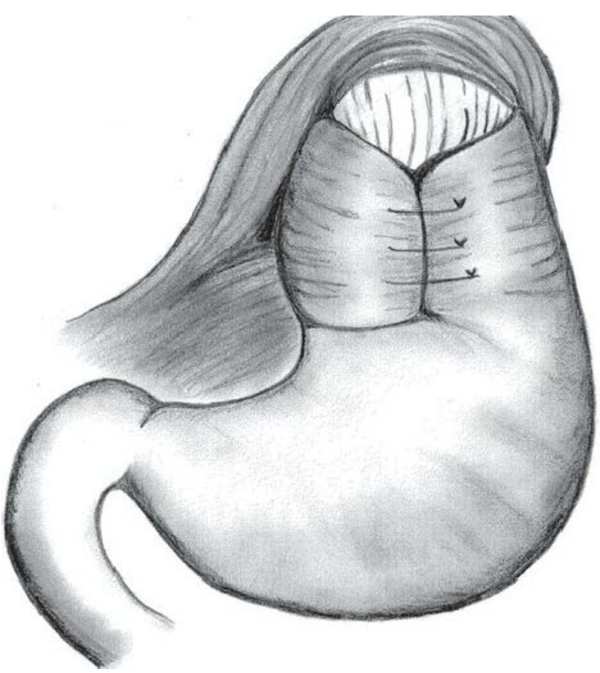

Figure 36.4 Nissen fundoplication.

**TABLE 36.1 10 Step Paraesophageal Hernia Repair**

(1) Five-trocar technique
(2) Division of short gastric vessels
(3) Division of pars flaccida and dissection of the right crus
(4) Reduction of the hernia
(5) Removal of the hernia sac
(6) Creation of a tunnel posterior to the esophagus and placement of a Penrose tube
(7) Closure of the hiatal defect
(8) Placement of mesh
(9) Fundoplication
(10) Closure

subcuticular 4-0 absorbable sutures and reinforced with steri-strips. All sites are injected with local anesthesia.

## POSTOPERATIVE MANAGEMENT

Patients are kept NPO until postoperative day 1 when clear liquids are introduced. An esophagogram is done on POD 1. Follow-up appointment in the clinic is 10 days postoperative. Patients are discharged home and adhere to a soft diet for 3 weeks.

## COMPLICATIONS

Pleural injury/pneumothorax can be caused by unintentional entry into the pleural cavity during dissection of the mediastinum.

Bleeding from the short gastric vessels or inadvertent injury to branches of the splenic artery may be controlled with the Harmonic scalpel or another energy source.

Injury to the spleen or liver upon dissection and retraction can occur.

Esophageal perforation may occur during blunt dissection and mobilization of the esophagus.

## RESULTS

At our institution, we have formulated a 10-step standardized approach (Table 36.1) for the repair of paraesophageal hernias. The principle steps include the reduction of the stomach to its anatomical position intraabdominally, resection of the hernia sac, and closure of the esophageal hiatus followed by an antireflux procedure.

## CONCLUSIONS

Hiatal hernias are a prevalent condition. The laparoscopic approach has afforded major development to decrease procedure-related morbidity and mortality. The use of mesh is still controversial.

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# 37 Single Access Laparoscopic Hernia Repairs

**Laura Dacks and Shawn Tsuda**

## Introduction

In the last decade, surgery has quickly evolved toward less invasive methods. Laparoscopic surgery has continued to be on the forefront for many general surgical procedures due to shorter hospital stay, less pain, and reduced complications. The development and mastery of minimally invasive methods has piqued interest among surgeons and industry toward innovative methods beyond traditional laparoscopy.

Laparoscopic surgery through a single access site is a minimally invasive surgical technique either through a single incision with multiple instruments inserted into the abdomen via separate trocars or through a multi-channel access port (Fig. 37.1). The procedure is then performed with the same steps as the conventional laparoscopic method. Inherent challenges through this technique would include decreased triangulation, instrument crowding or "sword fighting," and poorer visualization. Several articles have been published recently focusing on trials and outcomes of laparoscopic single incision surgery for ventral, incisional, and inguinal hernia repairs (Table 37.1). The focus of this chapter is to familiarize surgeons with the most updated techniques of single access laparoscopic surgery (SALS) hernia repairs.

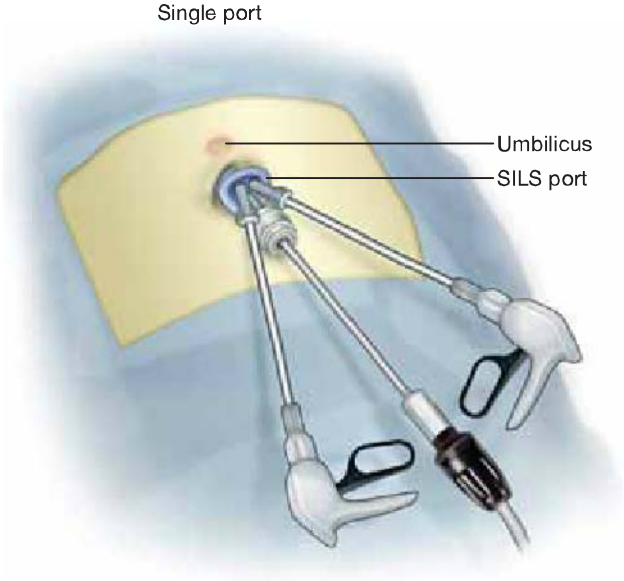
## INDICATIONS/CONTRAINDICATIONS

Indications and contraindications are essentially identical to those of the standard laparoscopic approaches.

### SALS Totally Extraperitoneal (TEP) Inguinal Hernia Repair

Indications:

- Bilateral hernias
- Recurrent hernias
- Unilateral hernias in young, active patients



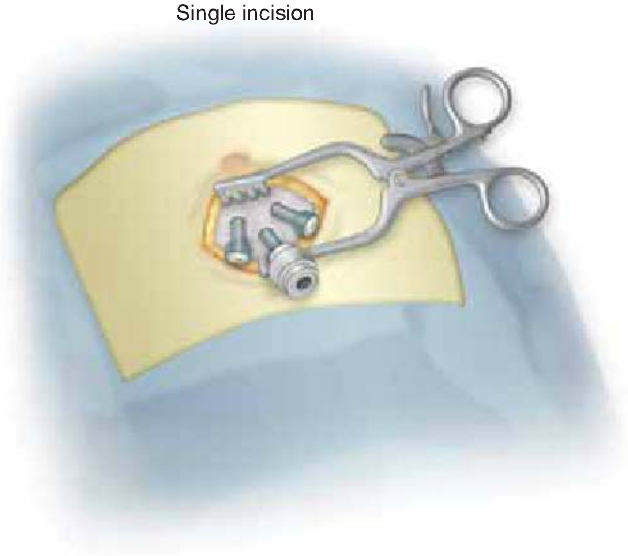




**Figure 37.1** Single port versus single ncision technique.

**TABLE 37.1 Compilation of Single-Site Laparoscopic Hernia Repair Research**

| Author | Type of Study | Patients (*n*) | Type of Surgery | Single Incision or Single Port | Conversion | Comments |
|---|---|---|---|---|---|---|
| Chung et al. (2011) | Prospective | 100 | TEP | Single incision | 2 | Converted to single site TAPP. One patient had recurrence. |
| Kucuk (2011) | Prospective | 15 | TAPP | Single port | No | All were recurrent hernias, 13 were open and 2 were previous TEP repairs. |
| Bucher et al. (2011) | Prospective | 52 | VH/IH/UM/IN | Single port | No | 6/52 previous surgeries were port-site incisional hernias. Used working channel endoscope. |
| Bower & Love (2011) | Prospective | 14 | VH/IH | Both | No | None |
| Barbaros et al. (2011) | Case report | 3 | IH | Single port | No | Giant hernias (15–18 cm) requiring 30 × 20 cm mesh. Transfascial sutures were not used on last two cases. |
| Tai et al. (2010) | Prospective/ retrospective | 54 | TEP | Single incision | No | Prospective for LESS TEP, retrospective for conventional TEP |
| Sherwinter (2010) | Retrospective | 52 | TEP | Both | No | Based on availability of products. |
| He et al. (2010) | Case report | 3 | TEP | Single port | No | None |
| Surgit (2010) | Prospective | 23 | TEP | Single port | 1 | Converted to standard laparoscopic TEP |
| Agrawal et al. (2010) | Prospective | 19 | TEP | Single port | No | None |
| Roy & De (2010) | Prospective | 15 | TAPP | Single incision | No | Intracorporeal suturing of the peritoneum was abandoned after two cases due to being technically difficult. |
| Podolsky et al. (2009) | Retrospective | 30 | VH/IH | Single incision | No | None |
| Rahman & John (2009) | Case report | 1 | TAPP | Single incision | No | None |
| Bucher et al. (2009) | Case report | 4 | TEP | Single port | 1 | Additional port placed due to bleeding. Used working channel endoscope. |
| Jacob et al. (2009) | Case report | 3 | TEP | Single port | No | None |
| Filipovic-Cugura et al. (2008) | Case report | 1 | TEP | Single incision | No | None |

TEP, totally extraperitoneal; TAPP, transabdominal preperitoneal; VH, ventral hernia; IH, incisional hernia; UM, umbilical hernia; IN, inguinal hernia.

Relative contraindications:

- Previous lower midline incisions
- Prior preperitoneal pelvic surgery
- Prior laparoscopic hernia repair
- Pelvic radiation
- Cesarean section
- Poor risk to anesthesia
- Bowel ischemia
- Chronic incarceration

### SALS Transabdominal Preperitoneal (TAPP) Inguinal Hernia Repair

Indications:

- Bilateral hernias
- Recurrent hernias
- Unilateral hernias in young, active patients
- Unidentified diagnosis

Relative contraindications:

- Large sliding hernias
- Chronic incarcerated scrotal hernias
- Prior pelvic surgery
- Poor risk to anesthesia

### SALS Ventral, Incisional, and Umbilical Hernia Repairs

Indications:

- Any ventral/incisional hernia that can be repaired using the open tension-free mesh repair
- Primary or first time recurrent umbilical hernia

Contraindications:

- Active wound infection
- Loss of abdominal domain
- History of several abdominal adhesions
- Previous intraabdominal mesh placement, specifically heavy-weighted polypropylene mesh
- Poor risk to anesthesia

In the loss of abdominal domain or giant ventral hernias, one recent study challenged this contraindication and had successful short-term outcomes.

## PREOPERATIVE PLANNING

Preoperative preparation for SALS hernia repair follows the same guidelines as standard laparoscopic approaches. Preoperatively, the patient is counseled on the benefits and risks of the procedure. As with standard laparoscopic and open methods, there is risk of bleeding, infection, injury, and recurrence. Specific to ventral/umbilical hernia repair, risk of seroma or hematoma formation are included.

Prior to entering the operating suite, patients undergoing inguinal hernia repair are asked to void their bladder. Placing a urinary catheter is now generally avoided in the operating room, as this is thought to increase the risk of postoperative urinary retention. However, catheters are placed in patients undergoing TAPP inguinal hernia repairs that have had previous lower abdominal surgeries. Catheters and orogastric or nasogastric tubes are usually placed during ventral hernia repairs for stomach and bladder decompression, depending on the proximity of the surgical site to these organs. Also, following skin preparation in ventral hernia repairs, an Ioban skin barrier may be used to limit contact of the mesh with the patient's skin during the procedure. Patients should receive preoperative intravenous antibiotics that cover skin flora and all patients are placed on sequential compression devices for deep venous thrombosis prophylaxis. The decision to use additional deep venous thrombosis prophylaxis is based on individual risk factors.

Preoperative planning for surgical instrumentation should include standard laparoscopic equipment along with a single access port (if available) or two to three trocars (one 12 mm and two 5 mm). Articulating instruments can be used, if desired and available. Ten millimeter, zero-degree and thirty-degree or forty-five degree cameras are generally used during the procedure. However, some prefer to use a flexible-tip endoscope during ventral hernia repairs.

Mesh of sufficient size should be available in the operating room prior to starting the procedure. The decision on what size mesh to use is usually made intraoperatively after accessing the size of the defect. Sutures for transfascial fixation or a laparoscopic tacking device should also be available and ready to use.

# SURGERY

## SALS TEP Inguinal Hernia Repair

### Positioning

The patient is placed in the supine position and general endotracheal intubation is accomplished. Either both arms are placed in the tucked position or at least the arm on the contralateral side as the hernia. The bed is placed in a 10- to 15-degree Trendelenburg position, with the side of the hernia slightly rotated up. The laparoscopic monitor is placed at the foot of the bed and the surgeon stands on the opposite side of the hernia. Two monitors at the foot of the bed can be used if a surgical assistant is being used.

### Technique

A single 1.5 to 2 cm incision is made at the umbilicus or just below the umbilicus in a periumbilical or vertical fashion. The subcutaneous tissues are dissected down to expose the rectus abdominis sheath. With a scalpel, a 2 to 2.5 cm transverse incision is made in the anterior sheath. In patients with a unilateral hernia, the incision in the rectus sheath is made on the same side as the hernia. In patients with bilateral hernias, the incision is made on the side of the larger hernia.

A balloon dissector is then inserted between the rectus muscle and the posterior sheath to open the preperitoneal space, as done in the standard laparoscopic TEP repair. The balloon dissector is removed and a single access device is then placed between the rectus muscle and the posterior sheath (Fig. 37.2). Through the device, one 12 mm trocar and two 5 mm trocars are introduced at different depths in the device to prevent the heads of the trocars from hitting each other. In our experience, we have used the device successfully with one 12 mm and 5 mm trocars when feasible and have not observed significant air leaking through the remaining 5 mm port site (Fig. 37.3).

If a single access device is not available, a 10 mm laparoscope port can be placed through the previous anterior sheath incision. While the preperitoneal space is being insufflated, two 5 mm ports can then be inserted through separate anterior sheath incisions approximately 1 cm laterally from the 10 mm port site. Another option described is the use of a home-made single access device. This involves placing an extra small Alexis wound retractor® with the green ring in between the anterior and posterior rectus muscle sheaths. Two sterile surgical gloves are attached onto the retractor and three trocars are inserted through the gloves and secured by purse-string sutures.

The preperitoneal space is then insufflated with carbon dioxide to pressures of 10 to 12 mm Hg and the TEP repair is accomplished in the same manner as the standard laparoscopic three midline port repairs. The device(s) are then removed allowing the gas to escape and the preperitoneal space to collapse. The umbilical fascial defect(s) are closed with absorbable suture followed by closure of the umbilical skin.

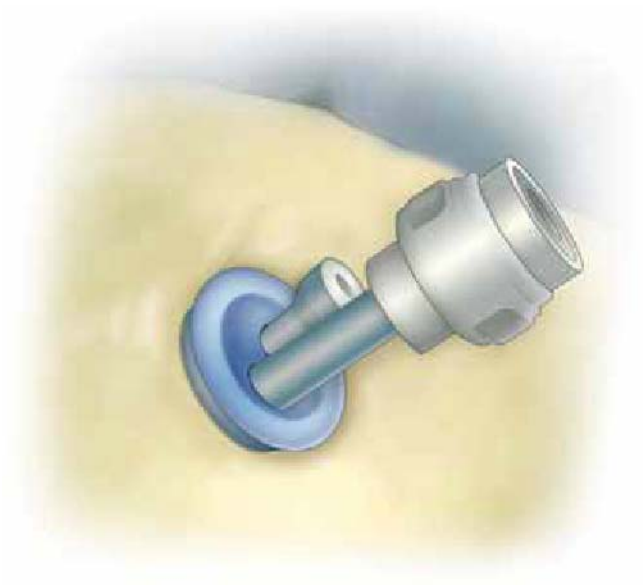


Figure 37.2 SILS™ port for TEP repair.

## SALS TAPP Inguinal Hernia Repair

### Positioning

The positioning is essentially the same as previously described in the SALS TEP procedure.

### Technique

A 1.5 to 2 cm periumbilical or intraumbilical skin incision is made followed by dissection of the subcutaneous tissues to expose the rectus fascia. A 1.5 to 2 cm vertical rectus fasciotomy is then created and entry into the peritoneum is accomplished. The single access port device is then inserted with the inferior portion inside the peritoneum. Three trocars are then introduced into the device, again at varying heights to reduce the trocar heads from hitting each other.

If a single access device is unavailable, three trocars (one 10 mm and two 5 mm) can be introduced into the abdomen through the single skin incision. The two 5 mm trocars are placed 1 cm inferiorly and to the left and right of the 10 mm trocar. A case report by Rahman and John describe using a Veress needle for carbon dioxide insufflation through a transumbilical incision followed by placement of three ports through the

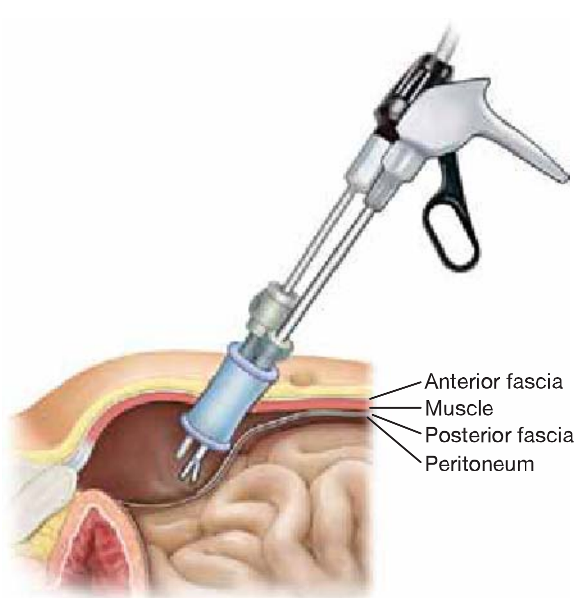



Figure 37.3 Single access TEP technique.

single incision. The particular technique used is based on surgeon preference and no one technique is considered superior to another.

SALS TAPP repair is then performed using essentially the same technique as the standard three port laparoscopic TAPP repairs. At the end of the procedure, instruments and port(s) are then removed allowing the abdomen to collapse. The fascia at the umbilicus is closed with absorbable suture, followed by closure of the skin incision.

### SALS Ventral, Incisional, and Umbilical Hernia Repairs

#### Positioning

The patient is placed in the supine position and general endotracheal intubation is accomplished. Both arms are either tucked or placed out to each side, in a 90-degree position. The laparoscopic monitors are placed on both sides of either the patient's head or feet, depending on surgeon preference and the position of the hernia. The surgeon typically stands on the right side of the patient, however, sides may be alternated during the procedure to facilitate reduction of hernia contents or mesh placement.

#### Technique

The hernia is first assessed, measuring the size and palpating the boarders. This is important as the port should be placed in the patient's native fascia lateral to the defect. A 1.5 to 2 cm incision is made in the right or left flank, approximately midway between the anterior superior iliac spine and the costal margin. Entry into the peritoneum is either accomplished under visual control or through an optical trocar, depending on whether or not a single port access device is used or 2 to 3 trocars through one incision is used. The multi-port access generally uses one 10 mm port and either one or two 5 mm ports through separate fascial incisions. If using a single access port, a 2 cm transverse incision is made in the fascia. The peritoneum is accessed by using a muscle-splitting technique and the single access port device is placed and the abdomen insufflated. Bower and Love describe the use of a Veress needle in the left upper quadrant of the abdomen to provide insufflation prior to the single access port placement. The procedure is carried out in the same fashion as the standard laparoscopic method. At the end of the procedure, port(s) are removed and the fascial defects are closed with absorbable suture followed by skin closure.

## POSTOPERATIVE MANAGEMENT

Patients may be discharged home between 4 to 48 hours. Generally, these procedures are handled as outpatient surgeries. Requirements for discharge are recovery from general anesthetic, able to tolerate clear liquids, and able to tolerate pain with oral medication. Prolonged operative time, organ injury or suspicion of organ injury, bleeding, or perioperative anesthetic complications would be indications for inpatient admission. Initial follow-up normally occurs from 1 to 4 weeks.

## COMPLICATIONS

Complications are rare intraoperatively and are primarily dependent on the experience of the surgeon. The literature for all types of single site or single port hernia procedures showed few conversions to the standard laparoscopic methods and no conversions to an open method. Postoperative complications were minor and were able to be corrected without any further surgery.

Common postoperative complications:

- Seroma or hematoma formation
- Delayed return of bladder function
- Minor wound infections

## RESULTS

Results, thus far, have been positive and appear to be equal to standard laparoscopic repairs. Generally, patient follow-up appointments have ranged from 2 weeks up to 24 months. Patients have been monitored for recurrence at the primary site as well as access site hernias. To date, no recurrences have been documented. However, prospective studies with adequate follow-up are needed.

## CONCLUSIONS

Abdominal and inguinal hernia repairs are a large part of a general surgeon's practice. The ideal technique for hernia repairs is still controversial. As advancements are made in laparoscopic surgery, newer methods are explored to provide improvements to the procedure as a whole. In the hands of an experienced surgeon, the concept of SALS is a fascinating and plausible innovation. Due to the novelty of this procedure, only a small amount of research with short-term outcomes is available. Questions have been posed as to whether or not this technique is superior to standard laparoscopic methods. Although SALS is comparable to the standard approach in providing less postoperative pain and less recovery time, it appears the primary benefit of this technique is cosmetic. Some surgeons dispute this thought, as they believe the incision needed for the single access port device is larger than what is needed for the standard laparoscopic approach. Also, another issue that is debated is the higher expense rate with the SALS approach, mainly due to the costs of the single access port device.

Ultimately, there are issues with this technique that need to be further evaluated. Continued research is needed in the efficacy, morbidity, expense, and patient cosmetic satisfaction of the SALS procedure compared to standard laparoscopic methods. There is also a necessity for more long-term randomized controlled studies in accessing recurrences of primary hernias as well as access site hernias.

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# 38 Reduced Port Surgery—Single Port Access Ventral Hernia Repair

**Paul G. Curcillo II**

## Introduction

Ventral hernia repair is unique from other surgeries we approach laparoscopically in two very particular aspects. First, unlike most other laparoscopic procedures, we approach ventral hernias from the opposite direction, and oftentimes in apposition to our field of view. We find ourselves looking "up" instead of down, and "at" ourselves instead of "ahead" of ourselves. Thus, we may need to manipulate mesh and tackers in reverse when the camera is coming from the contralateral side. Aside from the difficulties of adhesiolysis being performed laparoscopically, these two factors alone can be challenging to most surgeons who may otherwise be very adept at other laparoscopic procedures.

In addition, when we repair a ventral hernia, we are exposing the patient to the very same problem we are addressing. Each incision or port site is a nidus for recurrence of the disease.

Further, the application of the reduced port techniques and single port access surgery should be applied with the same thought process as multiport laparoscopy. The additional loss of the "triangulated" view for an inline view can be a difficult transition as well.

When undertaking the practice of laparoscopic ventral hernia repair, these factors play an important role in moving forward. Both as hurdles we must overcome, as well as potential learning points from which we can improve the technique and outcomes when positioned correctly.

Attention to a new approach as well as the potential for subsequent hernia formation at the port site must remain in the forefront.

## INDICATIONS/CONTRAINDICATIONS FOR SINGLE PORT ACCESS VENTRAL HERNIA REPAIR

The indications for these are now proving themselves to be all levels of ventral hernias. Simple primary ventral hernias are the easiest with which to begin. Any hernia less than 2 cm can generally be repaired without the application of mesh and an open technique would be in order. However, if a laparoscopic repair is going to proceed, then the single port access technique is a viable alternative.

All patients for ventral hernia repair can be considered to have the procedure performed laparoscopically, but both science and common sense will dictate which patients are appropriate candidates for this approach. Oftentimes, patients will be prepared for a laparoscopic approach and repair, but intraoperative findings or conditions may dictate an open procedure needs to be performed. In this light, a surgeon performing laparoscopic hernia surgery should also be well versed in all open repair techniques, meshes, and reconstructive procedures.

Single port access ventral hernia repair is a new technique. The most important contraindication would be lack of familiarity with single port access surgery. Clearly you have to decide at what level of skill you can proceed with the hernia repair through decreasing number of port sites. In the past, the author's developed a simplified approach to laparoscopic ventral hernia repair with a "two-port, single-stitch" technique. This allowed us to repair small hernias and ultimately we graduated to much larger hernia repairs. However, as you move forward with single port access, the most important contraindication will be your level of skill with this new procedure. As you develop your technical skills, single port access ventral hernia repair can be offered to the patients with small and large hernias as well as multiple or complex defects. Again, the most important aspect is safety and it should always be remembered to add another port site or trocar whenever necessary to maintain a safe operative procedure.

The simplest of ventral hernias are not only the obvious clear indicators for the laparoscopic approach, but also the best hernias to begin a surgeon's development of the laparoscopic hernia repair practice. Each of these hernias can be repaired easily and oftentimes with success, serving as a bridge to larger and more complex hernias.

- Umbilical
- Epiploceles
- Low midline hernias from pelvic surgery
- Trocar site hernias from laparoscopy
- Recurrent umbilical hernias

One should master multiport ventral hernia repair before moving onto reduced port repairs. Just as is taught with single port access cholecystectomy and colectomy surgery, the "step-down" approach is a gradual transition from multiport to single port surgery. In fact, as the developers of single port access surgery, the author began the road to reduced port surgery with the introduction of the "two-port, one-stitch" technique for ventral hernia repair. The surgeon should begin by eliminating one of the port sites at a time. Only add one extra instrument to a port site at a time. Not only does it make for an easier transition, but it also allows for a better chance at success at each level, encouraging the surgeon to move to the next level.

In our experience, as reported initially in our first series, we have repaired not only primary defects but also recurrent hernias. We had been able to apply this technique to multiple defects as well as small to large defects. In addition, we have been able to apply the repairs with prior mesh repairs that need a new sublay mesh.

Once mastered, moving to more complex repairs becomes easier and manageable.

- Multiple defects
- Multiply recurrent hernias
- Lateral hernias
- Long midline incision hernias
- Complicated hernias
- Complex hernias

The contraindications for single port ventral hernia repair are the same as for multiport ventral hernia repair. Any medical contraindication that would disallow the application of carbon dioxide or the implantation of mesh would also be a contraindication in these patients.

Other preoperative considerations would be the following:

- Bleeding dyscrasias (can result in excessive bleeding from tacks)
- Retractable ascites (unless a draining catheter is placed simultaneously)
- Infected abdominal wall (potential to infect mesh to be placed)

Intraoperative considerations/concerns would be the following:

- Inability to obtain a safe access point
- Extensive adhesions not amendable to laparoscopic takedown
- Necessity to resect bowel if not fascile in laparoscopic bowel anastomosis
- Contraindication to mesh placement
- *Any concerns about bowel injury or safe continued dissection*

## PREOPERATIVE PLANNING

As we approach the patient with a ventral hernia, the need to reduce the trauma we incur on the patient must also decrease in order to ultimately defeat this process. We need to plan the surgery before we arrive in the operating room, so we are ready to handle all possibilities. Conversion from single port access to reduced port surgery to multiport laparoscopy to open surgery is not a complication, but rather a natural progression in the "safe" approach to ventral hernia repair.

Over the next several pages, we will demonstrate to you a technique that offers the ability to approach ventral hernia repair through a single port site, thus not only minimizing the patient's discomfort and recovery periods, but also offer the least possibility of recurrence of this disease process through our treatment site.

The planning for these patients is somewhat different. With most laparoscopies we can generally enter through the umbilicus. However, most patients generally have a midline scar through which the hernia has occurred. We need to decide based on the patient's anatomy and abdominal wall examination where we want to place our first and sometimes only trocar. Obviously, you need to plan this based on the patient's prior surgeries. A surgical procedure in a particular quadrant of the abdomen would make that a quadrant we would want to avoid. In some instances, the initial port site may need to be just to the left of the xyphoid process. It can be very difficult to manipulate and tack the mesh from this point, so we will have to prepare the patient for at least a second site of entry.

It is often wise to obtain a CAT scan of the abdomen in order to define the size of the defect. This ensures that you have the appropriate size mesh available. In addition, if there is prior mesh, it may be visible on CT scan if it is PTFE based, or not if it is polypropylene based. If permanent tacks were used, this could help delineate the size and position of the mesh that has been placed in the past, which may help with the decision on the size of the mesh you will be placing.

Another important aspect of recurrent ventral hernias we have found is to obtain a copy of the prior operative reports. These operative reports will certainly help in planning whether or not you will need to remove or replace mesh. In addition, they may also help to plan the overall procedure.

## SURGERY

1. General Anesthesia
2. Supine Positioning
3. Arms tucked for low or midline hernias
4. Arms out for wide hernias in order to place trocars far lateral
5. Foley catheter
   a. In simple hernias, you can oftentimes avoid placement of a Foley catheter if the patient has just urinated and you are going to be entering high in the abdomen or lateral where the bladder would not be positioned.

6. Nasogastric decompression
   a. We routinely place a nasogastric tube should we get into a more complex procedure and nasogastric decompression will be necessary postoperatively. This also facilitates placement of the trocar in the left abdominal wall to ensure that the stomach is not over inflated.
7. Prep and draped wide "table top to table top" to allow far lateral placement of trocars
   a. Only shave the area where the port site will go as well as a small area where we may need to place a central suture. We do not recommend tape for the removal of the hair as this can itself damage the skin, which is the body's first line of defense against infection.
8. Trocar sites
   a. The most important trocar is going to be the first trocar that is placed. This is generally placed in the open technique. Given all ventral hernia repairs, a 1 cm incision is generally necessary in order to insert the mesh. A 1 cm skin incision is enough to allow you to proceed down in an open technique separating each layer individually. Grasping the fascia and ultimately peritoneum with hemostat is an excellent technique. The other option is to use a bladeless trocar and enter in the manner in which they are proven to work with a slow 180-degree turn that allows you to separate the tissue rather than puncturing. Given that you are entering the abdomen blindly, we generally use the Optiview to only enter with a very tip to allow a very small hole thus ensuring that a sharp instrument does not enter into the abdomen. We then withdraw the obturator and insert the camera allowing us to insufflate the abdomen through the small hole and then actually insert the scope through this hole. This allows us to insert the trocar over that. Once we are in we can examine the abdominal contents for any signs of adhesions and the prior surgery if it is present.
9. If the hernia can be repaired from this position then the single port access port technique is followed (Fig. 38.1). The single port access technique as described in the past is done by raising skin flaps off the fascia in order to allow the insertion of a second trocar through the same site approximately 3 to 4 cm from the first affording a mild degree of triangulation. For this, extra-long very-low profile trocars or "sleeves" (trocar heads less than 2 cm) are generally employed. We avoid the use of trocars with large threadings as the two can run together and ultimately cause problems with $CO_2$ leakage.
   a. We avoid the use of the SILS™ (Covidien) or LESS devices as techniques of reduced port surgery as these employ port access devices to allow multiple instruments to pass through. These devices can require larger fascial incisions which may lead to increased hernia formation themselves.
10. If a third instrument is needed then this can always be done in the single port access technique by raising a flap in the other direction and assuming the triangulated position away from the hernia itself (Fig. 38.2).
11. A combination of blunt and sharp dissection as well as minimal heat or energy dissection is then used in order to take down the adhesions. Again, this can be

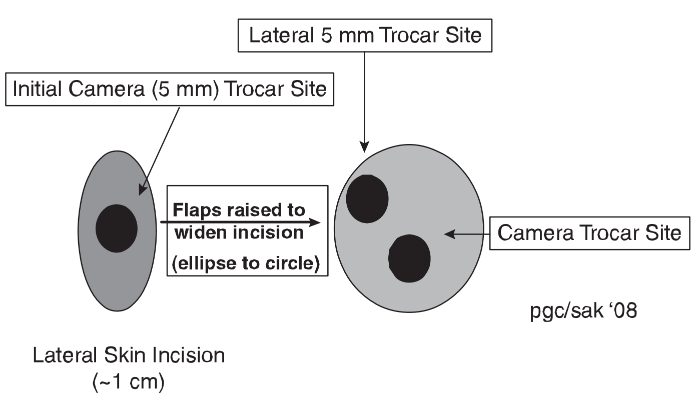


**Figure 38.1** Single port access (SPA): Access schematic for ventral hernia.

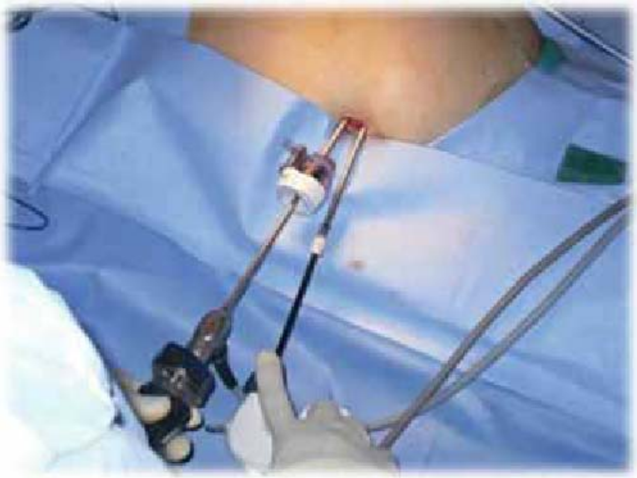

Figure 38.2 Complete lateral incision.

done simply with a simple or primary hernia and will require much more skill as you progress to the more advanced hernias.

12. Once the defect is completely visualized and cleaned, we do ensure that there is at least a 3 to 5 cm margin around the entire fascial edge. Oftentimes, this requires taking down the falciform ligament in order to ensure that this does not sit above the mesh once placed.
13. Mesh
    a. Mesh type: Our practice has been to use a polypropylene-based mesh. We feel this is the best as it promotes tissue ingrowth. However, as this is being placed in the abdomen, a barrier does need to be present that will help minimize the formation of adhesive scarring to the small bowel and omentum. Clearly, there are a number of these in the market and any one of these can be used based on your preference and the degree of dissection. We have found that in patients with primary or simple hernias, there is very little of any dissection and a temporary barrier that may only last 4 to 6 weeks is sufficient. However, if there is a fair amount of dissection then you may want the barrier to be remaining for a longer time in which case a coating that lasts up to 6 months may be necessary.
    b. We have stayed away from the PTFE-based mesh. Unfortunately PTFE, although it may minimize adhesion formation, the concern over infection has led us to a more incorporating mesh. In our experience, we have been able to salvage polypropylene mesh with infection, but not PTFE. In addition, our personal experience has now seen a number of PTFE-based meshes that have become infected several years later after the patients have developed skin abscesses or undergone subsequent surgery with seeding of PTFE.
    c. Mesh size: We routinely measure the defect and then add 6 cm to both dimensions. This gives us at least a 3 cm overlap in all directions. We then chose the next larger mesh size that allows an adequate overlap.
    d. Mesh insertion (Fig. 38.3):
        i. Place suture through the center of the mesh.
        ii. Roll the mesh tightly.
            1. It is best to roll this on a Mayo stand or hard surface.
            2. The mesh is then inserted using a Kelly clamp through one of the trocar defects.
                a. We generally use the trocar site that was placed first, which is in the center of the wound and the easiest to both find and reproduce for subsequent trocars. We do not insert the mesh through a trocar or through any device (in our series of over 300 patients thus far using the reduced port technique we have not had any infections of the mesh).

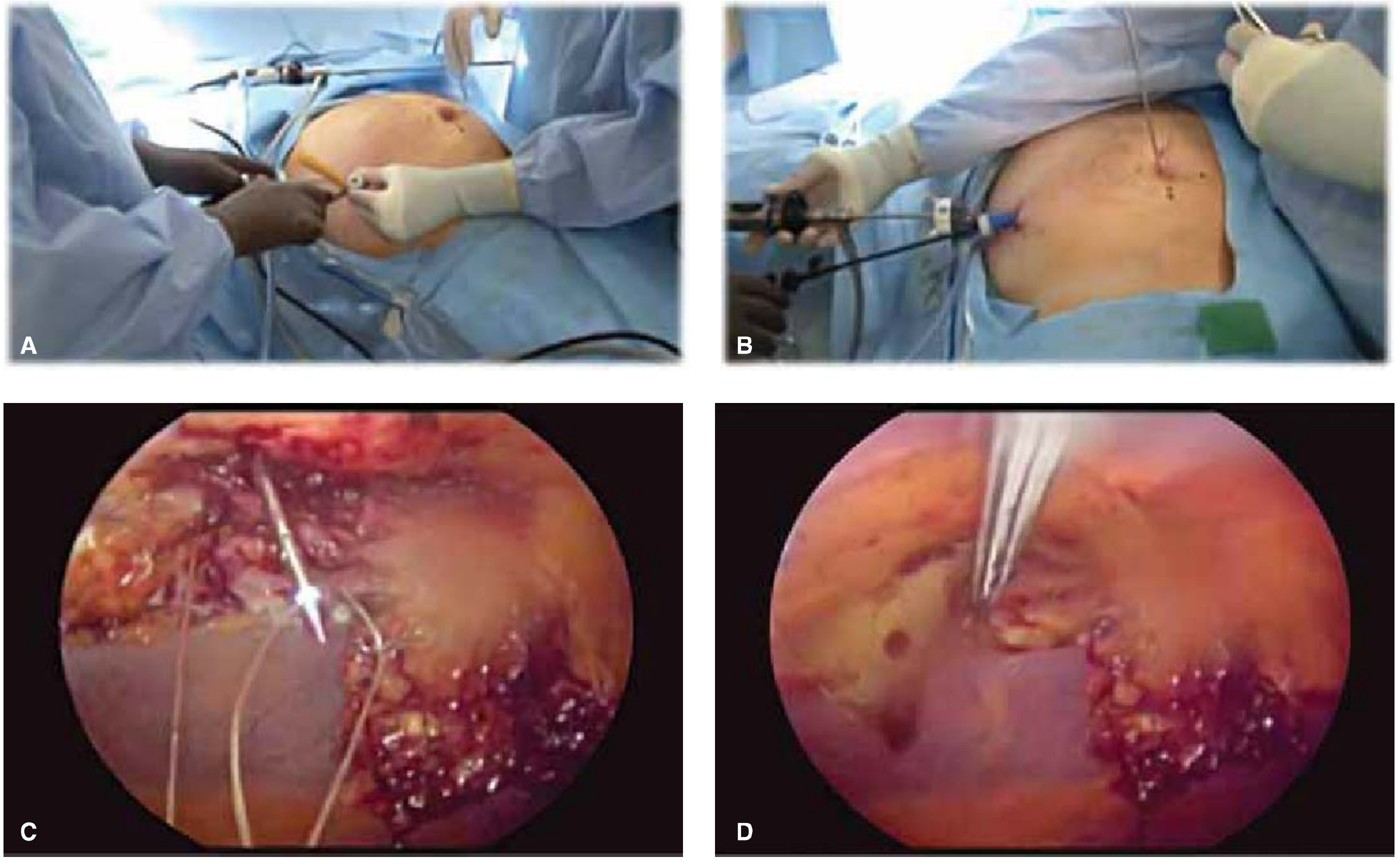


Figure 38.3 **A:** Insertion of mesh. **B:** Position of central suture grasping device. **C:** Grasping centered suture. **D:** Positioning of mesh to abdominal wall.

e. Mesh placement: A central suture is then placed. This is the technique we originally described in our two-port, single-stitch technique.
   i. Placement of the stitch in the center of the mesh and pulling it through the center of the defect(s) externally automatically centers the mesh on the defect.

As always, if the dissection requires a subsequent trocar be placed in a distant location to the single port access site then we simply do this and we have considered this the reduce port technique, which still allows us to repair the hernia with two holes instead of four or five as has been commonly reported.

Tacking: Once placed, proceed with tacking with either absorbable or non-absorbable tacks. We have found that the non-absorbable tacks work best in obese patients. However, in most patients the absorbable tacks work nicely and are then placed around the perimeter of the mesh. Our first tacks are placed at the North, East, South, and West positions, which allow the mesh to be secured. We then placed tacks into the corners of the mesh. Sometimes, we will place markings on the mesh in order to orient it if rectangular or oval piece of mesh is being placed rather than a circle or square.

Once the perimeter of the mesh is tacked at intervals of 2 to 3 cm, we then place an inner circle of tacks as well outside of the fascial defect in order to help prevent mesh migration.

At the end of every procedure, we then grasp the mesh in order to ensure that we cannot pull off the abdominal wall. In fact, when we pull on it, we make sure that the abdominal wall shakes demonstrating that it is adherent to the mesh. If this pulls the mesh then obviously it is not intact and we have to replace it. Any aberrant or lost tacks are always retrieved in order to prevent any subsequent problems.

Once the mesh is secured we desufflate the abdomen to ensure that it comes down nicely.

Of note, it is best to place the tacks with the fascia at a right angle through the tacker. If the tacks are placed in an acute or obtuse angle, it does not give a good grasp of the tissue and the mesh can easily move. The abdomen is then reinsufflated and inspected for bleeding or any bowel injuries. Any sign of bowel injuries obviously need to be corrected or the patient open for the repair.

Trocar site closure: For the single port access incisions, since we are tenting the skin in several directions, we now close the incisions with a running subcuticular prolene suture to allow it to stay longer. We found with our early experience that a number of these incisions were not fully healed before the suture dissolved.

## POSTOPERATIVE MANAGEMENT

Postoperatively, patients for small hernias are admitted to the same day procedure unit or for a 23-hour observation. We have found that most patients are discharged within 24 hours with some staying an extra day or two for pain control or ileus. We have had several patients with urinary retention and this has been treated with a Foley catheter. Although, antibiotics are given preoperatively, we do not routinely use antibiotics postoperatively in these patients.

Diets are advanced within the day.

## COMPLICATIONS

Complications that can occur from this procedure:

- Wound infection at the site of insertion
- Bleeding from the tacks resulting in areas of ecchymosis that usually resolve
- Seromas occur in almost all patients and they generally resolve
  - Binders have helped control these
    - Unavoidable as the peritoneum in left intact
- Mild postoperative ileus
- Urinary retention
- Readmissions with persistent pain
- Major Complications
  - Bowel injury
    - Attention to dissection and maintaining instruments (hot and cold) in view at all times is mandatory.
    - Any evidence of injury needs to be explored and if you do not have an adequate and safe view laparoscopically then certainly an open procedure is warranted in order to prevent this. Any bowel injury that occurs postoperatively needs to be treated emergently and expeditiously.
  - Bowel obstruction

## RESULTS

The results of this technique need to absolutely mirror the results of the standard laparoscopic technique. Our recurrence rate has been zero at this point, but we are still only within 3 to 4 years of performing this procedure. This clearly needs to be followed for several years as hernias can develop at least 2 years out and up to 5 to 10 years.

Otherwise, our results do mirror those of multiport laparoscopic surgery. This demonstrates proof of concept as we move forward to more complex repairs.

## CONCLUSIONS

Proof of concept is the most important aspect of a new procedure. We need to demonstrate applicability, safety, and successful outcomes. We also need to prove that we have not increased the risks of standard and proven techniques. The gain from single port access as of yet has only been cosmetic. No other benefits have yet been shown. There is no room for increased complications if we are not improving overall outcomes yet.

The approach to the patient with a ventral hernia is oftentimes an approach not seen in other surgical diseases. Although primary ventral hernias certainly do occur in the case of epiploceles and umbilical hernias, a ventral hernia is most often the result of a prior surgical procedure. Thus, we not only treat the disease, but we also must realize that we are oftentimes the cause of the disease itself. With this said, it is important that we actually develop not only a treatment plan for the patient with ventral hernias, but also act to develop a plan to prevent the patient from undergoing another ventral hernia.

As we move forward in the era of laparoscopy, we have seen a dramatic decrease in large ventral hernias. Although, with laparoscopic ventral hernias, port or trocar site hernias have certainly become an issue with which we have to attend. Subsequently, the repair of these hernias laparoscopically has now offered us not only a better repair technique, but also it offers us an improvement in that the incisions are smaller and hopefully large ventral hernias will become a thing of the past.

## Recommended References and Readings

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