Laparoscopic Urologic Surgery in Malignancies

Jean J. M. C. H. de la Rosette · Inderbir S. Gill
Editors

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With 178 Figures

Springer

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Foreword

The era of endo-oncology has arrived. Endo-oncology is now firmly entrenched in the diagnosis and management of urologic cancers. From its early days with transurethral resection of bladder tumors, to the more recent decades with establishment of techniques for percutaneous resection of transitional cell carcinoma, endo-oncology is the endoscopic treatment of cancer. More recently, the application of laparoscopy to the treatment of urologic cancers has continued the tradition. Laparoscopy has expanded and evolved from a diagnostic modality with laparoscopic pelvic lymphadenectomy for prostate cancer to include radical therapy for surgical management of every abdominal organ in the genitourinary system.

This textbook is important for many reasons. The integration of oncologic therapeutic intervention with a minimally invasive modality must bear the scrutiny of direct comparison with open surgery in terms of actuarial survival statistics and functional results. Laparoscopic radical nephrectomy for renal cell carcinoma has withstood the test of time in terms of disease-free survival, blood loss, postoperative discomfort, tumor port site implantation, hospital stay and convalescence. For other procedures, we look to achieve the same standards.

The advance of laparoscopy into the realm of oncologic surgery has also challenged individuals who perform open surgery to re-examine their practice in order to improve their functional results. The challenge to improve the morbidity of any procedure is to the ultimate benefit of our patients.

Just as there are multiple ways to cook in the kitchen, there are numerous techniques for laparoscopic radical prostatectomy. From a transperitoneal approach to an extraperitoneal approach, to subtle changes in addressing the seminal vesicles and vas deferens, vesical–urethral anastomosis or port placement, the optimal method continues to evolve. Significantly less blood loss and earlier achievement of urinary continence are proven benefits of this procedure. With the learning curve, recognition of earlier difficulties have led to modifications that are reducing margin-positive rates to the standards set by open radical retropubic prostatectomy. We look forward to reviewing long-term of PSA follow-up and survival statistics with which vigilant surveillance will prove the true efficacy of this procedure.

Endo-oncology, with a natural extension to include laparoscopy, has been seeded into the roots of surgical practice and training of urologists worldwide. We look forward to the fruit that will continue to spring forth from the education and dissemination of this information.

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Preface

Long adept at sophisticated endourologic techniques that exclusively address the intraluminal aspects of the urinary tract, urologic surgeons are now embracing laparoscopic techniques which, like open surgery, address the extraluminal aspect of the genitourinary system. In tandem, endourology and laparoscopy complete the spectrum of minimally invasive urology.

The horizons of laparoscopic surgery are expanding, such that the overwhelming majority of abdominal urologic procedures have now been performed laparoscopically. In some of these procedures the laparoscopic alternative has been demonstrated to be superior to its open counterpart, in others comparative analyses are currently ongoing, and in yet others only the initial forays of minimally invasive surgery have yet been undertaken.

Change must not be embraced just because it is different, or new. The tried and trusted must not be cast aside until its novel replacement has undergone an honest, duly diligent evaluation. Following this dictum, laparoscopy is being gradually incorporated into mainstream urology, with appropriate caution and healthy, constructive critique.

Clinical advances of any significance cannot occur in isolation. As regards laparoscopic urology, minimally invasive surgeons must join forces with their open surgical colleagues, so as to advance the field together. Free discussion and close collaboration are necessary to ensure that long-established surgical principles are adhered to, and outcomes are evaluated critically on an ongoing basis. Only by fulfilling its promise of being "minimally invasive – maximally effective", will laparoscopic urology truly enter the mainstream. It is our belief that laparoscopy is likely to have a far-reaching impact on our field.

This book is an effort towards compiling the current body of knowledge in laparoscopic urology under one cover. The various authors, respected experts in the field, have provided concise updates on their respective topics. We are deeply indebted to them for their thoughtful contributions. We hope that the information contained in this book will help interested urologists to advance their laparoscopic knowledge and skill set.

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1.1 Transperitoneal Laparoscopic Adrenalectomy in Malignancies

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Contents

Introduction

Since its first description by Gagner et al. [1], laparoscopic adrenalectomy has gained in popularity within the urological community, and it is presently considered to be the gold standard in the treatment of benign adrenal lesions [2, 3].

Though there appears to be worldwide consensus for the use of laparoscopy in the treatment of benign functional and nonfunctional adrenal pathologies (even though the tumor may be large in diameter and possibly benign, as shown by Henry et al. [4] and Karazayan et al. [5]), several concerns and controversies have arisen regarding the efficacy and effectiveness of laparoscopic adrenalectomy in malignancies, either primary or metastatic.

Following the pioneering report by Elashry et al. [6] on the feasibility of laparoscopic adrenalectomy in malignancies (namely two cases of adrenalectomy for solitary, contralateral adrenal metastasis from renal cell carcinoma), the number of publications dealing with the removal of neoplastic or metastatic adrenal lesions by laparoscopy has increased progressively. However, data regarding the results of laparoscopic adrenalectomy in malignancies are still limited mainly to case reports or small cohort studies, with short follow-ups.

Details regarding the feasibility of laparoscopic radical adrenalectomy have already been reported, while both the oncological efficacy and potential risks related to laparoscopy in treatment of this kind of malignancy should be properly assessed in the future.

Indications and Contraindications

Although the precise role of laparoscopic adrenalectomy in malignant lesions is still controversial, an analysis of available literature and our own personal experience [7] indicate that this procedure appears to be gradually gaining acceptance.

Laparoscopic adrenalectomy in malignancies can be performed both in cases of primary adrenal malignant tumors as well as in cases of metastatic lesions.

Conditions for laparoscopic adrenalectomy in case of a malignancy are considered plausible if the lesion appears to be organ-confined, with no evidence of local invasion and neoplastic involvement of the adrenal vein [8, 9].

Taking into account the highly malignant characteristics of primary adrenal carcinomas (having a strong tendency towards local invasion and metastatic diffusion) and the goal of a laparoscopic surgical procedure (adequate oncological, surgical margins with wide excision), it is suggested that lesions greater than 6–7 cm may render the laparoscopic adrenalectomy a nonradical procedure.

In a metastatic disease, if the lesion appears to be solitary and organ-confined, the procedure could result in prolonged, disease-free patient survival [10]. Indications for laparoscopic adrenalectomy in metastatic lesions include:

- Curative reasons, in solitary adrenal metastasis
- Diagnostic purposes, in suspected adrenal metastasis

Contraindications for transperitoneal laparoscopic adrenalectomy in malignancies can be divided into: contraindications to laparoscopy in general such as severe broncopulmonary or cardiovascular diseases; previous major surgery on the same upper-abdominal region of the adrenal lesion; and contraindications related to pathology such as the evidence of malignant lesions greater than 6 cm, involvement of the adrenal vascular pedicle and of the surrounding tissues [11, 12].

Surgical Technique

Patient Preparation. Fully informed about the surgical technique, its risks and the possibility of conversion to classical, open surgery, the patient is requested to sign a written consent form.

The bowel is mechanically prepared in order to decompress the intestine, providing a better operative field. At the time of anesthesia induction, a broad-spectrum, antibiotic prophylaxis is employed, consisting of a third-generation cephalosporin as well as the administration of 4,000 units of low-molecular-weight heparin. Close collaboration with an anesthesiologist and an endocrinologist is essential – especially in cases of functional diseases, as is often the case with primitive lesions [13] – in order to give the patient proper perioperative substitute therapy, if necessary.

The aim of the surgical procedure is the removal of the adrenal gland en bloc, with an extensive portion of the surrounding, fibrofatty tissue. As such, the wide dissection field remains between the margins of the kidney laterally, the aorta or inferior vena cava medially, the lumbar musculature posteriorly, the renal vein inferiorly and the spleen or liver superiorly. As in open surgery, the first step is the early ligation of the main adrenal vein; moreover, laparoscopy permits proper inspection of the adrenal vein in order to evaluate its potential neoplastic involvement prior to proceeding with adrenal laparoscopic dissection.

Considering the pathology to be treated (malignant lesions), particular care should be taken not to touch the adrenal tissue directly, to avoid potential fractures and a subsequent risk of neoplastic dissemination into the peritoneal cavity.

Under general anesthesia, a nasogastric tube and Foley catheter are inserted, and the patient placed in a $60^{\circ}/90^{\circ}$ flank position, with the bed flexed to increase the space between the costal margin and the iliac crest and to elevate the surgical area (Fig. 1).

The surgeon and the assistant, who holds the camera, stand facing the patient, while the first assistant stands in front of the surgeon. In order to facilitate vision, two monitors are used, thus avoiding head rotation on the part of the first assistant.

A different trocar positioning and a slightly different surgical technique are employed on the left and right sides, according to the different surgical anatomy

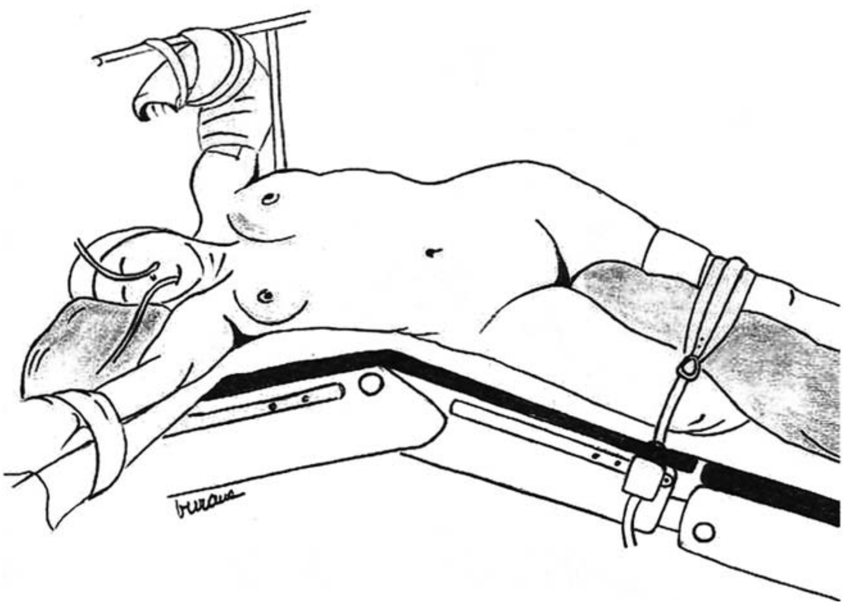

Fig. 1. Patient positioning on the operative table. The bed is flexed in order to increase the space between the costal margin and the iliac crest, thus widening the surgical area

between the two adrenal areas. We normally use five trocars to obtain an adequate surgical field with optimal retraction of the surrounding organs and to avoid potential adrenal injuries during the procedure.

We induce the pneumoperitoneum with a Veress needle. If the patient has undergone previous surgery on the upper abdominal quadrants, the open technique (Hasson technique) is preferable to avoid potential injuries to the intra-abdominal organs. We also use a 25° laparoscope.

At the end of the procedure, it is mandatory to use an impermeable, organ-entrapment bag for extraction of the surgical specimen. Particular care should be taken to avoid rupturing the bag during abdominal extraction. A sufficiently wide skin incision could eliminate this problem.

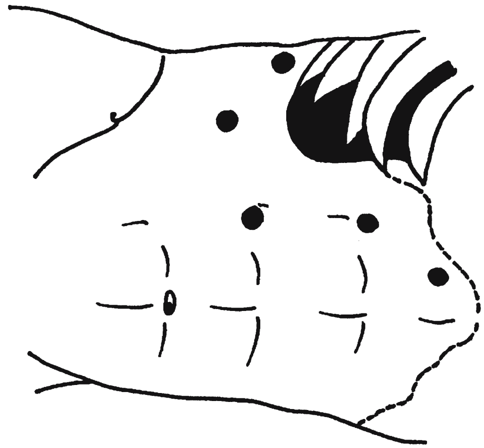

Fig. 2. Port placement for right laparoscopic adrenalectomy (see text for details)

Right Laparoscopic Adrenalectomy. Trocar positioning for right adrenalectomy is shown in Fig. 2. Specifically, the 10-mm optical trocar is inserted 3–4 cm above the umbilicus on the pararectal line. The operative trocars are positioned on the pararectal line 2 cm under the costal arch (5 mm) and on the mammillary line at the level of the umbilicus (10 mm), respectively. A fourth port, used to elevate and retract the liver anteromedially, is positioned 2–3 cm below the xiphoid, and the fifth port is positioned for the assistant on the anterior axillary line, just below the costal margin (the assistant holds the camera in his left hand and the liver retractor in his right hand).

The hepatic triangular ligament is sectioned, if necessary, to mobilize the liver better and widen the surgical area. The adrenal mass can then be viewed in transparency, under the posterior parietal peritoneum.

The first step of the procedure (Fig. 3) is the longitudinal incision of the parietal peritoneum, lateral to the inferior vena cava. This incision should be extended caudally until the renal vein is clearly visible at its junction with the vena cava, and the liver is well separated cranially from the adrenal region. During this dissection, the main right adrenal vein is found, identified and isolated. Prior to ligation, the vein is explored to assess possible neoplastic thrombosis. The short adrenal vein should be isolated in the minimum amount of space needed to position two clips on the proximal edge and one clip on the distal edge. Once clipped, the vein is divided with endoscopic scissors. The use of linear scissors is recommended for this surgical step since the clips are often close to each other due to the short length of the vascular stump.

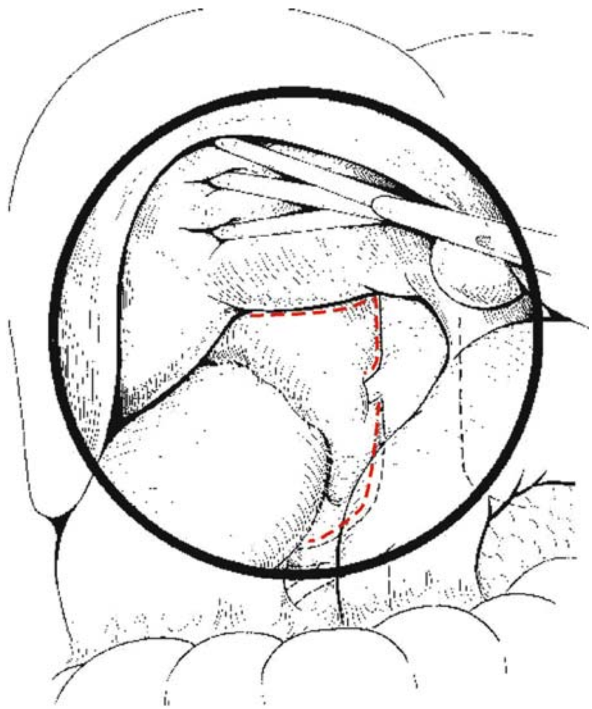

Fig. 3. The posterior peritoneum is incised laterally to the vena cava from the renal vein towards the liver with identification of the main right adrenal vein. The short adrenal vein should be dissected free as much as possible so that at least three clips can be positioned

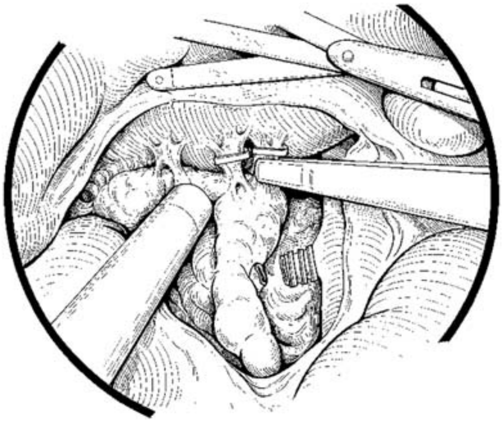

Fig. 4. The adrenal gland is dissected free with wide surgical margins and without direct grasping of the adrenal tissue to avoid tumor fracture during the procedure

Once the adrenal vein has been divided, space between the lateral aspect of the vena cava and the periadrenal fat is created in order to reach the psoas muscle (Fig. 4). During this step, it is essential to develop the plane as closely as possible to the vena cava in order to obtain resection margins that are sufficiently wide. An avascular plane between the adrenal gland and the psoas muscle is easily created, and the gland, surrounded by its fibrofatty tissue, is elevated to expose its plane of cleavage between the kidney's upper pole and the liver. The adrenalectomy is then completed, with wide resection margins; the small arterial branches and secondary veins can either be clipped or controlled with bipolar forceps. It is important to remove all the fibrofatty tissue surrounding the adrenal gland and the kidney's upper pole (Fig. 5).

Fig. 5. The surgical field as it appears following right laparoscopic radical adrenalectomy. The vena cava, liver, lumbar muscles and upper pole of the kidney are clearly evident, as are the wide surgical margins achieved following removal of all the fibrofatty tissue in the adrenal region

Once the adrenalectomy is completed, the specimen is immediately placed in the requisite impermeable organ-entrapment bag; the pneumoperitoneum is reduced to 6–8 mmHg in order to control hemostasis, and a drain is left in place, if needed, for 24 h. After port and specimen extractions, the parietal incisions are closed in the standard fashion.

Left Adrenalectomy. Port positioning in left adrenalectomy is shown in Fig. 6. Optical and operative trocars are positioned in the same way as described for right adrenalectomy, while two additional 5-mm ports are positioned for the assistant, if necessary, along the costal margin on anterior and midaxillary lines, respectively. The more anterior port is used to retract medially the left colonic flexure and the spleen or pancreas tail, if necessary.

The first step in the procedure is the incision of the line of Told, from the splenic flexure to the sigmoid junction, to mobilize medially the left colon and expose Gerota's fascia (Fig. 7). The splenocolic ligament is dissected, if necessary. In case of large lesions, the peritoneal incision at the level of the splenic flexure is

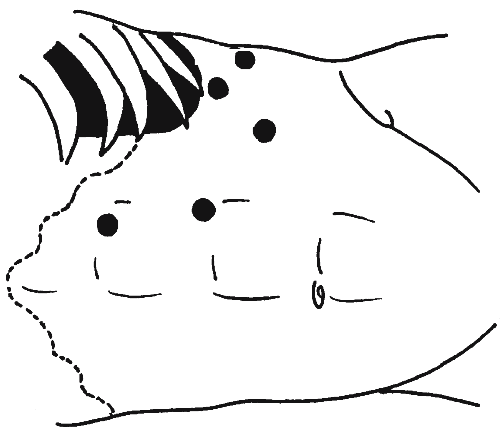

Fig. 6. Port placement for left laparoscopic adrenalectomy (see text for details)

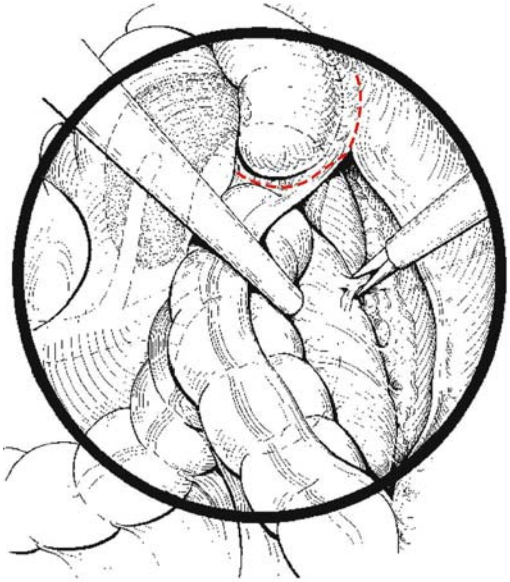

Fig. 7. To expose the left adrenal region, it is necessary to incise the line of Told, from the colonic flexure to the sigmoid junction, in order to mobilize medially the descending colon and to expose Gerota's fascia

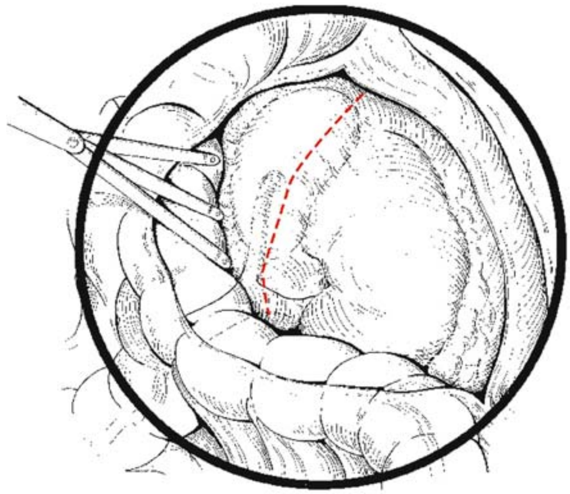

Fig. 8. Once clearly exposed, Gerota's fascia should be incised from the upper pole of the kidney to the left renal hilum to identify the superior aspect of the left renal vein and the junction with the left adrenal vein

extended cranially in order to release the spleen, which shifts medially, resulting in better exposure of the surgical area. Once Gerota's fascia is adequately exposed, it is incised longitudinally from its cranial aspect toward the renal hilum (Fig. 8) to identify and isolate the upper aspect of the renal vein. The main left adrenal vein is then identified at its junction with the left renal vein. The left adrenal vein is generally longer than the right adrenal vein, and its isolation permits easy positioning of the clips (Fig. 9). The vein is then transected and the stump followed as a guidewire to identify clearly the adrenal gland within the perirenal fibrofatty tissue, particularly abundant on the left side. Following the transected adrenal vein inferiorly, the avascular space between the adrenal gland and the psoas muscle is created. The dissection is then continued along the adrenal gland's medial side, along the wall of the aorta, and care is taken to obtain wide resection margins. A secondary vascular pedicle is often encountered during this step and must be clipped and divided. The adrenalectomy is then completed, dissecting the gland for adequate oncological margins from the upper pole of the kidney and from attachments to the diaphragm (Fig. 10).

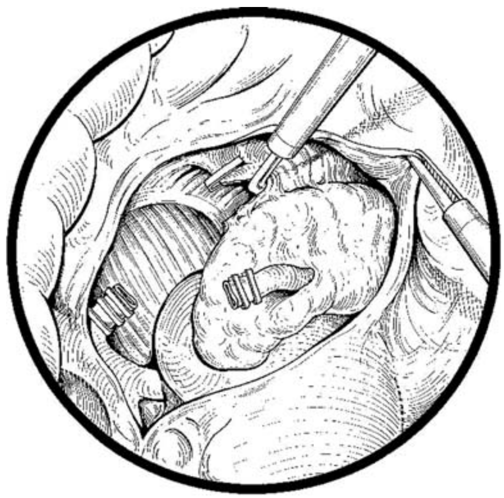

Fig. 9. The adrenal vein is isolated and clipped. Once divided, the stump of the adrenal vein is used as a guidewire to develop adequately the posterior plane between the adrenal gland and lumbar muscles

Fig. 10. The surgical field as it appears following left laparoscopic radical adrenalectomy: the left renal vein with a clip at the junction with the adrenal vein can be seen; a clipped, secondary vascular pedicle on the medial aspect of the plane of surgical dissection and wide surgical margins are also clearly visible

Results and Discussion

Achieving adequately wide surgical margins with en bloc excision of the periadrenal fat is the final key objective in laparoscopic radical adrenalectomy for cancer, including both primitive and metastatic lesions.

After the initial experience in radical laparoscopic adrenalectomy reported by Elashry [6], the feasibility of this surgical procedure has been widely demonstrated by several authors [8, 9, 11].

From an analysis of the available literature [6, 8, 9, 11], it is clearly apparent that the surgical technique is nearly the same as that used for benign lesions, the only differences being wide resection margins and the prevention of direct specimen contact during dissection.

As far as perioperative patient outcomes are concerned, laparoscopic adrenalectomy offers all the typical advantages of minimally invasive surgery when compared to classical open surgery in case of malignancies.

Operating time is slightly longer and conversion rates slightly higher when compared to those reported in benign lesion cases. This could be related to difficulties in the dissection of the periadrenal tissue; the possible presence of adherence with the surrounding organs; the presence of multiple, aberrant vascular pedicles; and, at times, lesion size. The above-mentioned conditions may lead to the conversion into an open procedure for oncological reasons. Similar to adrenalectomy in benign diseases, the postoperative stay is short, with a rapid return to normal health.

When considering the pathologies treated (primary vs secondary), it appears that metastatic lesions are more frequently encountered than primary adrenal carcinomas (AC).

The frequency of AC is low, and the diagnosis is often made at a late stage in the disease; the adrenal mass frequently shows extracapsular invasion, an absolute contraindication to laparoscopic surgery. Luton et al. [13] reported that 79% of ACs are hyperfunctioning lesions and, according to Belldegrun et al. [14], these are usually larger than 6 cm in size at diagnosis: in reviewing 114 ACs, 105 had a diameter of over 6 cm.

With increased lesion size, the possibility of having an extracapsular disease with the involvement of the adrenal vein and/or surrounding organs is substantial; in such cases of locally advanced, aggressive, invasive AC, open surgery remains the approach of choice. Invasive AC is associated with an 18% risk of local recurrence and a 5-year survival rate of 50% or less [15].

Although anecdotal, successful laparoscopic adrenalectomy for AC has been reported even in cases of neoplastic adrenal vein thrombus in a 7-cm adrenal lesion, achieving negative surgical resection margins [16]. This procedure should obviously be undertaken only in centers with great experience in laparoscopy but widens once more the horizons of laparoscopic adrenal surgery.

Adrenal secondary lesions are encountered in cases of lung, kidney, colon and breast cancers and melanoma.

Patients followed up for nonadrenal malignancies usually receive a diagnosis of adrenal secondary lesions when the lesions are still limited in size and are confined intracapsularly. In cases of solitary adrenal metastases, the complete excision may result in a 5-year survival in 20%–45% [8]. Moreover, Luketich and Bart compared adrenalectomy to chemotherapy in treating solitary adrenal metastases and observed that survival in the surgical group was significantly longer [10].

Table 1. Results of major clinical series in laparoscopic adrenalectomy for malignancies

Author	No. of cases	Primary	Metastatic	Mean lesion diameter (cm)	Operative time (min)	Conversion (no. of cases/%)
Elashry et al. 1997 [6]	2	0	2	6	202.5	0/0
Suzuki et al. 1997 [11]	2	1	1	5	Na	0/0
Heniford et al. 1999 [8][a]	12	1	11	5.9	181	1/8
Valeri et al. 2001 [23]	6	0	6	4.5	160	0/0
Kebebew et al. 2002 [9]	20	5	15	5.1	166	1/5
Guazzoni[b]	9	3	6	3.5	155	2/20
TOTAL	51	10	41	5.0	172.9	4/5.5

[a] Eight cases using a transperitoneal approach, four cases using retroperitoneoscopic approach
[b] Unpublished personal series

From an analysis of Table 1, the mean diameter of the lesion in malignancy cases was less than 5 cm; the authors agreed that, in malignancies, the limit for laparoscopic adrenalectomy should be 6 cm, while the limit in benign lesions is related mainly to the surgical team's laparoscopic experience [4, 5]. Limitations of laparoscopic resection in large, malignant lesions are related to the difficulties in developing a proper oncological surgical field, with an increased risk of intraoperative tumor injuries during surgical dissection.

Some authors [9–11, 17, 18] have reported a widespread dissemination of the disease following laparoscopic surgery in AC cases and, less often, for secondary lesions [19] at three sites: in the retroperitoneal space, in the abdominal cavity and at the trocar site.

The literature is, unfortunately, controversial: while cases of intraperitoneal and port-site recurrence are reported, the reviews (11 cases) of other authors [8] at two institutions did not report any local or port-site recurrence.

Similar reports have also been made in cases of open surgery, with neoplastic dissemination at the level of the surgical wound [20]. This reflects how potentially aggressive an AC malignancy may be and how laparoscopy itself is not related to neoplastic dissemination [21].

Proper surgical technique is mandatory in order to perform the procedure according to optimal oncological rules. Moreover, most of the authors prefer the transperitoneal approach in cases of adrenal malignancy; this is probably related to the fact that, for most surgeons, the small working space provided by the retroperitoneoscopic approach is unsuitable for dissecting tumors with diameters of 5 cm or more.

Performing adrenalectomy for malignancy should be limited to those centers having adequate experience in laparoscopic surgery and, particularly, in laparoscopic adrenal surgery, mainly due to the potential difficulties that can arise during this procedure. It is fundamental to avoid excessive adrenal manipulation during surgery to avoid fractures of the parenchyma, with consequent neoplastic seeding into the surgical field and a subsequent risk of local or port-site recurrence of the disease; it should be remembered that the adrenal capsule is thin and delicate, although most of the metastases at the adrenal gland level are organ-confined.

The review series carried out by Henry [22] on 12 cases of primary adrenal carcinoma recurrence treated by laparoscopy showed that complications occurred during dissection of five tumors (four fractures of the lesions and one case of severe bleeding); the authors mentioned that the tumor was removed without rupturing its capsule in only two cases. Recurrences may have been due to incomplete resection or capsular disruption of the tumor during dissection. It should be remembered, however, that these intraoperative complications can also be observed during open surgery.

The possibility of laparoscopic exploration of the adrenal region for suspected malignancies offers the modern urologist both an excellent diagnostic as well as therapeutic tool. Similar to the management of adrenal incidentalomas, the minimal invasiveness of the procedure permits more aggressive behavior in case of suspected adrenal metastases in patients previously treated for other cancers: instead of a time-consuming follow-up of the progression of the lesion (typically resulting in a state of anxiety in the patient), laparoscopic adrenalectomy provides both the correct diagnosis of the clinical condition and a valid therapeutic option.

Conclusions

Our personal experience combined with a meticulous review of the literature suggest that although laparoscopic radical adrenalectomy is feasible in cases of adrenal malignancies, it should be performed only if all oncological rules are respected.

It is mandatory that the surgical team has adequate laparoscopic experience prior to approaching adrenal malignancies in order to avoid unnecessary hazards, namely vascular injuries and tumor fracture. It should be remembered that open surgery still continues to be an important value in adrenal malignancy management.

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1.2 Retroperitoneal Laparoscopic Adrenalectomy for Malignancy

Simon V. Bariol, David A. Tolley

Contents

Introduction

Laparoscopy facilitates access to the adrenal more than any other organ. Since the first laparoscopic adrenalectomy performed in 1992 by Go et al. [1], the indications have expanded beyond small functioning benign tumours to include phaeochromocytomas and localized malignant lesions. The description of the retroperitoneal balloon dilatation technique by Gaur in 1992 [2] revolutionized adrenal surgery, as this approach in particular provides exceptional access to the organ. Nevertheless, *no consensus has been reached regarding the laparoscopic management of malignant adrenal tumours*.

Despite the advantages of retroperitoneal laparoscopy, a wide experience in laparoscopic surgery is required if excessive morbidity associated with learning a difficult technique is to be avoided. This chapter outlines the indications for retroperitoneal laparoscopic adrenalectomy, operative technique, complications and their avoidance.

Patient Selection

Indications

Traditionally retroperitoneal laparoscopic adrenalectomy was reserved for the management of tumours up to 7 cm in size, including aldosterone-secreting tumours, phaeochromocytoma and Cushing's syndrome. Indications have been broadened in a number of centres to include tumours up to 10 cm diameter or greater [3, 4], including primary malignant tumours (adrenocortical carcinoma and malignant phaeochromocytoma) or metastases (usually from lung or renal primary), *provided there is no evidence of local invasion on preoperative imaging* [5, 6].

A retroperitoneal, rather than transperitoneal, approach is of particular benefit in patients with obesity or a history of previous abdominal surgery.

Contraindications

Tumours greater than 10 cm in diameter, local infiltration of surrounding tissues or caval invasion should be managed by open surgery.

Preoperative Preparation

Specific Investigations

The preoperative diagnosis of adrenal malignancy can be difficult to make. *Magnetic resonance imaging (MRI) is the best investigation*, with sensitivity and specificity of 89% and 99%, respectively, in one European study [7], yielding a positive predictive value of 90.9% and a negative predictive value of 94.2%. Size is the most reliable indicator, with a diameter of more than 6 cm observed in 105 out of 114 adrenal cancers in one series [8]. The border between tumour and surrounding tissue must be well defined by preoperative imaging, as this will influence the surgical approach. This is also best appreciated by MRI.

Informed Consent

Patients must be warned of the risk of conversion to open surgery, particularly those with larger lesions or when preoperative imaging reveals a hazy border between tumour and surrounding tissue, possibly indicating infiltration. *The adrenal to be removed should be confirmed with the patient* and the patient marked with indelible ink. The side should be indicated clearly on the operating list and patient's consent form. The risk of local recurrence of the tumour should also be discussed.

Preoperative Preparation

In the case of functioning tumours, appropriate endocrine support must be administered under the supervision of an endocrinologist. High-dose corticosteroids should be administered perioperatively to patients with Cushing's syndrome, to cover their impaired stress response. Patients with a phaeochromocytoma should be adequately blocked (beta-blockers, calcium-channel antagonists and/or alpha-blockers) for at least 2 weeks prior to surgery and they should be well hydrated immediately preoperatively. Patients with aldosterone-secreting tumours are placed on potassium-sparing diuretics and given potassium supplements as required.

Technique

Retroperitoneoscopic adrenalectomy is performed through a lateral or posterior approach, in the lateral and prone positions, respectively. Here, we describe the lateral approach.

Description

Anaesthetic Considerations

Laparoscopic adrenalectomy requires general anaesthesia with muscle relaxation and endotracheal intubation. Patients with a phaeochromocytoma require invasive arterial pressure monitoring. Prophylactic antibiotics are administered.

Patient Positioning

An indwelling urethral catheter is inserted. The patient is placed in a standard lateral decubitus position with the umbilicus over the break of the operating table. The table is flexed to increase the space between costal margin and iliac crest. Lumbar and thoracic supports with padding are placed behind the patient to secure the position. The arm on the side being operated on is flexed with the shoulder at 90° to the chest in an armrest, with padding over bony prominences; the contralateral arm is similarly flexed and protected (Fig. 1). A peripheral warming blanket and compression stockings are applied.

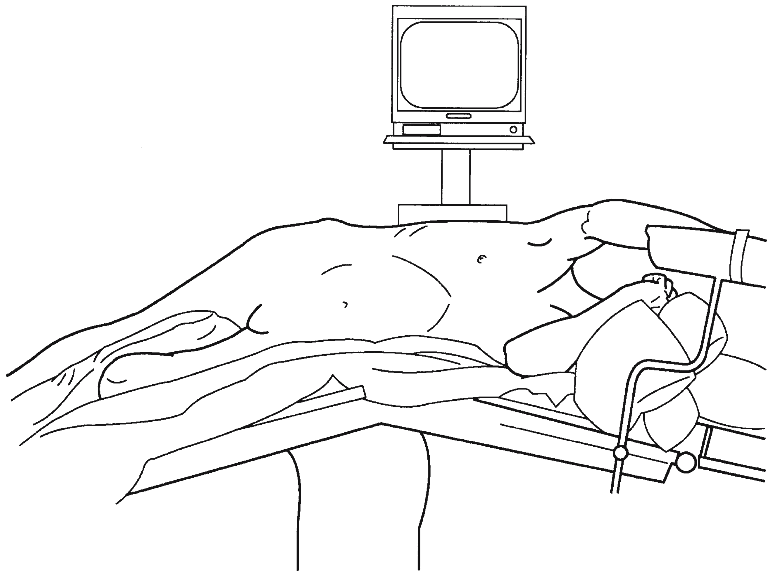
After the patient's skin is prepared and draped, the surgeon and scrub nurse stand facing the patient. The camera stack is moved to a comfortable position directly opposite the surgeon and the assistant sits to the side of the operator.

Retroperitoneal Access

A 2-cm horizontal incision is made immediately below the tip of the 12th rib. Sharp and blunt dissection is used to deepen the incision down to the level of the thoracolumbar fascia. At this point, a finger or artery forceps is forcefully introduced to pierce the fascia and a sweeping action used to create space for the balloon dilator between the psoas muscle and its overlying fascia (posterior) and Gerota's fascia (anterior).

A trocar-mounted balloon device is then inserted and distended to 600–800 ml, with the balloon centred on the mid portion of the kidney. The laparoscope is inserted to ensure the balloon is in an appropriate position. At this point, the balloon can be deflated and manually advanced more cranially along the psoas and deployed again [9]. This creates further space below the diaphragm in the vicinity of the adrenal.

Fig. 1. Patient position



Trocar Placement

After removal of the balloon trocar, a 10-mm primary port is inserted and fixed with a silk suture. CO_2 pneumoperitoneum is established and pressure maintained at 12–15 mmHg. Gas leakage is prevented with a ring-shaped sponge that fits around the trocar. Secondary ports are inserted under laparoscopic control: for right-sided tumours, a 5-mm port is inserted posteriorly, below the 12th rib and lateral to the erector spinae muscles, and a 5- to 12-mm port anteriorly, so that the three ports form a line corresponding to a subcostal incision (Fig. 2). In the case of a left-sided tumour, the ports are reversed so that the 5–12 mm port is at the surgeon's right hand (assuming the surgeon is right-handed).

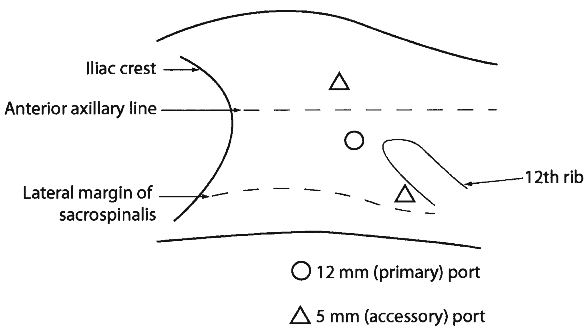


Fig. 2. Retroperitoneal laparoscopic adrenalectomy trocar placement

Initial Dissection

A 30° laparoscope is introduced. The posterolateral aspect of Gerota's fascia is incised longitudinally along the upper pole of the kidney. Once the upper pole is defined, the incision is carried transversely to separate the upper pole of the kidney, within Gerota's fascia, from the adrenal gland. Caution with this dissection, to avoid bleeding from upper-pole vessels, is necessary. The harmonic scalpel is especially useful for this part of the procedure, especially in the presence of a large adrenal tumour. This dissection should result in the kidney and perinephric fat dropping down away from the adrenal. The adrenal gland maintains its position by virtue of its undisturbed peritoneal attachments.

Control of Adrenal Vein

Gerota's fascia is incised posteriorly from the diaphragm to the renal pedicle. Careful blunt dissection, using the sucker-irrigator tip and right-angled forceps, defines the upper limit of the renal hilar vessels. The different venous drainage of the left and right adrenal glands (the left adrenal vein drains into the renal vein, while the right drains directly into the inferior vena cava) demands that they are approached differently.

For right adrenalectomy, the lateral aspect of the inferior vena cava is carefully followed above the origin of the renal vein until the right adrenal vein is identified. It is normally encountered superomedial to the gland itself. The vein is dissected clean, clipped and divided.

On the left side, dissection along the renal vein will identify the adrenal vein arising from its superior aspect. The vein is clipped and divided. Other small branches between the renal hilar vessels and adrenal are commonly encountered, and should be dealt with in the same way.

Adrenal Mobilisation

Following the adrenal vein facilitates identification of the gland, particularly on the left side. Dissection is completed medially, with ligation and division of aortic branches using laparoscopic clips. The remainder of the gland is mobilization with blunt and sharp dissection, although caution should be exercised along the glands' superior aspect where inferior phrenic branches are encountered. We have found the endo-GIA or the harmonic scalpel to improve haemostatic control during dissection of the gland's medial and superior borders. Oncological surgical principles must be maintained during dissection: never handling the tumour or adrenal directly and removing tumour and all surrounding fat en bloc. If oncological safety appears to be compromised because of poor vision or inadequate working space, open conversion must be undertaken.

Specimen Retrieval

The adrenal is grasped with heavy laparoscopic forceps (Babcock forceps are ideal). The specimen is held away as the adrenal bed is inspected for bleeding. This inspection should always be performed at low intra-abdominal pressure, to ensure that venous bleeding is not masked. The pneumoperitoneum is re-established and a small laparoscopic catchment bag is inserted through the 12-mm secondary port and the specimen carefully placed within it and removed intact.

Wound Closure

A drain should be placed if there is concern about bleeding from excessive ooze. The 10- or 12-mm port sites are closed in fascial layers with absorbable suture on a J needle. The 5-mm port sites do not need muscle closure, nor do those placed on the costal margin. Skin is closed with clips or subcuticular suture.

Technical Modifications

Blind trocar insertion is employed in exceptional cases when the ports are too close together to enable reliable laparoscopic viewing. This method carries an increased risk of bowel (from anterior ports) or major vascular injury (posteriorly), which is not present when all trocars are introduced under vision, but Hsu et al. have described a relatively safe bimanual technique which involves directing the new trocar onto an S-shaped retractor, cradled by the surgeon's left index finger, which has been introduced through the primary port [10].

Balloon dilatation is not practised in all institutions, some preferring to create the working space under visual control [11] or with finger dissection [12]. In one comparison of balloon and finger dissection, operative time was shorter with finger dissection and all other surgical parameters, including blood loss, peritoneotomy, analgesic requirement and convalescence, were equivalent [12].

There are two alternative laparoscopic approaches to the adrenal gland. The transperitoneal laparoscopic approach to adrenalectomy, for benign and malignant conditions, is perhaps more widely practised. The main advantages are greater working space and increased familiarity with the approach. The excellent chapter by Guazzoni (Transperitoneal Laparoscopic Adrenalectomy in Malignancies) in this text outlines this approach in detail.

Posterior retroperitoneal laparoscopy is the preferred technique for some [13]. Apart from the advantages of all retroperitoneal approaches, avoiding the peritoneal cavity and therefore reducing the risk of bowel injury, the posterior approach provides direct access to the main adrenal blood supply before the gland is manipulated [14].

Postoperative Care

Patients receive oral analgesia with intramuscular narcotics if required. The catheter is removed on the first postoperative day. Diet is progressed as tolerated, and the patients can mobilize without restriction. Many patients are now managed in 23-h stay wards. Heavy lifting is avoided for 6 weeks to allow muscular healing.

Technical Tips

Peritoneal Injury

Breach of the peritoneum during access, balloon dilatation or dissection causes air to enter the peritoneum, which then reduces the retroperitoneal working space. *This is easily overcome by inserting a cannula into the peritoneum to vent intraperitoneal gas.*

Trocar Placement

Trocars should be separated as much as possible from each other and from bony landmarks, especially the iliac crest, which may otherwise compromise instrument manoeuvrability.

Fourth Trocar

The use of an extra port for retraction purposes is encouraged. This decision should be made early at the first sign that additional retraction of the kidney or adrenal is likely to be needed. A 5-mm trocar is inserted in line with the primary port in the anterior axillary line.

Obese Patients

Consider using long trocars and a purse string suture of the sheath to facilitate closure at the end of the procedure.

Ribbon Gauze

Intracorporeal ribbon gauze strips can be used for temporary haemostatic control, to absorb any blood or clot, and to facilitate blunt dissection [15].

Complications

Intraoperative Complications

The major intraoperative complication is bleeding following vascular injury, with the inferior vena cava (IVC) and accessory renal vessels particularly susceptible, tension pneumothorax due to diaphragmatic/pleural injury, liver, pancreatic and splenic injury [4, 16, 17]. Carbon dioxide absorption is higher during retroperitoneal laparoscopy; however, if hypercapnia occurs it is easily controlled by ventilation [18].

Open conversion rates vary between institutions, ranging from 0.8%–7.7% [14, 16, 17, 19]; however, this is affected by the indication for surgery and surgical experience.

Postoperative Complications

Major complications are unusual following retroperitoneal laparoscopic adrenalectomy. Complications that have been described include haematoma, wound infection and incisional hernia. Subcutaneous emphysema can also occur but is rarely troublesome.

Tumour dissemination is a potential complication of the laparoscopic approach. Tumour recurrence, either locally, in port sites or metastatic, has been described following laparoscopic adrenalectomy for primary tumour and isolated metastasis [20, 21].

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2.1 Transperitoneal Radical Nephrectomy

Alwin F. Tan, Adrian D. Joyce

Contents

Introduction

Robson in 1963 established the technique and principles of open radical nephrectomy [1], and today the technique of radical nephrectomy is still regarded as the standard treatment for localized renal cell carcinoma.

It took another 27 years before Clayman et al. at Washington University in 1990 undertook the first laparoscopic transperitoneal radical nephrectomy. The patient was an 85-year-old woman and the operation took 6.8 h and was a success [2]. The first transperitoneal simple nephrectomy to be performed in Europe was by Coptcoat et al. [3] 1 year later, in 1991, and the rest is history.

Over the last 10 years, the combined worldwide experience has established laparoscopic transperitoneal simple nephrectomy as a safe procedure, with the added advantages of decreased analgesia requirements, improved cosmesis, shorter hospital stay and early return to premorbid activity. It is therefore not surprising that laparoscopic nephrectomy for benign disease has gained acceptance both by the urological community and patients as a standard of care. It is natural to assume that the next challenge would be to apply the acquired skills to radical nephrectomy for malignancy and currently, the transperitoneal route remains the most popular approach.

This chapter aims to explore the current status of the practice of transperitoneal laparoscopic radical nephrectomy. The discussion will cover the indications and contraindications for the technique, the preoperative preparation, positioning, surgical technique, potential complications, morbidity, functional impact, efficiency and oncological effectiveness. The related cost benefits, controversies and current limitations of the technique will be assessed together with possible future horizons. Where possible, we will compare the technique to the current traditional standard of care of open radical nephrectomy. However, as yet there are no randomized controlled data available comparing the laparoscopic with the open technique, but a number of comparative studies have been published, and the key issues are whether the laparoscopic approach is surgically equivalent or better compared to the open technique and whether there is equivalence in oncological outcome with the new technique.

Indications and Contraindications

Indications

The indications continue to expand as the surgeon's expertise grows, and we feel that all patients who are a candidate for an open radical nephrectomy should be potentially considered for their suitability to a laparoscopic approach. There is growing evidence that suggests that for T1 and T2 tumours, laparoscopic radical nephrectomy is emerging as a strong alternative to the open procedure [4, 5]. The upper limit of T2 in terms of size is very much coloured by the individual surgeon's experience, and laparoscopic removal of T3a and even T3b tumours have been reported.

In 1999, Walther et al. pushed the ceiling even further by performing laparoscopic nephrectomy in patients as a cytoreductive procedure prior to immunotherapy. Interestingly, they noted that the recovery of these patients was significantly better than their open-surgery counterparts, such that they were able to initiate their immunotherapy treatment by up to 1 month earlier [6].

Contraindications

Patient selection is important and current relative contraindications include T3 and T4 tumours together with bulky nodal disease and caval involvement. Other relative contraindications rather than absolute factors include:

- Severe COAD
- Difficult body habitus
- Previous upper abdominal scar or adhesions
- Patient's choice after full informed consent

The published literature supports the caveat that laparoscopic radical nephrectomy is indicated for stages T1–T3a where the tumour is confined to the kidney with no radiological evidence of venous or nodal involvement. The upper limit of size is again a reflection of the surgeons' experience with the technique and their ability to perform a radical nephrectomy without comprising the oncological safety of the procedure.

Preoperative Preparation

Imaging

Diagnostic staging is mandatory prior to embarking on the procedure involving a contrast computer tomography (CT) urogram, where the tumour is identified as showing contrast enhancement. CT angiography, or MRA may be used as an adjunct, especially if there is concern over vascular invasion from the tumour and it should be noted that aberrant vessels can occur in as many as 30%–40% of cases. Some institutions have the luxury of 3D reconstruction imaging facilities readily available, even in the operating theatre, which may assist in operative planning, particularly in nephron-sparing procedures (Fig. 1).

Consent

Laparoscopic surgery demands special skills and it is important to discuss with your patient that there are specific risks that they must be aware of before consenting to this approach:

- Possible risk of access injury due to the inadvertent puncture of an organ if a Veress needle is used to create the pneumoperitoneum

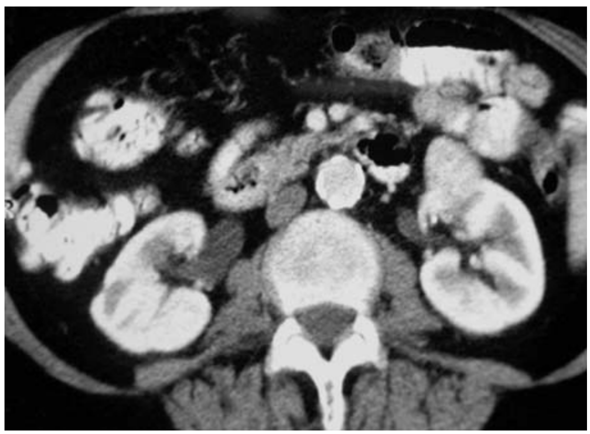

Fig. 1. CT showing typical features of renal malignancy in the (*L*) kidney

- Possible risk of inadvertent injury to another organ during the dissection of the kidney (< 1%)
- Possible risk of bleeding from the artery and vein
- The potential need to convert to the traditional open operation if difficulties arise (< 10%)

Optimal preoperative medical and anaesthetic assessments should include:

- Basic investigations – full blood count, electrolytes, liver function tests, blood gas estimations, X-match
- Bowel preparation – not routine in the author's approach, although some advocate an enema for a left-sided tumour
- Instrument check list, with both open and laparoscopic set up available

Positioning Patients

Our preferred placement is the flank position – lateral decubitus – with the affected side up with break at the level of umbilicus and a degree of posterior rotation, but the break is only to open up the area beneath the 12th rib and is not the typical renal position (see Fig. 2). Meticulous padding of the soft tissues and bony sites is extremely important to avoid possible neuropraxia due to a lengthy procedure, with particular support given especially to the downside shoulder, hip, knee and ankle. This is crucial, particularly at the start of the surgeon's experience where the procedure times tend to be longer.

We also advocate the use of a body warmer to minimize patient cooling and calf stimulators to reduce the potential risk of deep vein thrombosis (DVT).

Operative Technique

Since its inception in 1990, the technique has constantly evolved with significant advancements. New technology and instrumentation have also emerged in the meantime. Therefore, it is not surprising that there is variation in the technique between centres. However, the authors consider the following key steps important in contributing to a successful outcome:

Peritoneal Access

We have long advocated the open technique (Hasson cannula technique), currently using the Tyco 10-mm blunt tip trocar (BTT) (see Fig. 3) for our initial port. This trocar arrangement provides a good occlusive seal with minimal gas leak and is especially helpful in obese patients. Alternatively, one may choose the closed technique utilizing the Veress needle, but we are concerned that one of the major risks of laparoscopy is associated with access. Four per cent of laparoscopic complications are related to access injury involving the Veress needle; therefore it is an easy complication to avoid with the open technique and only adds a few minutes to the procedure.

- CO_2 insufflation is initially delivered at low flow. A low abdominal pressure confirms that the tip of the trocar is in the peritoneum. If there is any concern, then elevation of the anterior abdominal wall with a subsequent pressure drop confirms a satisfactory position.
- An overview inspection is necessary to ensure no inadvertent injury to underlying bowel caused by peritoneal access, particularly in patients where the Veress needle technique is utilized, and to look for alternative pathology.

Fig. 2. Illustrating the position of the patient on the table

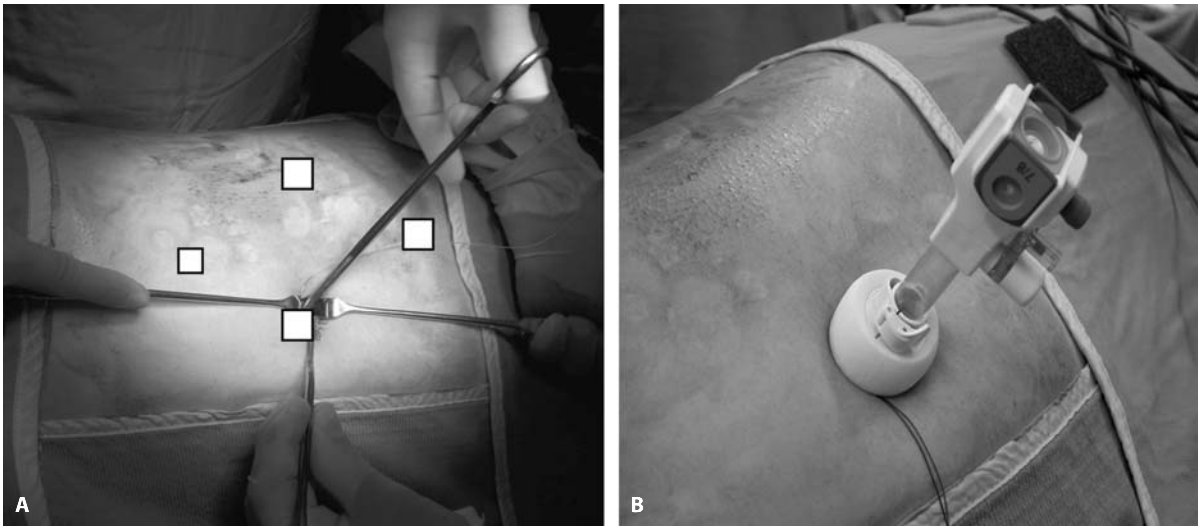

Fig. 3 A, B. Illustrating the open approach and the position of the blunt-tip trocar

- Port placement. Three other working ports as indicated by the white boxes in the figure above is standard (occasionally an extra port is required for liver or spleen retraction).

Colon Mobilization and Retroperitoneal Incision

On the right side the kidney, the splenic flexure often lies above the hepatic flexure, whereas on the left side the it usually has to be mobilized (Fig. 4).

- Line of Toldt – incise and reflect colon medially.
- Identify the "crackly" bloodless plane between the bowel mesentery and the anterior surface of Gerota to allow peeling as in the open approach.

Right Radical Nephrectomy

- Incise along posterior hepatic ligament to free the inferior posterior liver edge from the specimen (the length of the line depends on whether the adrenal is to be spared).
- Incise the peritoneum parallel to ascending colon and above the hepatic flexure medially until the inferior vena cava (IVC) is exposed.
- The duodenum, which is medial to the IVC, must be identified and dissected free from Gerota and rotated medially (Kocher manoeuvre) to further expose the anterior surface of IVC.

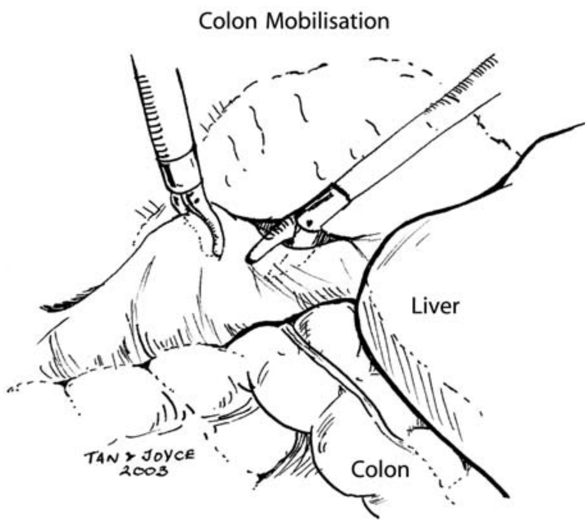

Fig. 4. Colon mobilization

Left Radical Nephrectomy (Beware of the Spleen!)

- Incise along the line of Toldt parallel to the descending colon to free the lienophrenic ligament first.
- Peel the left colon away from Gerota by dividing the splenocolic ligament at the splenic flexure.

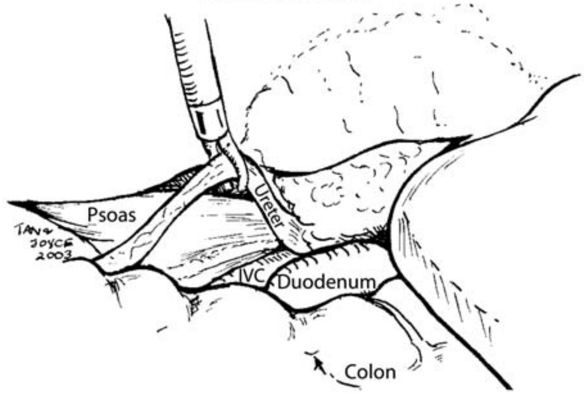

Fig. 5. Identification of ureter, gonadal vein and psoas (key landmark)

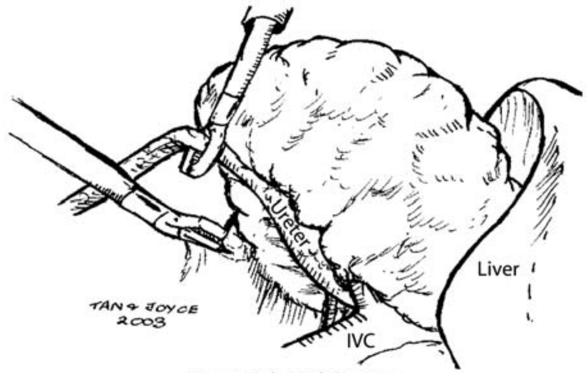

Fig. 6. Lower renal pole mobilisation

- Great respect and time must be taken to mobilize the spleen from the upper pole of Gerota by dividing the splenorenal peritoneal attachments.
- Delicate care must be exercised when handling the tail of the pancreas, which can be nestled across the renal hilum (Fig. 5).
- The fourth port is placed using a grasper for the ureter to provide lateral traction and elevation (we prefer not to divide the ureter at this point).

Dissection Continues up the Groove by Elevating the Ureter and Mobilizing the Lower Pole of the Kidney

- Mobilization is achieved by a combination of dissection with the harmonic scalpel and blunt dissection using the sucker tip or Endo-dab along the IVC (on right) and the aorta (on left) (Fig. 6).
- Blunt dissection of Gerota frees the lower pole – to facilitate the anterior rotation of lower pole – to bring out the renal artery, which is usually located posteriorly.

Hilar Dissection and Vascular Control

- Right side: often the gonadal vein needs formal ligation (clip and divide), to minimize the risk of traction avulsion and awkward bleeding. The renal vein is usually just superior.
- Left side: also identify the gonadal vein, which will lead to the trifurcation of the renal, adrenal and gonadal veins. Divide the last two and use the gonadal vein to facilitate posterior dissection of the renal vein for any posterior lumbar veins.

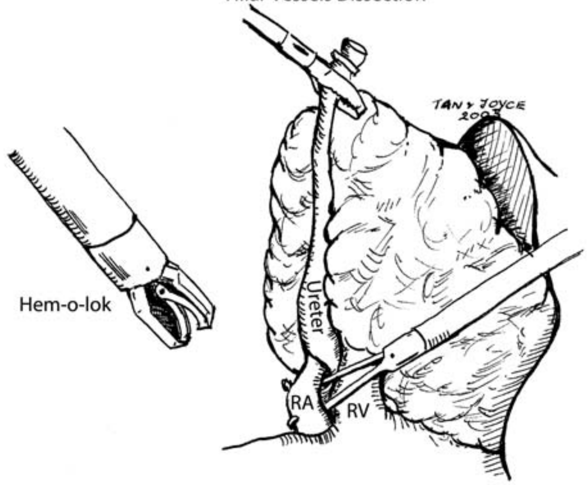

Fig. 7. Illustrating dissection and Hem-o-Lok ligation of the renal artery

- Renal artery: mobilized circumferentially using a right-angle dissector (see Fig. 7) – then ligated using the Hem-o-Lok device with a minimum of three on the major vessel side. If there is concern over access, then a single clip can be applied and further ligation after division of the renal vein.
- Renal vein: careful dissection right down to the vessel wall to display the branches, especially the adrenal vein (left nephrectomy) and beware of any lumbar veins posteriorly.

– Renal vein: generally secured with an endo-GIA stapler via the size 12 port (care must be taken not to fire across any adjacent clips which can result in misfiring and profuse bleeding!)
- Be cautious of any aberrant vessels.

Adrenalectomy is indicated in upper pole tumours, but is not routinely advocated for lower pole lesions:
- Right side: continue superior dissection along vena cava medial to adrenal, which is short and often posteromedial to the cava and may need further Hem-o-Lok ligation. Beware of the adrenal vein.
- Left side: the adrenal vein is usually quite evident once the renal vein is displayed at the trifurcation.

Upper Pole Detachment

- The authors prefer to utilize a grasper via the fourth port to retract a peritoneal leaf still attached to the liver or spleen. Apply medial traction within the pseudo-triangle made up of the psoas, liver/spleen and diaphragm. This pseudo-cave facilitates detachment of the upper pole, especially if there is more than the usual adhesions to the Gerota fascia (Fig. 8).

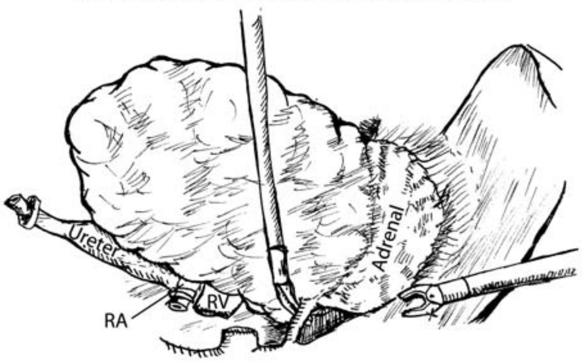

Fig. 8. Illustrating division of any additional adrenal veins

Specimen Entrapment and Extraction

- Various entrapment sacs can be utilized, e.g. Endocatch/Endopouch/Bert series of bags made of parachute superdurable material. Currently the 15 mm Endocatch bag (Tyco) is preferred.
- Extraction is done via small muscle splitting with an extension of the size 12 port preferred.
- Morcellation is not advocated.

Final Check for Haemostasis and Closure of Port Sites

- Haemostatic check with carbon dioxide flow lowered
- Closure and tube drain

Results

The latest published data for transperitoneal laparoscopic radical nephrectomy are shown in Table 1.

Complications

As most centres started with laparoscopic simple nephrectomy, it is not surprising that progression to radical nephrectomy resulted in few complications relating to the laparoscopy learning curve. Thus the operative complication rates are generally low in the laparoscopic radical nephrectomy series, with major complication rates under 10%. However, the reporting of complications is highly variable and subjective, with some authors including conversion as a complication and others not.

Analysis of early experience demonstrates minor complication rates as high as 34%. However, a follow-up analysis in 2000 by Gill et al. [7] of a worldwide aggregate of experience with 266 patients demonstrates figures of 23% for minor complication rates and 7% for major complication rates. The overall conversion rate was 4%. However, there were four re-

Table 1. Published data for transperitoneal radical nephrectomy

Series	No. of patients	Operating time (hours)	Blood loss (ml)	Hospital stay	Complication minor	Complication major	Conversion rate
Janetschek et al. (2002) [9]	121	2.4	154	6.1	5%	4%	0 patients
Dunn et al. (2000) [8]	60	5.5	172	3.4	34.4%	3.3%	1 patient
Ono et al. (1999) [13]	60	5.2	255	–	3%	8%	2 patients
Barrett et al. (1998) [12]	72	2.9	–	4.4	3%	5%	6 patients

Table 2. Classification laparoscopic complications

Access related	Organ or abdominal wall injury
Intraoperative	Vascular, bowel, splenic injury or failed entrapment
Postoperative	E.g. respiratory, gastrointestinal bleeding

Siqueira et al. [21]

ported deaths: three were from myocardial infarction and one was unknown.

Shalhav's group in Indiana reported a series of 61 laparoscopy radical nephrectomies with most of them approached transperitoneally. Their major complication rate was 5%, predominately due bleeding. More significantly, they have proposed a classification table for laparoscopic complications, as shown in Table 2, which will require universal acceptance.

Operative Time (Efficiency)

Operative time is definitely a function of experience. At Washington University where the technique was first reported, with experience they were able to drop the operative time from 7 h to 5.5 h [8]. A recent publication from Janetschek in 2002 reported a mean operative time as low as 2.4 h [9]. Our standard operative time for an uncomplicated laparoscopic radical nephrectomy is 2.3 h.

Various suggestions have been made with regard to reducing operative time utilizing alternative techniques for dissection such as the harmonic scalpel, the system for bipolar dissection in the nondominant hand, aquajet dissection, the CO_2 insufflation heating device and projecting the image [9–11]; however, the most significant factor is the team approach so that instruments are ready and available with minimal delay between instrument change, leading to a smooth uninterrupted sequence of steps.

Morbidity

Universally, there has been a clear advantage in comparative studies of nephrectomy for similar tumour sizes in patients in favour of the laparoscopic approach.

Studies undertaken at Washington University demonstrate a clear advantage [10] with the laparoscopic approach. This approach requires 67% less analgesia, a 29% reduction in the time spent in hospital, has 10% fewer complications and has 73% less convalescence time. Patients also lose less blood and thus have a lower transfusion rate. Hospital stays ranged from 3 to 7 days in the large reported series [4, 8, 9, 12, 13]; however, the length of stay can be a reflection of local healthcare issues.

Biochemically, there is evidence to suggest a reduced stress response in the laparoscopic cohort of patients. Miyake et al. retrospectively compared humoral stress mediators released 48 h preoperatively to 96 h in the postoperative period between laparoscopic and open urological surgery. Their cases included radical nephrectomy, nephroureterectomy, prostatectomy and cystectomy. They focused on levels of interleukin-6 (an early mediator of tissue damage), granulocytic elastase (a serine protease released by granulocytes in response to necrosis) and interleukin-10 (a marker of tissue damage severity). The maximum levels of all three mediators were significantly higher in the open surgery group [14].

It has also been suggested that there is less immunosuppression in studies from laparoscopic cholecystectomy patients [15].

Oncological Control

Immediate Adequacy

Laparoscopic transperitoneal radical nephrectomy provides an equivalent specimen to the open procedure. It adheres to the principle of open surgery in providing an en bloc excised kidney, adrenal, perirenal fat, hilar nodes and the Gerota fascia [4]. In comparing specimen weight, it is important to remember that morcellation can account for a specimen weight reduction of 21% [8].

Seeding Risk (Peritoneum or Port)

Despite earlier fears, so far there is no recorded case of intraperitoneal seeding. However, there is one local recurrence in a multinational study at the 5-year mark reported by Portis et al. in 2002, as well as a case of local recurrence in the comparative open group [4].

As far as port site seeding is concerned, there has been one case reported to date [16]. It involved a 76-year-old man, and the tumour recurrence was detected after 25 months of follow-up at the nonmorcellated site. The original operation was for an 862-g specimen with T3NoMo tumour, and the histology revealed a renal cell carcinoma with sarcomatous elements.

Metastasis and Survival

The question of equivalence with open surgery at 5-year survival was addressed by a landmark paper by Portis et al. in 2002. It was a retrospective international multicentre study involving three centres in Nagoya, Japan, Saskatoon, Canada and St. Louis, Missouri [4]. It reported on all patients who had undergone radical nephrectomy before November 1996. In total, there were 64 laparoscopic vs 69 open radical nephrectomies. Most of the laparoscopic cases (52/64) were performed transperitoneally. Forty-three of the 64 specimens included the adrenal en bloc; 39 tumours out of 64 were removed intact. However, the average tumour size was smaller in the laparoscopic group (4.3 vs 6.2 cm). Table 3 illustrates their results [4].

Thus, the intermediate data at the 5-year mark indicates that laparoscopic transperitoneal radical nephrectomy appears to be every bit as effective as the open procedure. There is no significant difference in terms of overall survival, cancer-specific survival and when analysed with the new TMN classification in terms of T1 and T2, as demonstrated in Table 3 above.

There was one recurrence in each group. In the laparoscopic group it was for a 9-cm lesion detected at 1 year follow-up, while the open group involved a patient with a 15-cm lesion detected at 8.2 years of follow-up.

The comparable actuarial disease-free rate and cancer survival appears to reiterate the results of earlier series with shorter follow-up by Ono [5] and Cadeddu [17].

Table 3. Laparoscopic versus open radical nephrectomy

Mass size (cm)	Laparoscopic	Open	P value
Mean follow-up (years)			
All	4.49	5.77	0.000
Less than 7 cm	4.65	5.89	0.002
7 cm or greater	3.82	5.69	0.017
Overall survival			
All	81%	89%	0.260
Less than 7 cm	82%	92%	0.272
7 cm or greater	89%	86%	0.883
Recurrence-free survival			
All	92%	91%	0.583
Less than 7 cm	92%	95%	0.951
7 cm or greater	87%	83%	0.804
Cancer-specific survival			
All	98%	92%	0.124
Less than 7 cm	97%	95%	0.303
7 cm or greater	100%	87%	0.383

Portis et al. [4]

Cost Benefits

"Although one cannot avoid the issue of cost, it is important that we do not forget that our foremost duty to our patients is to do no harm."

Cost-benefit analysis very much reflects local health care provision and has been an important factor in the overall analysis in the United States. For example, an analysis in a US health provider setting at Washington University showed that laparoscopic nephrectomy is only cost-effective if the surgeon can reduce the operating time below 3.5 h [10].

Further analysis by The Cleveland Clinic showed that despite a 5-day reduction in hospital stay, laparoscopic radical nephrectomy was still 29% more expensive than the open procedure [2].

The same institution also pointed out in an earlier study that costs do come down with time, especially with reduction in operating times. They priced laparoscopic nephrectomy initially as 33% more expensive but with experience the laparoscopic procedure can be 12% cheaper than open nephrectomy, as the most expensive factor seems to be the operating theatre cost in terms of time and disposables.

However, taking the bigger picture into consideration, one needs to remember the reduction in community cost made possible by the reduction of the convalescence period of up to 4–6 weeks in the laparoscopic group [8]. Another factor that is often ignored is the cost to primary health care of managing the patient in the community as a consequence of problems related to the incision in the open group.

Controversies

Morcellation

Although the issue of tumour spillage has been plagued with much concern, there is only one reported case of port-site recurrence [16]. Even so, care must be taken to drape the field and isolate the port prior to morcellation. There are now entrapment bags available that are impermeable and disruption-resistant, as demonstrated by Urban et al. [18].

Supporters of morcellation claim that with a smaller incision, there is less morbidity. This was certainly not supported by Gettman et al. 2002 [19]. In a prospective trial of laparoscopic radical nephrectomy, seven specimens were fragmented and extracted via the umbilical port incision (average, 1.2 cm) while five other specimens were removed intact via an incision averaging 7.6 cm in diameter. There was no significant difference in intraoperative parameters, postoperative pain or time to resumption of normal activity.

Furthermore, in a retrospective case controlled cohort study, Savage and Gill [20] found no significant difference with regard to opiate analgesia requirements, hospital stay, recovery or convalescence between muscle cutting and muscle splitting incisions relating to extraction.

If that is the case, then one should consider the implication of the sacrifice of exact pathology where the specimen is morcellated in the name of cosmesis.

Tumours 4 cm or Less – Laparoscopic Radical vs Open Partial Nephrectomy

The difficult issue that has plagued open surgery of a radical vs partial nephrectomy for a small tumour in the presence of a normal functioning contralateral kidney is certainly a challenging one to address and is the subject of ongoing discussion and prospective trials.

Transperitoneal vs Retroperitoneal Approach

Currently there is no randomized prospective trial comparing the two procedures even though the operative time seems to favour the retroperitoneal approach [7].

The obvious advantages for the transperitoneal approach include familiarization of anatomical landmarks and greater freedom for mobilization and organ entrapment. Disadvantages must include bowel handling, which can lead to prolonged ileus, and also the extra time taken for dissection.

The general consensus is that one should perform the operation that has the best outcome in the hands of the individual surgeon. However, techniques may need to be varied to suit the individual patient differences; for example, evidence of previous abdominal surgery may favour an extraperitoneal approach.

Future Horizons

After more than a decade since laparoscopic radical nephrectomy was introduced, one can say with confidence that the evidence supports the contention that this is a reasonable alternative to open radical nephrectomy for T1 and T2 disease. Patients can expect less morbidity in terms of a shorter hospital stay, less pain, less blood loss, lower complication rates and an earlier return to premorbid activities and life style, without compromising the oncological outcome. With regard to long-term cancer control, the analysis at the 5-year mark shows promise. Only time will determine the ultimate role of laparoscopic radical nephrectomy as the standard of care in the new millennium.

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2.2 Extraperitoneal Laparoscopic Radical Nephrectomy

András Hoznek, Laurent Salomon, Clément-Claude Abbou

Contents

Introduction

Radical nephrectomy is the gold standard treatment of kidney cancer. Its principles were described by Robson [1] in 1963: primary ligature of the renal artery and vein, removal of the kidney together with its envelopes, including Gerota's fascia, the adrenal gland, and regional lymphadenectomy. These principles are still considered valid; however, during the last decade the operative approach has been modernized. Since the first laparoscopic radical nephrectomy reported by Clayman [2] in 1991, this minimally invasive technology has gained much popularity. Three variants are currently used worldwide: the transperitoneal laparoscopic, the extraperitoneal laparoscopic and the hand-assisted approach for radical nephrectomy.

All these techniques have their specific advantages and drawbacks. The transperitoneal laparoscopic approach is preferred by many surgeons because it offers a large working space. Hand-assisted laparoscopic renal surgery is a hybrid procedure, during which the surgeon places his nondominant hand into the abdominal cavity. This helps to overcome some inherent obstacles associated with conventional laparoscopy, such as loss of tactile feedback and special orientation, thereby reducing the learning curve. In our department, we decided to develop the extraperitoneal laparoscopic approach, because the access to the renal pedicle is quicker, safer and easier. Postoperative morbidity is diminished because of the absence of intraperitoneal complications: patients have less pain and there is no ileus.

Preoperative Preparation

The patient must fast starting at midnight on the night before surgery. Blood type and cross-match are determined. When inducing anesthesia, prophylactic antibiotic therapy with a second-generation cephalosporin is administered. Prophylactic treatment with low-molecular-weight heparin is begun on the day of surgery.

Instruments

- Video unit
  - Preferably two monitors
  - Insufflation system
  - Suction device
  - Monopolar and bipolar cautery energy source
- Trocars
  - 12-mm blunt port trocar
  - Two 12-mm trocars
  - Two 5-mm trocars
- Laparoscope
  - Zero degree lens
- Primary surgeon
  - Rotating tip coagulating scissors
  - Bipolar coagulator

- Suction-irrigation
- Clip applier, medium large (9-mm) metallic clips
- Linear stapler (Endo-GIA)
- Entrapment sac (Endocatch)
- Needle holder (required only exceptionally)

- Assistant
  - Two 5-mm fenestrated graspers

In addition, standard open surgical instruments should be immediately available in case of an emergency conversion.

Fig. 2. Patient positioned with flexed legs

Operative Technique

- A nasogastric tube and a Foley catheter are inserted prior to surgery.
- The patient is positioned in lateral decubitus, with the lumbar support raised to its maximum height (Fig. 1). The legs are flexed slightly forward and paced on the anterior leg rest. The posterior leg rest is removed to leave room for the assistant who holds the laparoscope and camera (Fig. 2). The primary surgeon stands behind the patient, his assistant and the scrub nurse in front of him. A second assistant or the scrub nurse holds the camera. The optimum is to have two video screens (Fig. 3).
- A mini-lumbotomy (2-cm incision) is done in the posterior axillary line 1–2 cm below the 12th rib (Fig. 4a). The abdominal wall and the transversalis fascia are incised. The posterior pararenal space is dissected with the finger, the peritoneal reflection is pushed forward (Fig. 5). Two 5-mm trocars are inserted with digital guidance in the anterior axillary line, one in the upper part and one in the lower part of the abdomen (Fig. 4d, e). A 12-mm trocar is placed 2 cm above the iliac crest, in the mid axillary line (Fig. 4c). A 12-mm trocar is placed in the posterior axillary line above the iliac crest (Fig. 4b). The blunt port trocar with a foam grip is placed and anchored with sutures to the initial mini-lumbotomy.
- After insufflation and insertion of the laparoscope, identification of the psoas muscle, and dissection

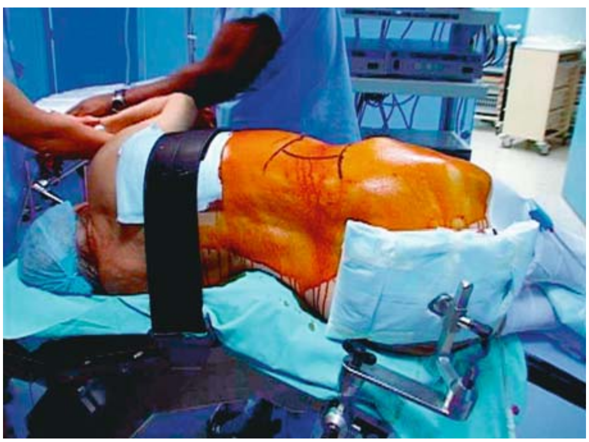

Fig. 1. Patients positioned in lateral decubitus

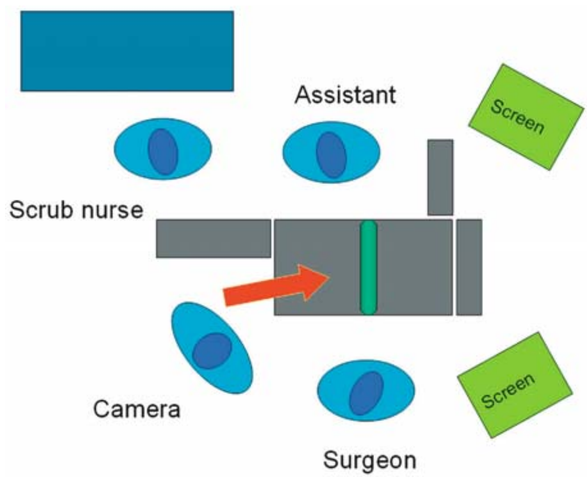

Fig. 3. Distribution surgical team and instruments

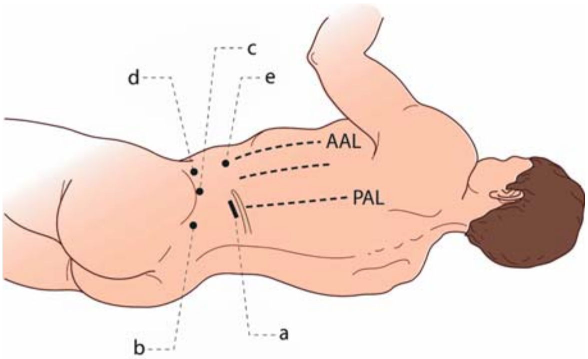

Fig. 4. Position of patient and access for arocards

of the posterior pararenal space. The surgeon uses trocars A and B, dissects with rotating-tip coagulating scissors and holds the suction irrigation in the other hand. Suction irrigation maintains a permanently clean operative field, by removing blood and smoke. In addition, together with the scissors, it allows dissecting tissues by divulsion. The camera is inserted through trocar C, and the assistant helps

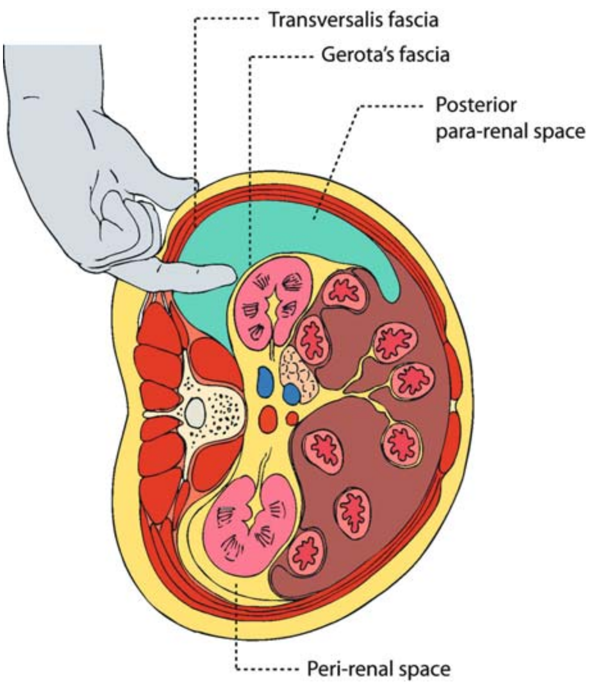

Fig. 5. Creation retroperitoneal space

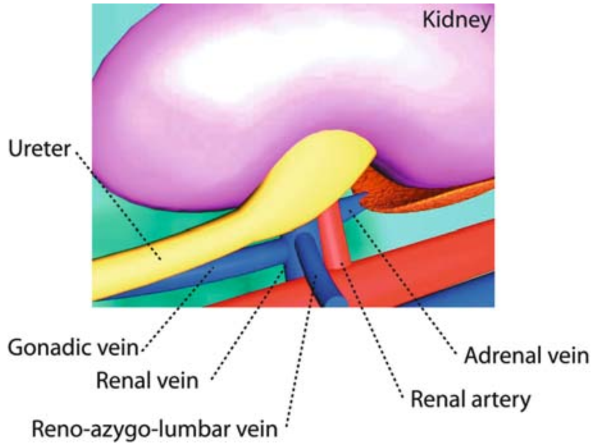

Fig. 6. Left sided access

retract the kidney and put the renal pedicle under tension with two forceps.

- The Gerota fascia is incised giving access to the perirenal space.
- On the left side, the ureter and/or the genital vein is identified (Fig. 6).
- On the right side, the inferior vena cava, the genital vein and the ureter are exposed (Fig. 7).
- Dissection continues upward along these structures leading to the renal pedicle.
- The renal vein and the renal artery are dissected. On the left side, the renoazygos-lumbar vein and

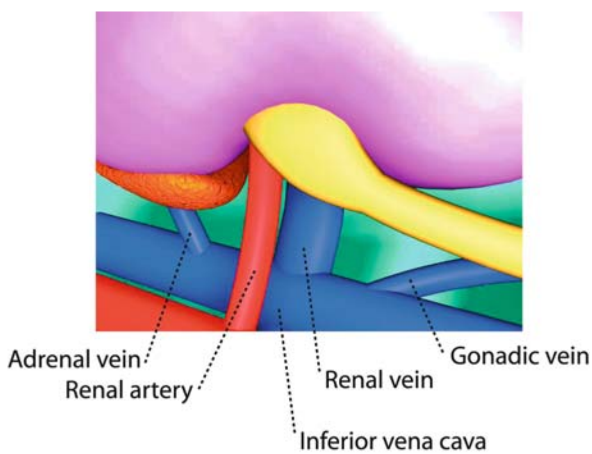

Fig. 7. Right sided access

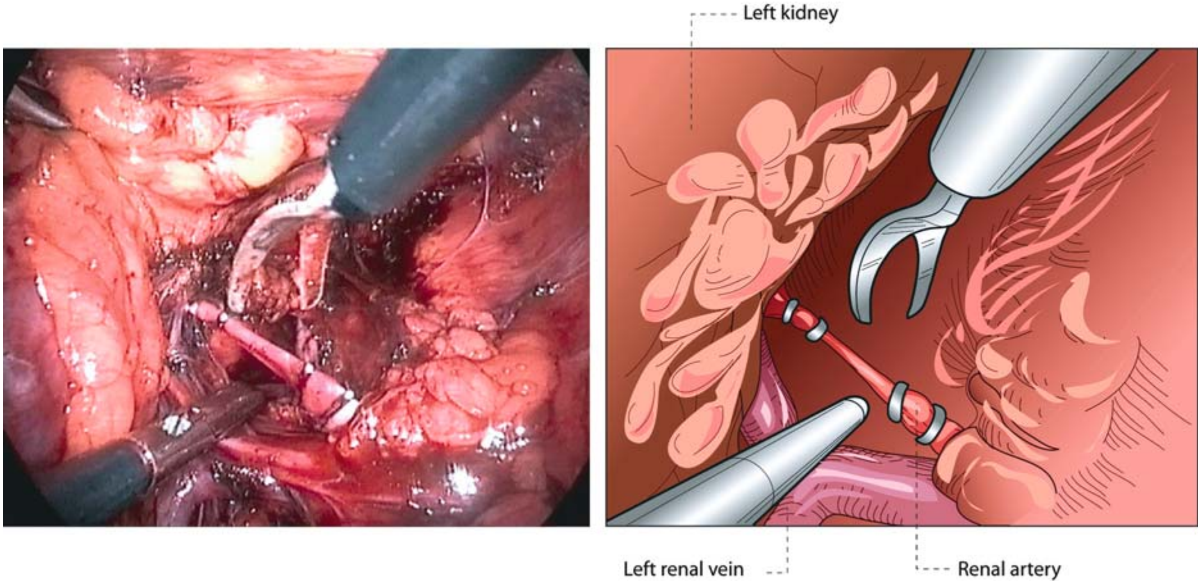

Fig. 8. Dissection of right renal artery

the genital vein, which drain directly into the renal vein, are also dissected.

- The renal artery is secured with 9-mm metallic clips (three clips proximally and two clips distally). Alternatively, Hem-o-Lok clips can also be used. The renal artery is sectioned (Fig. 8). On the left side, this brings out the adrenal vein, which is anterior to the renal artery.
- The dissection of the renal vein is completed. This allows safe placement of the linear stapler on the vein. The renal vein is section-ligatured (Fig. 9).
- The mobilization of the kidney surrounded by perirenal fat and Gerota's fascia begins at its posterior surface and is extended cephalad (Fig. 10). At this point, the anterior and lateral attachments are left intact. They keep the kidney suspended and along with the retraction effect of the pneumoretroperitoneum, facilitate the posterior cleavage. The surgeon reaches the diaphragm and can free the superior pole entirely.
- The operative specimen should not include the adrenal gland in case of a small tumor situated at the lower pole of the kidney. In such circumstances, the adrenal vein is not sectioned. The adrenal is dissected by cleaving the plane between the renal capsule and the surrounding fatty tissue at the anterior face of the kidney at its upper pole. If an adrenalectomy is necessary, the adrenal vein is first clipped and sectioned, and the adrenal gland is included to the operative specimen.
- The dissection continues at the anterior aspect of the kidney, in the anterior pararenal space, i.e., between the peritoneum and Gerota's fascia (Fig. 11).
- The lower pole of the kidney is freed.
- The ureter is clip-ligated and sectioned.
- The specimen is placed into an Endocatch in order to avoid direct parietal contact with the tumor.
- The operative specimen is removed through an iliac incision (Fig. 12). The site of the extraction is closed in two layers. A suction drain is left for 24 h. Trocar sites are closed with intracutaneous absorbable running sutures.

Surgical Tricks

- Access creation: When doing the mini-lumbotomy, the surgeon has to be sure that the posterior pararenal space has been entered. This cleavage plan is easily identified by the possibility of palpating the posterior surface of the 12th rib.
- Dissection of the renal pedicles: to identify the zone where the dissection of the renal pedicle should be begun, simply place the instrument in trocar A per-

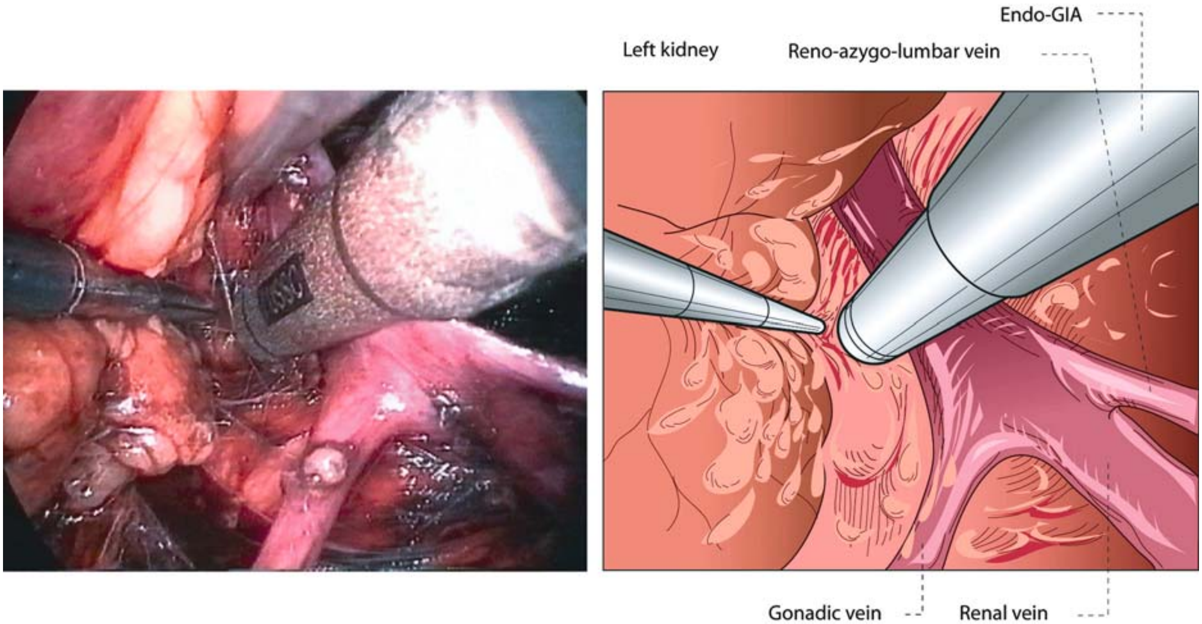

Fig. 9. Dissection of right renal vein

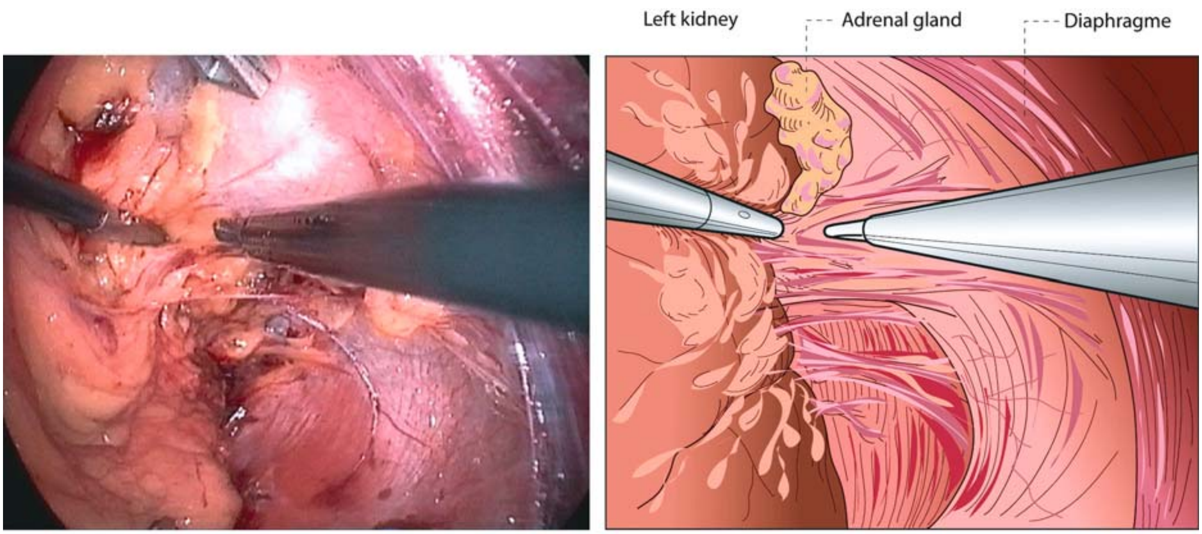

Fig. 10. Mobilization of kidney from perirenal tissue

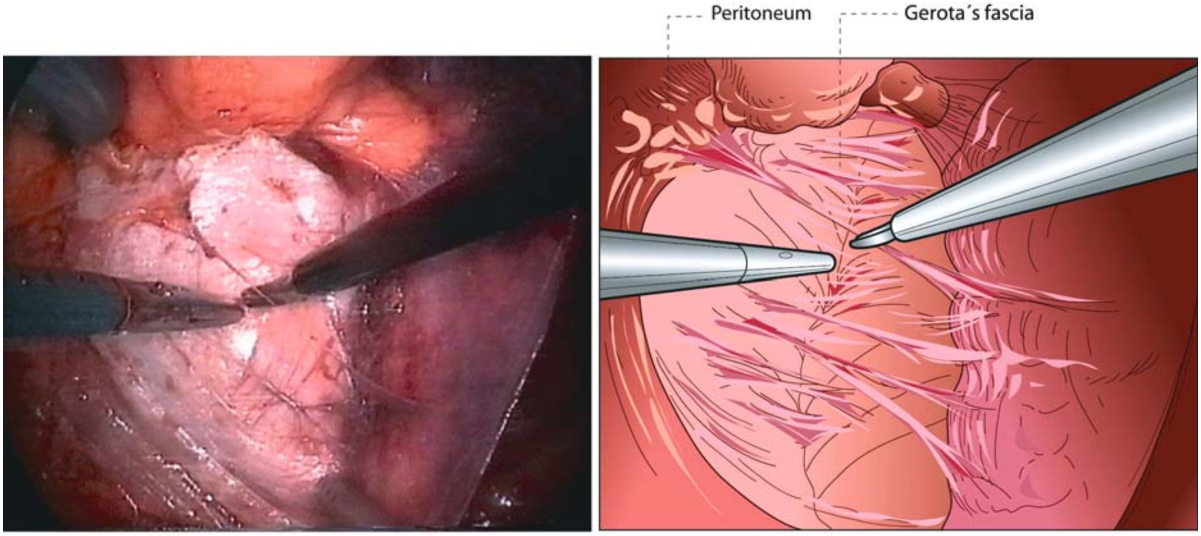

Fig. 11. Dissection between peritoneum and Gerota's fascia

pendicular to the abdominal wall (Fig. 4). The tip of the instrument points toward the zone where the renal pedicle should be expected. On the right side, simply follow the inferior vena cava cephalad. Be careful with the right gonadic vein; it can easily tear off the inferior vena cava.

- Ligature of the renal artery: the more proximal clip on the renal artery has to be placed at a safe distance from the aorta (at least 5–10 mm). This is because if the clip accidentally cuts or injures a calcified artery, one should be able to clamp more proximally, near the aorta.
- Ligature of the renal vein: the endo-GIA has to be placed sufficiently near the kidney, to allow putting a forceps on the distal portion of the vein in case the endo-GIA malfunctions.
- Dissection of the upper pole: optimal triangulation of instruments can be obtained if the surgeon uses trocars A and E (Fig. 4) during this step.
- Dissection of the anterior pararenal space: this is an avascular plane, usually; no hemostasis is required. However, if bleeding occurs, do not use monopolar electrocautery.
- Specimen entrapment: Be sure to open the endobag respecting the inscription "this side up." Otherwise it is impossible to open the sac correctly.

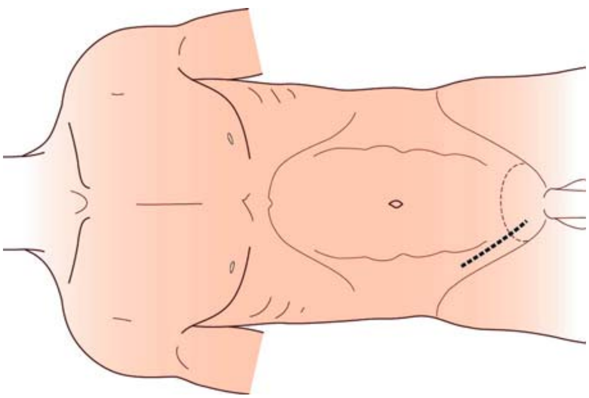

Fig. 12. Iliac incision for specimen removal

Troubleshooting

- Injury to the vena cava results in limited bleeding because of the absence of a pressure gradient between the blood in the venous system and the pneumoretroperitoneum. A surgeon performing laparoscopic nephrectomy should be sufficiently skilled and trained in reconstructive laparoscopic surgery. In this case, suturing the injury is not a major challenge.

- Injury of the peritoneum sometimes occurs accidentally but interferes only mildly with the rest of the surgery.

Postoperative Care

The day after surgery, the Foley catheter and suction drain are usually removed. The patient returns to a full diet. The patient leaves the hospital the 3rd or 4th postoperative day.

Indications

Renal Cell Cancer. Classically, the main indication is represented by tumors less than 7 cm in diameter (T1 tumors). With larger tumors, laparoscopy somewhat losses its advantages because of the large parietal opening required to extract the specimen.

Contraindications

Local spread to the perirenal fat or to the renal vein are considered as the main relative contraindications.

Past history of retroperitoneal lumbar surgery is a relative contraindication, as it makes the dissection difficult. In this case, traditional open surgery may be considered.

Surgical Outcomes, Morbidity Issues

The proponents of the retroperitoneal approach point out certain advantages such as the direct access to retroperitoneal organs without the need to mobilize the colon or the spleen; no difficulty created by previous abdominal surgery; early access to the renal artery; and postoperative fluid collections/infections limited to the retroperitoneum outside the abdominal cavity. These advantages make this approach valuable despite the relatively small space available for operating. Moreover, some of the severe complications reported by the transperitoneal series (duodenal and splenic injuries) have not been reported in the retroperitoneal approach. The retrospective analysis published by McDougall et al. [3] suggested that the retroperitoneal approach is associated with decreased operative time, hospital stay, complication rate, blood loss and narcotic requirements when compared to transperitoneal laparoscopy.

In one of our earlier studies, we analyzed the retroperitoneal approach to laparoscopic radical nephrectomy with regard to feasibility, safety, morbidity and cancer control [4]. We compared the results and outcomes in patients who underwent retroperitoneal laparoscopic or open radical nephrectomy from 1995 to 1998. The records of 58 consecutive patients with renal cancer who underwent radical nephrectomy during this period were reviewed. Twenty-nine patients underwent open radical nephrectomy (group 1) and 29 underwent retroperitoneal laparoscopic radical nephrectomy (group 2). The two groups were similar with regards to age, gender and side of the tumor. Operative time was slightly shorter in group 1 (mean 121.4 vs 145 min in group 2, $p=0.047$). Mean tumor size was larger in group 1 than in group 2 (5.71 vs 4.02 cm, respectively). Laparoscopy patients had significantly less operative blood loss (mean, 100.0 vs 284.5 ml) and used significantly less parenteral pain medication ($p<0.05$). The postoperative hospital stay was significantly longer in the open surgery group (9.7 vs 4.8 days). The complication rate was higher in the open group (24% vs 8%). At follow-up, one patient in open nephrectomy group died of renal cancer (pT2G2) after 14 months. In the laparoscopy group, one patient with a pT3G2 tumor presented with a local recurrence and hepatic metastasis, which occurred after 9 months. We concluded that retroperitoneal laparoscopic radical nephrectomy is superior to open nephrectomy in terms of blood loss, narcotic requirements, hospital stay and overall complication rate. We consider laparoscopic nephrectomy as a viable and safe alternative for T1–T2 tumors.

Similar results were reported by Gill [5]. In his series, he compared outcomes of 34 open radical nephrectomies to 34 retroperitoneal laparoscopic radical nephrectomies. With laparoscopic approach, blood loss was significantly diminished (97.4 ml vs 370 ml, $p<0.001$). The hospital stay was shorter (1.4 days vs 5.8 days, $p<0.001$) and the narcotic analgesia requirement was less (13.5 mg vs 295.1 mg, $p<0.001$). Patients returned to normal activities sooner (4.1 weeks vs 10 weeks).

Controversies and Evolution of Indications

In all the above series, the indication of laparoscopic radical nephrectomy is limited to potentially curable stage T1–T2 kidney tumors.

However, recent studies suggest that exophytic well-marginated renal masses of less than 4 cm should be considered as candidates for nephron-sparing surgery. Some concern has been voiced regarding laparoscopic techniques because their minimal invasiveness has led to a risk that urologists will prefer laparoscopic radical nephrectomy to open partial nephrectomy [6]. The existence of a technique enabling removal of the entire kidney because it is a less invasive approach should not change the strategy of surgical treatment of small kidney tumors.

Arguments also exist in favor of extending the indications to more advanced stages. Patients who undergo excision of their primary tumor prior to systemic immunotherapy may have better response rates than those receiving their treatment without previous nephrectomy. Nephrectomy may prevent from hemorrhage, diminish pain and allow harvesting immunoreactive cells for certain treatment protocols. In addition, debulking of the tumor reduces the volume of residual cancer cells, which may be easier to control with adoptive immunotherapy. However, if open surgery is performed, the immunotherapy can be initiated only after full convalescence, which usually requires 2 months. This delay may be significantly reduced if laparoscopic radical nephrectomy is performed. In a comparative study, Walther et al. [7] found that the median delay to the start of the immunotherapy was significantly less in laparoscopic nephrectomy using morcellation for specimen delivery when compared to either hand-assisted or conventional laparoscopic nephrectomy.

Indication of laparoscopic nephrectomy has also broadened toward cases of renal vein involvement. Desai [8] reported eight successful laparoscopic radical nephrectomies with level I renal vein tumor thrombus.

Specimen Extraction

After the kidney has been dissected, it is generally placed in a laparoscopic bag and then extracted. The laparoscopic entrapment sacs have been widely studied in terms of permeability to tumor cells. It is generally accepted that they are safe for use in malignant tumors, as they have been shown to be perfectly impermeable to fluids, gas or various cell suspensions [9].

There are currently two techniques for removal of the kidney: enlarging one of the 10-mm trocar incisions and removing the whole piece or morcellating it into the sac. The advantages of removing the kidney intact mainly concern the oncological aspects: an accurate pathological staging is possible, surgical margins can be observed, and there is virtually no danger of tumor spillage or port seeding at this step of the procedure. The disadvantage is that a larger muscle incision is needed. Gill [10] reported that in their series of radical nephrectomies with intact specimen removal, the incision length was 6.3 cm. They state that this does not seem to have any implication in postoperative morbidity rates. Moreover, their data concerning postoperative analgesia requirements are not different from data reported by authors routinely using morcellators [11].

The morcellators are designed to work in conjunction with the endoscopic entrapment sacs. A cylindrical recessed blade morcellates tissue that is cored into the atraumatic sheath. The morcellated tissue is aspirated through the device and stored within the handle. This process obviously does not allow defining the pathological stage, the surgical margins and the adequacy of the resection. Moreover the prolonged contact of the bag with its malignant contents can at least in theory be implied in the port seeding phenomena.

Barrett et al. [12] published the largest series of patients undergoing laparoscopic radical nephrectomy with specimen morcellation. Out of 72 patients, six were converted to open surgery due to bleeding or difficult hilar dissection. In the authors' opinion, the clinical stage as established on preoperative CT scan was sufficient for managing the patients, whereas precise pathological staging does not give any extra information that would actually change the subsequent management. In their series, review of the histological finding revealed renal cell carcinoma in 57 patients, benign tumors in six and no diagnosis in three. Follow-up on the malignancies ranged from 1.5 to 58 months with no port site or other disease recurrence.

A literature review of the larger series reveals that most authors do not feel comfortable with morcellating cancer-containing organs and opt instead for the intact removal of the specimen.

Oncologic Issues

The main objection raised by opponents to laparoscopic surgery for oncologic indications is that laparoscopy may compromise oncologic principles (minimal manipulation, wide resection, safe margins). One of the most controversial and debated issues is port site recurrence.

Fentie et al. [13] reported a relatively long follow-up (mean 33.4 months) for patients undergoing laparoscopic radical nephrectomy with morcellation for renal cell carcinoma. Their results show a 5% (3/57) rate of metastases. In two of these cases, the course was consistent with the natural history of the disease, but the third patient had a port site recurrence. This is the first report of port site recurrence in a patient undergoing laparoscopic resection of a kidney cancer. The patient had a high grade, clinical T3 disease and the authors provide this and maybe the morcellation technique as theoretical explanations.

Another case of port site metastasis was reported by Castilho [14]. A patient with alcoholic cirrhosis (T1N0M0) presented ascites at the time of laparoscopy. No cytologic examination was done. The operative specimen was delivered with morcellation. The potential etiologic role of immune deficiency due to alcoholic cirrhosis could not be excluded.

The importance of the use of watertight endoscopic bags for specimen removal was emphasized by Iwamura et al. [15]. The authors reported a port site recurrence in a case where the specimen was removed without an entrapment sac or wound protector.

Based on a literature review, Tsivian and Sidi [16] suggested the following preventive steps:

- Avoiding laparoscopic surgery in case of ascites
- Trocar fixation to prevent dislodgment
- Avoiding gas leakage along and around the trocar
- Adequate laparoscopic equipment and technique
- Minimal handling and avoiding tumor boundary violation of the tumor
- Using a bag for specimen removal
- Placing drainage when needed before desufflation
- Povidone-iodine irrigation of instruments, trocars and port site wounds
- Suturing 10 mm and larger trocar wounds

Kidney tumors do not belong to malignancies with a high risk of port site metastases. During a radical nephrectomy, the oncologic principles are fully respected. Primary ligature of the renal vessels guarantees the lack of spread of tumor cells into the blood stream. Since the kidney is surrounded by a large amount of perirenal fat and Gerota's fascia, the instruments are never in direct contact with the tumor. Furthermore, contrary to some highly aggressive tumors such as transitional cell carcinoma, renal cell carcinoma does not have a high propensity to implant at distant areas. And lastly, the specimen is always removed with a watertight entrapment sac.

Conclusions

Based on a literature review and on our own experience, we can conclude that laparoscopic radical nephrectomy is a viable option for treating low-stage kidney cancer. This relatively novel technique offers several advantages over the open technique, especially in terms of patient comfort, postoperative pain and shorter convalescence.

Oncologic concerns appear largely unwarranted, as longer follow-up data shows that laparoscopy does not alter the natural history or the outcome of this disease.

We therefore assume that laparoscopic radical nephrectomy is potentially becoming a new standard of care in kidney cancer.

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2.3 Hand-Assisted Laparoscopic Nephrectomy

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François Desgrandchamps

Contents

Introduction

Since the first procedure by Clayman and associates in 1990, laparoscopic nephrectomy is becoming the gold standard for kidney removal [1]. The technical difficulty of laparoscopic nephrectomy is a major factor preventing its widespread dissemination.

Tschada et al. in 1995 [2] and Winfield et al. in 1996 [3] described the insertion of the gloved finger into the laparoscopic operative field to assist an otherwise purely laparoscopic procedure; Cuschieri and Shapiro, in 1995, reported a pneumoperitoneum access bubble to allow the hand into the abdomen for dissection and organ removal [4], and in 1994 Tierney et al. reported hand assistance for splenectomy and colectomy and nephrectomy [5].

Leakage of CO_2 and spraying of blood limited the usefulness of (hand-assisted laparoscopy (HAL), but in 1996 the first hand-assisted laparoscopic port was approved by the Food and Drug Administration for use in the United States and since has been used extensively [6].

Hand-assisted laparoscopic surgery bridges the gap between open and laparoscopic surgery. As has been said by Dr. R.V. Clayman, "one hand is worth a thousand trocars" (Ramon Guiteras Lecture, American Urologic Association Annual Convention 2000). It involves inserting the surgeon's hand into the insufflated abdomen. Hand-assisted laparoscopy is clearly advantageous for those laparoscopic procedures that require removal of a relatively large amount of tissue intact, which would otherwise necessitate an extended trocar incision.

Hand-assisted laparoscopic surgery has many theoretical advantages. These may benefit the surgeon, but may also have a positive clinical impact for patients. In addition, through improved control of complications, reduced operative time and technical simplification in comparison with standard laparoscopy, the hand-assisted procedure has economic advantages.

If an incision is needed to remove a specimen at the end of a laparoscopic procedure, then it is advantageous to make the incision at the start of the procedure, through which the hand may be inserted in order to facilitate surgery [7, 8]. Also, hand-assisted laparoscopic surgery returns the tactile sensations lost to the surgeon in laparoscopic surgery. The use of palpation allows the surgeon to locate pathology that is not immediately visible and to identify structures such as blood vessels and ureters [9]. A further advantage is that, whereas three-dimensional perception is lost using standard laparoscopy, having a hand inside the body assists the surgeon in locating structures and directing instruments in three-dimensional space.

The ability to dissect tissues bluntly is restored using hand-assisted laparoscopic surgery. This allows natural tissue planes to be separated and adherent tissues to be safely divided. In addition, hand-assisted laparoscopic surgery permits safe retraction of large organs such as the spleen, esophagus, liver and intestines. These organs are difficult to handle using standard laparoscopic instruments, and are easily damaged. Furthermore, in the hand-assisted procedure, the surgeon's hand works in conjunction with laparoscopic instruments during suturing, clip application and stapler positioning. Clip security is easily verified and presentation of tissue to staplers is greatly enhanced. With regard to perioperative infection, hand-assisted laparoscopic devices cover the wound, and protect it from contamination during specimen removal [10].

Hand-assisted laparoscopic surgery gives surgeons the added confidence they need while learning advanced laparoscopic procedures. Urologists with minimal laparoscopic experience can perform difficult procedures, such as laparoscopic radical nephrectomy, safely and efficiently [10, 11]. In addition, hand-assisted laparoscopy allows the surgeon to control situations that might otherwise require conversion to open surgery (e.g., excessive bleeding). Hand-assisted access can also be used as an intermediate step, rather than converting from laparoscopy-assisted to open surgery.

Hand-assisted laparoscopic surgery procedures typically require fewer ports and instruments than do corresponding laparoscopic-assisted procedures. Further advantages of having the surgeon's hand in the abdomen include tactile feedback, the ability to palpate, blunt dissection, organ retraction, control of bleeding and rapid organ removal. These advantages render the laparoscopy technically simpler, with resultant shorter operative time [6, 12, 13].

The improved efficiency of hand-assisted laparoscopic surgery over standard laparoscopy results in decreased operative times. Most major laparoscopic procedures can be reduced by up to 1 h or more, depending on their complexity.

Clinical trials indicate that hand-assisted laparoscopic surgery outcomes (e.g., patient pain, return to normal activity, time of surgery and duration of ileus) are equal to or better than those with laparoscopic surgery. The postoperative advantages of laparoscopy in reducing morbidity and hastening convalescence are not sacrificed. Studies comparing patient postoperative discomfort after laparoscopic and hand-assisted laparoscopic procedures have not identified a significant difference [13, 14], although long-term convalescence has been shown to be 1–3 weeks longer [15].

With regard to cosmetic appearance following the procedure, hand-assisted laparoscopic surgery incisions are much smaller than those used with standard open surgery, and are closer to those employed in standard laparoscopy than one might imagine. For example, because the PneumoSleeve (Dexterity Inc., Atlanta, GA, USA) the incision is made on the insufflated abdomen (see "Technique: Placement of Ports and Hand-Assisted Device (Hand-Port System)"), the average 7-cm incision measures only 5.5 cm postoperatively [12]. Furthermore, hand-assisted surgery typically requires fewer ports than do laparoscopy-assisted procedures. Finally, the use of fewer ports and a muscle-splitting incision may result in reduced pain for the patient [16].

Indications

- Simple nephrectomy
- Live-donor nephrectomy
- Radical nephrectomy
- Nephroureterectomy
- Adrenalectomy (large)

HAL is indicated for simple and radical nephrectomy, and nephroureterectomy where the surgical specimens are large and so the use of a hand port incision does not disadvantage the benefits of reduced wound morbidity in laparoscopy. Regardless of specimen size, where the use of HAL discourages open nephrectomy in favor of the laparoscopic approach it is to be encouraged.

Theoretically HAL is counterintuitive for partial nephrectomy as the specimen is small, not requiring an extended incision for retrieval. However, a significant advantage is that HAL may avoid the need to clamp the renal hilar vessels by allowing simple manual polar compression for hemostasis [17].

Contraindications

- Lack of training
- Small workspace
- Small or benign specimen

HAL is an adjunct to laparoscopy or may facilitate its uptake. It is not a means to bypass laparoscopic training.

We do not recommend HAL in young children and during retroperitoneoscopy, as the hand takes up too much space, complicating exposure. Small atrophic kidneys or nonfunctioning kidneys of other etiologies are suitable for morcellation and therefore better performed by pure laparoscopy, although in the presence of chronic inflammation or prior surgical procedures, such as xanthogranulomatous pyelonephritis or autosomal dominant polycystic kidney disease, may complicate a pure laparoscopic procedure.

Techniques

Hand-Assisted Laparoscopy Devices

Hand-assisted laparoscopy devices [13] facilitate intraabdominal placement of the hand during laparoscopy. To date, various devices are available for hand-assisted access during laparoscopy. Each of them has advantages and disadvantages. There are currently four devices available: the PneumoSleeve, the Hand-port (Smith and Nephew, Andover, MA, USA), the Intromit (Applied Medical, Rancho, Santa Margarita, CA, USA) and the Lap Disk (Hakko Shoji, Tokyo, Japan). The base adapted to the abdominal wall can be either adhesive (PneumoSleeve, Intromit) or compressive (Hand-port, LapDisk).

All the devices are effective and selection depends on surgeon preference, location of hand incision, body habitus and the past surgical history of the patient.

Compressive Base

The Hand-port system is composed of a base that is adapted to the abdominal wall and a sleeve that covers the surgeon's arm. The Hand-port can be installed at the beginning of the procedure, and before or after insufflation, as described by Wolf et al. [13]. The primary advantage of inserting the system before insufflation is that all trocars may be introduced under direct vision, which may help to reduce potential vascular or visceral injuries [14, 18]. The default of such a system is that the base may be ejected during the procedure [16]. In our experience, the base is easy to reinsert.

The LapDisc [18] system has no plastic sleeve that attaches the surgeon's wrist to the device. A three-layer silicone valve connected by a rubber membrane, which covers the peritoneum and abdominal wall, forms the mechanical occlusion.

Adhesive Base

The PneumoSleeve and the Intromit devices require clean and dry skin before positioning. When the abdomen is fully insufflated, the adhesive base is placed in its final position.

Devices that require adherence to the abdominal wall may loosen during the procedure, and may induce leakage of the pneumoperitoneal gas and loss of intra-abdominal pressure. Some authors [19, 20] have described the use of Mastisol (surgical adhesive; Ferndale Laboratories Inc., Ferndale, MI, USA) or benzoin to produce a stickier abdominal surface, thus permitting more secure placement of the hand-assisted device [19]. It is also possible to seal the interior of the abdominal wall template with a patch of Tegaderm (Johnson & Johnson Inc., Arlington, TX, USA) in order to reduce escape of intra-abdominal fluid and gas between the adhesive ring and the skin. An alternative solution to reduce the incidence of air leak is application of a large Steri-Drape (3-M Health Care, St Paul, MN, USA) to the abdominal wall at the start of the surgical procedure [21].

Technique: Placement of Ports and Hand-Assisted Device (Hand-Port System)

Under general anesthesia, the patient is placed on a flexed table in a full flank position as per open and standard laparoscopic nephrectomy, prepared and draped in the normal way. A mid-line incision above the umbilicus is made, in length equal to the surgeon's glove size (6.5–8.5 cm). The peritoneum is then entered, the hand-port device is inserted (Fig. 1) and the surgeon's nondominant wrist is inserted into the abdominal cavity. Port sites are placed 2–3 cm around the area of the base. A 10-mm trocar is introduced under finger control. This first trocar is placed at the level of the mid-axillary line where the laparoscope will be placed, and the pneumoperitoneum is created. Two additional trocars (5–12 mm in diameter) are inserted under direct vision, one above the iliac crest and the other under just below the costal margin at the level of the mid-axillary line. Those two trocars are used as operative trocars for the placement of scissors, stapler and clip applier. A fourth trocar may be placed during the procedure to insert a laparoscopic liver retractor. The kidney is then approached as previously described for simple or radical nephrectomy (Fig. 2) [9, 20, 22].

Fig. 1. Right nephrectomy. The base of the hand-assisted device (Hand-Port) is placed and the surgeon inserts his hand into the abdominal cavity

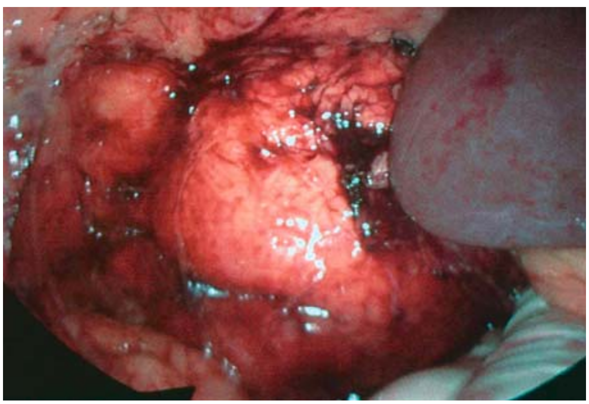

Fig. 2. Exposing the right kidney

Results: Comparison with Other Techniques

Hand-assisted laparoscopic nephrectomy must be compared with other surgical approaches, including open surgery and pure laparoscopy.

Simple nephrectomy is usually done using standard transabdominal or retroperitoneal laparoscopy. Chronic inflammation or prior surgical procedures may lead to hilar and perinephric fibrosis, resulting in technical difficulties. In these cases, hand-assisted laparoscopic surgery may be useful in performing simple nephrectomy. Hand-assisted laparoscopic surgery has also simplified the management of larger renal tumors while maintaining the benefits of a minimally invasive procedure. Laparoscopic radical nephrectomy specimens can be removed intact and without morcellation [7, 13, 20, 23].

Simple Nephrectomy

Various surgical approaches have been reported for simple nephrectomy. Laparoscopic procedures may be performed by either retroperitoneal or transperitoneal approach. Compared with open surgery, patients undergoing standard laparoscopic nephrectomy have less pain, shorter duration of hospital stay and faster resumption of normal activities [20].

Wolf et al. [13] compared hand-assisted with standard laparoscopic nephrectomy; morcellation was used for kidney removal. These investigators reported a shorter operative time and fewer complications for the hand-assisted group, and no significant differences in analgesic use, time to oral intake, duration of hospital stay and time to full recovery, as compared with the laparoscopic group.

However, pure laparoscopy is preferred for simple nephrectomy as the specimen is suitable for morcellation, i.e., extraction without port-site extension, and often the extraperitoneal route is preferred, which is less suited to HAL.

Radical Nephrectomy

When compared to the hand-assisted laparoscopic approach, open radical nephrectomy has been shown to give an advantage in terms of operative time [22] (Table 1). However, Stifelman et al. [17] noted an operative time of 3.3 h among 74 patients undergoing a hand-assisted laparoscopic nephrectomy, versus 3.3 h for 20 patients undergoing an open nephrectomy. There was reduced blood loss, analgesic requirement and length of stay in the HAL group. Cleveland clinic

Table 1. Comparison of HAL, pure laparoscopy and open surgery in radical nephrectomy

Procedure	Operative time (hours)	Blood loss (cc)	Duration of stay (days)	Convalescence (weeks)
Stifelman [17]				
HAL ($n=74$)	3.3	131	3.7	<4
Open ($n=11$)	3.3	372	5.2	–
Wolf [36]				
HAL ($n=18$)	205	194	–	–
Pure laparoscopy ($n=15$)	280	304	–	–
Gill [26]				
Pure laparoscopy ($n=100$)	2.8	212	1.6	4

Table 2. Comparison of HAL, pure laparoscopy and open surgery in nephroureterectomy

Procedure	Operative time (hours)	Blood loss (cc)	Duration of stay (days)	Convalescence (weeks)
Stifelman [17]				
HAL ($n=22$)	4.5	180	4.1	2.7
Laparoscopy ($n=25$)	7.7	199	6.1	2.8
Open ($n=11$)	3.9	311	6.3	>6
Gill [26]				
Pure laparoscopy ($n=42$)	3.9	242	2.3	8
Landman [15]				
HAL ($n=16$)	4.9	201	4.5	8
Pure laparoscopy ($n=11$)	6.1	190	3.3	5.2

data [24], ($n=100$), show a modest advantage for pure laparoscopy.

Nakada et al. [23], comparing hand-assisted and open laparoscopic radical nephrectomy, demonstrated that the hand-assisted laparoscopic technique is a safe, effective and minimally invasive option for treating renal cell carcinoma. Operative times with hand-assisted laparoscopic nephrectomy were significantly longer than those with open nephrectomy, but the hand-assisted laparoscopic nephrectomy patients had a shorter duration of hospital stay, an earlier return to work and to a complete recovery [22].

Batler et al. [10] retrospectively compared their experiences with 24 initial hand-assisted and retroperitoneal laparoscopic nephrectomies. All but one of those procedures were radical laparoscopic nephrectomies. Their data revealed no significant differences in operative time, estimated blood loss, narcotic usage, hours to oral intake, duration of hospital stay, or activity level at 2 weeks after the procedures. The same team previously reported on "the experience of the inexperienced" [25]. In that study, novice laparoscopic surgeons performed the first six hand-assisted laparoscopic nephrectomies. Because half of the hand-assisted procedures were performed by young and inexperienced surgeons, it is difficult to draw meaningful comparisons of operative times [22]. A randomized prospective study comparing these techniques performed by the same surgeons would provide us with more accurate answers.

Nephroureterectomy

Stifelman et al. [17] have shown superior results for HAL versus open and pure laparoscopic nephroureterectomy. Most notable in their series is the time saving of more than 3 h in the HAL nephroureterectomy series compared with the pure laparoscopic series. The Cleveland clinic data [26] demonstrate a superior pure laparoscopic experience in terms of operative time and length of stay, although a particularly long convalescence time of 8 weeks (Table 2).

Live-Donor Nephrectomy

In terms of live-donor nephrectomy, the results are again similar between the pure laparoscopic and HAL, with recovery advantages for both over open surgery [17, 37, 38, 42]. However, allograft function is another factor of utmost importance that needs to be considered. Stifelman et al. [27] showed similar allograft function between open and HAL live-donor nephrectomy. Comparing pure laparoscopic and open live donor nephrectomies. Noguiera et al. [38] reports higher nadir creatinine in laparoscopic cases. This phenomenon has not been seen with the HAL technique (Table 3).

Others have confirmed shorter operating times and warm ischemia time in HAL donor nephrectomy [43] but no functional difference in the transplanted graft at 1 year [43, 44].

Fabrizio et al. [41] have stated that since introducing HAL live donor nephrectomy to John Hopkins In-

Table 3. Comparison of HAL, pure laparoscopy and open surgery in live-donor nephrectomy

Procedure	Operative time (hours)	Blood loss (cc)	Duration of stay (days)	Convalescence (weeks)
Stifelman [17, 42]				
HAL (*n* = 60)	4	83	3.7	4
Open (*n* = 30)	4.4	364	4.5	9.2
Laparoscopy (*n* = 100)	3.9	266	3	4
Wolf [37]				
HAL (*n* = 10)	3.6	103	1.8	–
Ratner [38]				
Pure laparoscopy (*n* = 175)	3.9	260	3	4

stitution in Baltimore, Maryland, the number of live-donor renal transplantations has increased by 100%.

Partial Nephrectomy

Hand-assisted laparoscopic partial nephrectomy is feasible and reproducible [28, 37]. The surgeon's hand in the operative field facilitates dissection, vascular control, hemostasis and suturing [28]. It is less ideal an indication than whole-specimen nephrectomy, as small specimen size negates the need for a large incision. The surgeon's hand may be used for manual compression of polar tumors, negating the need for hilar vessel clamping and whole kidney ischemia. In experienced hands, the Cleveland Clinic data [29] shows that similar results may be achieved without hand assistance and the resultant wound, as large specimen retrieval is unnecessary (Table 4).

Table 4. Comparison of HAL, pure laparoscopy and open surgery in partial nephrectomy

Procedure	Operative time (hours)	Blood loss (cc)	Duration of stay (days)	Convalescence (weeks)
Wolf [37]				
HAL (*n* = 10)	3.3	460	2	–
Stifelman [28]				
HAL (*n* = 11)	4.6	319	3.3	–
Gill [29]				
Pure laparoscopy (*n* = 50)	3	270	2.2	–

Complications

There is a learning curve to hand-assisted laparoscopy. In a 1999, the Southern Surgeon's Club study [30], in which 27 highly skilled laparoscopic surgeons from 16 states across the United States evaluated hand-assisted laparoscopy, recommended its use "only for experts in laparoscopic surgery and for procedures that are either too complex or take too long to be managed by pure laparoscopic surgery."

Hand-assisted laparoscopic surgery has some inherent disadvantages: PneumoSleeve device malfunction 53% (including device replacement in 14%) [30]. The devices can be unwieldy and they leak gas frequently. On small abdomens, the space that they occupy may interfere with port placement. The cosmesis of the incisions for the HAL device is less favorable than it is for laparoscopic ports. For the true minimalist, undertaking pure laparoscopy, the specimen may be retrieved via a Pfannenstiel incision in the male or transvaginally in the female [31]. Convalescence may be prolonged by the longer incision. Although both Wolf et al. [32] and Slakey et al. [33] found that hand-assistance did not alter convalescence significantly compared with that after standard laparoscopy, there is likely a small degree of increased postoperative pain and duration of convalescence for hand-assisted vs standard laparoscopic procedures. Open conversion (22%) [30], device air leak (25%), and postoperative complication rate (26%) [22] are also factors to consider. Importantly, intra-abdominal hand fatigue, ranging from mild fatigue to severe cramping, was noted in an additional 21% of cases [34, 35].

Okeke et al. 2002 [35] reported complications related to hand ports in three of 13 cases. There were two severe hand port wound infections and one incisional hernia. One patient required conversion to open surgery due to irresolvable air leakage around the port. In one patient, the tumor ruptured during extraction. Although no local recurrence has been identified 21 months postoperatively, this calls into question whether or not it is safe to remove tumors without some form of sack. This group has abandoned hand-assisted techniques for upper tract malignancy.

The additional cost of the hand-assistance device is often cited as a disadvantage of the technique. Its supporters cite that the cost is recouped by the reduction in operating room time and other supply cost savings when HAL is used, such as the requirement for fewer ports and in the case of live-donor nephrectomy, no entrapment sack [36].

Future Horizons

HAL nephrectomy clearly has a future for those overwhelmed by the skill level of pure laparoscopy when starting a service. By acting as a bridge between open surgery and laparoscopy, it may bring laparoscopy into the armamentarium of surgeons who would otherwise continue to perform open surgery in situations where it is essentially becoming contraindicated.

It is likely to hold a position for transperitoneal total nephrectomy where a similarly sized incision would otherwise be made at the end of a pure laparoscopic procedure, and for the same reason it is unlikely to become the procedure of choice for partial nephrectomy that does not require significant incision extension for specimen retrieval. Simple nephrectomy is probably best performed retroperitoneally, which is less suited to HAL, unless the specimen is very inflamed or large when transperitoneal nephrectomy may be preferred.

Conclusion

Hand-assisted laparoscopic surgery is a promising technique, has clear advantages to open surgery, is comparable to pure laparoscopy and may further the indications for laparoscopy. It is well tolerated and effective in nephrectomy. Logical indications for its application include those laparoscopic cases that require removal of a large amount of tissue intact and as a bridge between open and laparoscopic alternatives. Moreover, with regard to efficacy and safety, hand-assisted laparoscopic surgery may also find application in technically difficult situations [25].

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3.1 Laparoscopic Partial Nephrectomy

Antonio Finelli, Inderbir S. Gill

Contents

Introduction

With widespread use of modern imaging techniques, renal tumors are commonly diagnosed incidentally. These tumors are often small with favorable biological behavior, including a slow growth rate and a low incidence of local recurrence and metastasis. Moreover, small incidentally detected renal tumors have a 22%–40% chance of being benign on final pathological analysis [1]. With strong evidence supporting nephron-sparing surgery (NSS) for renal tumors less than 4 cm and the evolution of minimally invasive surgical technique, there has been a trend away from radical nephrectomy in the management of small renal tumors.

In the past decade, several minimally invasive therapy options for NSS have been developed in an attempt to minimize operative morbidity while achieving comparable oncological outcomes and preserving renal function. These minimally invasive procedures comprise tumor excision (laparoscopic partial nephrectomy), which aims to duplicate the established technique of open partial nephrectomy and probe-ablative strategies (cryotherapy and radiofrequency ablation). In this chapter, we discuss the current status of laparoscopic partial nephrectomy.

Compared to radical nephrectomy, laparoscopic partial nephrectomy is a considerably more technically challenging procedure. Issues of renal hypothermia, renal parenchymal hemostasis, pelvicaliceal reconstruction, and parenchymal renorrhaphy by pure laparoscopic techniques pose unique challenges to the surgeon. Nonetheless, ongoing advances in laparoscopic techniques and operator skills have allowed the development of a reliable technique of laparoscopic partial nephrectomy, which aims to replicate the established procedure of open partial nephrectomy [2]. As such, laparoscopic partial nephrectomy is emerging as an attractive minimally invasive nephron-sparing option at select institutions. The worldwide experience with laparoscopic partial nephrectomy is summarized in Table 1 [3–9].

Indications and Contraindications

Initially, laparoscopic partial nephrectomy was reserved for the select patient with a favorably located, small, peripheral, superficial, and exophytic tumor [10–12]. With experience, we have carefully expanded the indications to select patients with more complex tumors: tumor invading deeply into the parenchyma up to the collecting system or renal sinus [13], upper pole tumors requiring concomitant adrenalectomy [14], completely intrarenal tumor, tumor abutting the renal hilum, tumor in a solitary kidney, or a tumor substantial enough to require heminephrectomy [15]. Although there is growing evidence supporting elective partial nephrectomy for select tumors 4–7 cm in size [16], laparoscopic partial nephrectomy for these complex tumors is most often utilized in the setting of compromised or threatened global nephron mass wherein nephron preservation is an important con-

Table 1. Published series of laparoscopic partial nephrectomy with at least ten patients treated

Reference	*N*	Mean tumor size (cm)	Hilar control	No. of pelvicaliceal repairs (%)	Hemostasis	Mean EBL (ml)	Mean OR time (h)	Mean hospital stay (days)	No. of urine leaks (%)	No. of complications (%)	Follow-up (months)
Janetschek et al. [3]	25	1.9	No	0	Bipolar, Argon beam, glue	287	2.7	5.8	0	3 (12)	22.2
Harmon et al. [4] [a]	15	2.3	No	3	Argon beam, bolster	368	2.8	2.6	0	0	8
Rassweiler et al. [5] [a]	53	2.3	–	–	Harmonic, bipolar, Argon beam, Nd:YAG	725	3.2	5.4	5 (9.4)	10 (19)	24
Gill et al. [9]	100	2.8	Yes (91)	64	Suture over bolsters	125	3	2.0	3 (3)	21 (21)	18
Guillonneau et al. [6]	28	1.9	No (12)	0	Bipolar, Harmonic	708 (3)	3.0	4.7	0	3 (25)	12.2
		2.5	Yes (16)	11	Suture over bolsters	270 (2)	2.0	4.7	0	3 (19)	1.2
Kim et al. [7]	79	2.5	Yes (52)	–	Suture over bolsters	391 (4)	3.0	2.8	2 (2.5)	12 (15)	–
Simon et al. [8]	19	2.1	No	0	Harmonic, TissueLink	120	2.2	2.2	0	4 (21)	8.2

Adapted from [17]
[a] Multi-institutional reports

cern. In 2004, our absolute contraindications for laparoscopic partial nephrectomy include renal vein thrombus, or a mid- or interpolar, completely intrarenal central tumor [17]. Morbid obesity and a history of prior ipsilateral renal surgery may increase the technical complexity of the procedure, and should be considered a relative contraindication at this time.

Surgical Technique

Laparoscopic partial nephrectomy is preferentially performed transperitoneally. However, posterior or posteromedially located tumors may be more ideally approached retroperitoneoscopically. Three-dimensional computed tomography (CT) is the preferred preoperative imaging study. 3D CT provides information regarding tumor size, location, parenchymal infiltration, proximity to renal sinus and renal hilum, and the number and location of renal vessels.

After general anesthesia is administered, an open-ended 5F ureteral catheter is inserted cystoscopically up to the renal pelvis. The basic operative strategy of laparoscopic partial nephrectomy has been previously described (Gill et al.). Generally, it involves preparation of the renal hilum for cross-clamping, followed by mobilization of the kidney and isolation of the tumor [2]. Early in our experience, laparoscopic bulldog clamps were used to individually occlude the renal artery and vein (Fig. 1). However, it soon became obvious that current laparoscopic bulldog clamps have somewhat suboptimal and inconsistent vessel compression that may result in intraoperative hemorrhage due to inadequate occlusion, especially in the setting of renal artery arteriosclerosis. In contrast, the laparoscopic Satinsky clamp is inherently more reliable for renal hilum clamping (Fig. 2). As such, we have modified our technique and now routinely clamp the renal hilum en bloc with a Satinsky clamp during transperitoneal and retroperitoneal approaches. Notably, there is occasion when the restricted working space in the retroperitoneum may make the use of a Satinsky clamp somewhat awkward. Development of more reliable bulldog clamps of similar quality to those available for open surgery would help avoid this problem.

Intraoperative laparoscopic ultrasonography (IOLUS) precisely delineates tumor size, intraparenchymal extension, distance from renal sinus, and may detect preoperatively unsuspected satellite renal tumors. Under sonographic guidance, an adequate margin of nor-

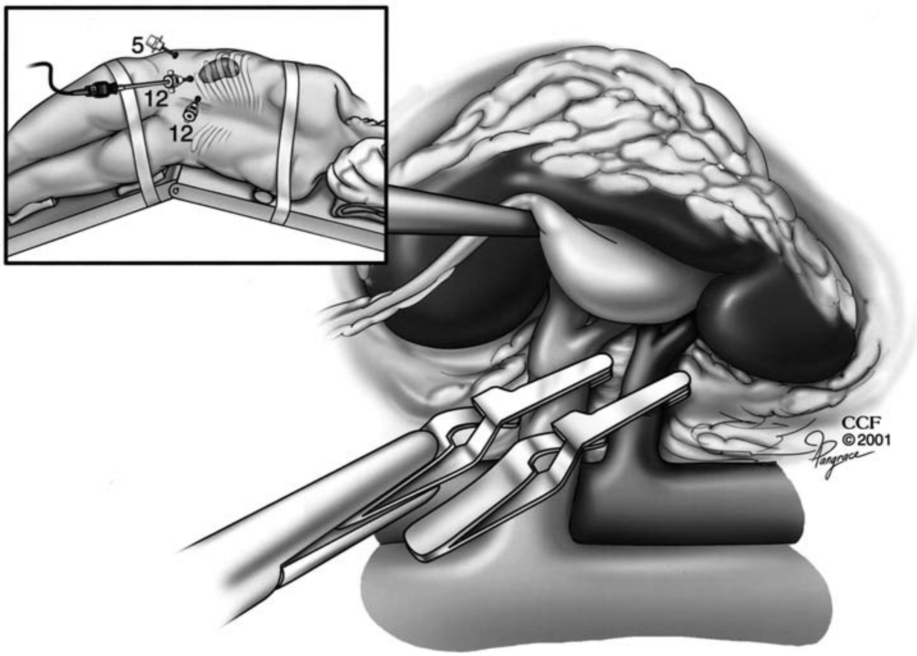

Fig. 1. Retroperitoneal laparoscopic partial nephrectomy. Because of the limited working space, the renal vein and artery were initially isolated and controlled with laparoscopic bulldog clamps. A Satinsky clamp is now routinely used. Adapted from [2]

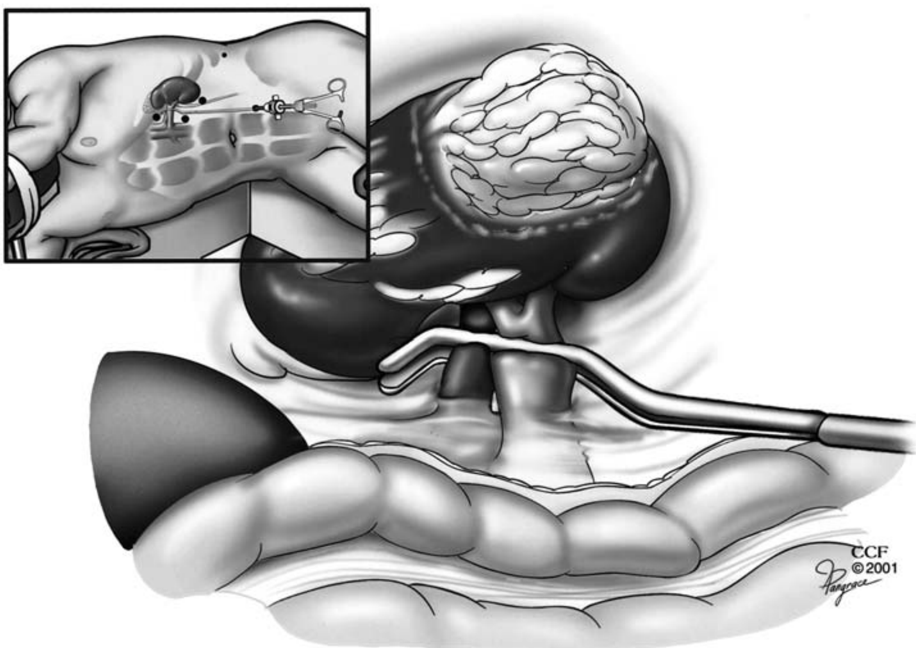

Fig. 2. Transperitoneal laparoscopic partial nephrectomy. A laparoscopic Satinsky clamp is used to clamp the hilum en bloc. Adapted from [2]

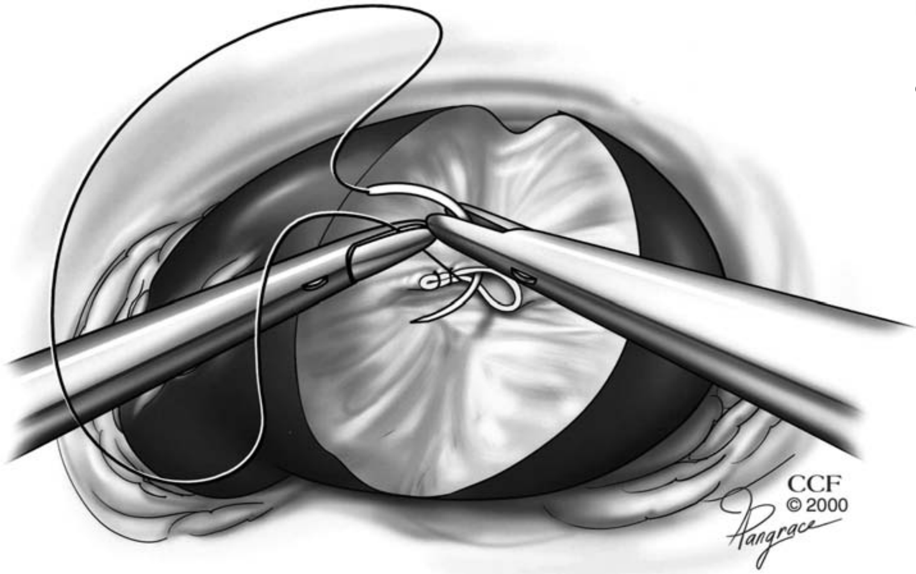

Fig. 3. Free-hand intracorporeal laparoscopic suture repair of the pelvicaliceal defect. Adapted from [13]

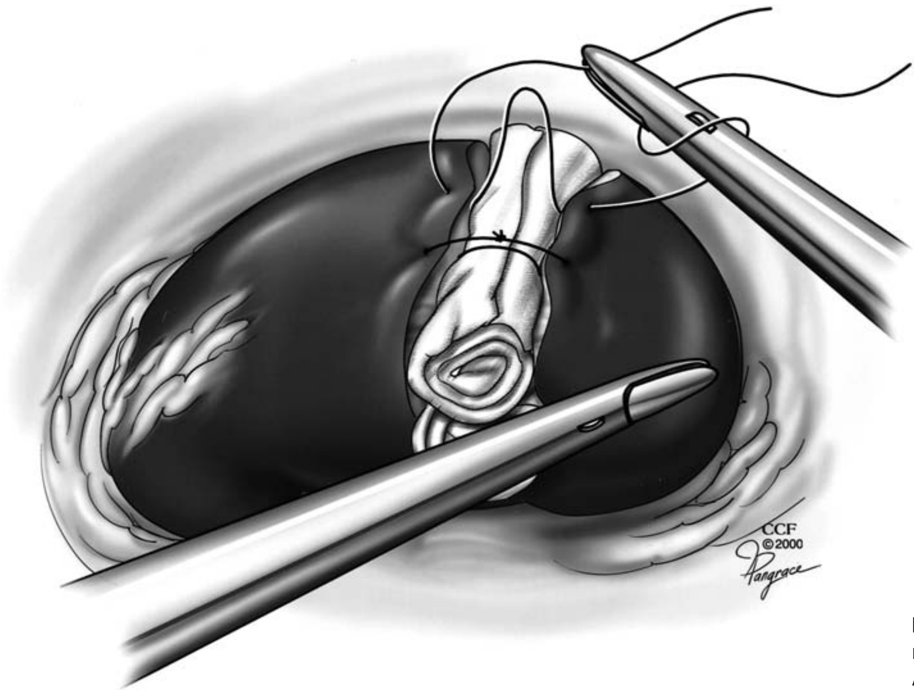

Fig. 4. Renal parenchymal repair over bolsters. Adapted from [2]

mal renal parenchyma is scored circumferentially around the tumor with the J-hook electrocautery. The hilum is then clamped, and the tumor excised with cold scissors in a clear, bloodless field. Retrograde injection of dilute indigo carmine through the preoperatively placed ureteral catheter identifies any pelvicaliceal entry, and facilitates precise suture repair by intracorporeal laparoscopic techniques (Fig. 3) [13]. Lastly, the renal parenchyma is reconstructed using Vicryl suture over a prefashioned Surgicel bolster completing a hemostatic renorrhaphy (Fig. 4). Hem-o-Lok clips (Weck Closure System, Research Triangle Park, NC, USA) are used to secure the suture on either side of the renal parenchyma on the simple interrupted stitches. Recently, the biological hemostatic gelatin matrix-thrombin tissue sealant FloSeal (Baxter, IL, USA) has been incorporated as an important hemostatic adjunct to our technique. A Jackson-Pratt drain is placed in all patients undergoing pelvicaliceal repair or if there is concern of inadequate hemostasis.

Comparison of Open and Laparoscopic Partial Nephrectomy

A recent retrospective review of 200 patients undergoing partial nephrectomy at the Cleveland Clinic compared the laparoscopic ($n=100$) to open ($n=100$) approach [9]. Median tumor size was 2.8 cm in the laparoscopic group and 3.3 cm in the open group ($p=0.005$), and a solitary kidney was present in seven and 28 patients, respectively ($p=0.001$). The tumor was located centrally in 35% and 33% of cases ($p=0.83$) and the indication for a partial nephrectomy was imperative in 41% and 54% of cases, respectively ($p=0.001$). Comparing the laparoscopic to open group, median surgical time was 3 h vs 3.9 h ($p<0.001$), blood loss was 125 ml vs 250 ml ($p<0.001$), and warm ischemia time was 28 min vs 18 min ($p<0.001$), respectively. Analgesic requirement was 20.2 mg vs 252.5 mg morphine sulfate equivalent ($p<0.001$), the hospital stay was 2 days vs 5 days ($p<0.001$), and convalescence averaged 4 weeks vs 6 weeks ($p<0.001$) for the laparoscopic and open groups, respectively.

All laparoscopic cases were completed without conversion to open surgery. The laparoscopic group had a higher incidence of intraoperative complications (5% vs 0%; $p=0.02$). This included hemorrhage ($n=3$), ureteral injury ($n=1$), and bowel serosal injury ($n=1$). The rate of postoperative complications was similar (9% vs 14%; $p=0.27$). Urological complications occurred in seven patients in the laparoscopic group and two patients in the open group. Median preoperative serum creatinine (1.0 mg/dl vs 1.0 mg/dl) and postoperative serum creatinine (1.0 mg/dl vs 1.1 mg/dl) were similar ($p=0.99$). Pathology confirmed renal cell carcinoma in 75% and 85% of the patients in the laparoscopic and open groups, respectively ($p=0.003$). Although the median width of margin was 4 mm in each group ($p=0.11$), the parenchymal margin of resection was positive in three laparoscopic cases and no open cases ($p=0.11$). No patient in the laparoscopic group developed a local or port-site recurrence. Of the published series (Table 1.) positive surgical margins were also reported by Kim et al. [7]. In their series there were two cases with positive surgical margins; one patient elected radical nephrectomy revealing pT3 a disease and the other patient chose to be observed and has been free of recurrence over 26 months of surveillance.

Complications of Laparoscopic Partial Nephrectomy

Ramani and colleagues performed a thorough review of the incidence and nature of complications following laparoscopic partial nephrectomy in our first 200 patients [18]. The procedure was approached transperitoneally in 122 patients (61%) and retroperitoneally in 76 (38%). Mean tumor size on preoperative CT scan was 2.9 cm (range, 0.9–10 cm) and the mean depth of parenchymal invasion on IOLUS was 1.5 cm (0.2–5 cm). Of the procedures, 198 (99%) were completed laparoscopically with two open conversions. Mean OR time was 199 min (45–360 min), mean blood loss was 247 ml (25–1,500 ml) and blood transfusion was administered to 18 patients (9%).

Thirty-nine (19.5%) patients developed urological complications, which included renal hemorrhage (21; 10.5%), urinary leak (nine; 4.5%), inferior epigastric injury (one), epididymitis (one), and hematuria (one). Renal hemorrhage occurred in 21 patients (10.5%): intraoperative eight (4%), postoperative five (2.5%), and delayed eight (4%). In seven of eight patients, intraoperative hemorrhage was due to inadequate clamping of the renal hilum: laparoscopic bulldog clamp malfunction (four), laparoscopic Satinsky clamp malfunction (one), accessory renal artery that was missed on preoperative 3D CT scan and not detected intraoperatively (two). Prior to discharge, five patients experienced hemorrhage, ostensibly from the partial nephrectomy bed. In all five patients, complete intraoperative hemostasis had been achieved to the surgeon's satisfaction. Four of these patients had no obvious precipitating cause and responded to conservative management with fluid resuscitation and blood transfusion. The fifth patient had been therapeutically heparinized for pulmonary embolism and this likely precipitated the renal bleed. This patient underwent successful exploratory laparotomy on postoperative day 7 to control renal parenchymal oozing. Delayed hemorrhage after discharge (day 6 to day 30) occurred in eight patients (4%). Potential precipitants could be identified in three patients: vigorous exercise on postoperative day 14 (one), fall (one), and coagulopathy (one). Treatment included transfusion in five patients, percutaneous selective angioembolization in two and delayed nephrectomy in one. One patient presented with delayed hematuria, managed with bed rest and bladder irrigation.

Urine leak developed in nine patients. Of these, six required placement of a double J stent, two required a double J stent plus CT-guided drainage of urine collection, and one resolved spontaneously with observation. No patient with a urine leak required operative re-exploration. A total of four patients (2%) required at least one session of hemodialysis following surgery. Two patients required transient dialysis for acute tubular necrosis (ATN) at postoperative days 8 and 30. One patient with a 6.5-cm tumor in a solitary kidney underwent heminephrectomy (65% resection) and developed acute renal failure requiring transient dialysis for 3 weeks.

Nonurological complications occurred in 29 patients (14.5%). A small (<1 cm) superficial, serosal bowel incision with the port site closure needle was repaired with a single intracorporeal figure-of-eight stitch. A recognized pleural injury was suture repaired. Segmental colonic ischemia of unknown etiology occurred in one patient. This may have occurred secondary to a thromboembolic event. Exploratory laparotomy and colon resection were performed without adverse sequelae. Other nonurological complications included deep venous thrombosis (four), pulmonary embolism (one), atelectasis (three), pneumonia (three), pleural effusion (two), wound-related complications (four), gluteal compartment syndrome (one), congestive heart failure (two), atrial fibrillation (two) prolonged ileus (one), sepsis (two) and a small splenic capsular tear managed by argon beam coagulation (one).

These data attest to the technical complexity of laparoscopic partial nephrectomy. This procedure requires advanced laparoscopic skills and has potential for serious complications. Reported experience with laparoscopic partial nephrectomy from other centers is summarized in Table 1. A multi-institutional series from Europe reported the outcomes of 53 patients undergoing laparoscopic partial nephrectomy and disclosed an overall urological complication rate of 23% [5]. Hemorrhage occurred in five patients (10%): intraoperative (four; 8%) and postoperative (one; 2%). Issues of hemostasis required emergent open conversion in two (4%), and secondary radical nephrectomy in one patient. Urine leak occurred in five patients (10%) requiring J-stenting (three), percutaneous nephrostomy (one), and nephrectomy (one). Overall, two kidneys (4%) were lost. In a recent review, Kim et al. [7] compared complications occurring during 35 laparoscopic radical nephrectomies and 79 laparoscopic partial nephrectomies. In the partial nephrectomy group, complications included intraoperative hemorrhage (six; 7.5%), urine leak (two; 2.4%), ureteral injury (one), acute renal failure (one), postoperative atelectasis (one), and clot retention (one). In each group open conversion was required in one patient to achieve hemostasis.

Current Issues and Future Directions

Renal Hilar Clamping

We believe that transient hilar clamping is an important prerequisite for a technically superior laparoscopic partial nephrectomy. Nonetheless, a small, completely exophytic tumor may be resected without hilar control. Recently, Guillonneau and colleagues compared the outcomes of laparoscopic partial nephrectomy with hilar clamping (group 1, 12 patients), and without (group 2, 16 patients) [6]. Mean laparoscopic operating time was 179 and 121 min for groups 1 and 2, respectively ($p=0.004$). Significantly higher intraoperative blood loss was reported in the patients without hilar clamping (708±569 ml vs 270±281 ml, $p=0.014$). Three patients in group 1 and two patients in group 2 required blood transfusion. Surgical margins were negative in all specimens. Although the authors acknowledged that bipolar cautery or ultrasonic shears may provide hemostasis without renal vascular control, these modalities of hemostasis char the tissue, and result in poor visualization of tumor margins. The main advantage of renal vascular clamping is the quality of visualization of the renal parenchyma, which facilitates accurate tumor excision.

Laparoscopic Renal Hypothermia

A hypothermic temperature of 15 °C or less offers adequate renoprotection from ischemic insult. During open partial nephrectomy, renal surface cooling with ice slush is the technique of choice for achieving adequate core hypothermia. In the minimally invasive realm, three techniques of achieving renal hypothermia have been described: surface cooling with ice-slush, retrograde perfusion of the calyceal system and intra-arterial perfusion. We recently described the technique of intracorporeal ice-slush renal hypothermia that mirrors the open approach of using ice-slush. Twelve selected patients with an infiltrating renal tumor underwent transperitoneal laparoscopic partial nephrectomy with hypothermia [19]. Median tumor size was 3.2 cm (range, 1.5–5.5 cm), and two patients had tumor in a solitary kidney. After an Endocatch-II bag (US Surgical, Norwalk, CT, USA) was placed around the mobilized kidney, and its drawstring cinched around the intact renal hilum, the renal artery and vein were occluded en bloc with a Satinsky clamp. The bottom of the bag was retrieved through a 12-mm port, opened, and ice-slush was introduced into the bag using modified 30-cc syringes (nozzle-end of the barrel cut off). With this approach, the entrapped kidney is completely surrounded by ice-slush within the bag. After renal hypothermia was achieved, laparoscopic partial nephrectomy was performed using our standard technique. Median time to deploy the bag around the kidney was 7 min (5–20 min), median volume of ice-slush introduced was 600 cc (300–750 cc), and time taken to insert the ice-slush was 4 min (3–10 min). Thermocouple measurements were taken in five patients and nadir renal parenchymal temperature ranged from 5 °C to 19.1 °C. Renal parenchymal temperatures upon completion of partial nephrectomy and just prior to hilar unclamping ranged from 19 °C to 23.8 °C following 43–48 min of ischemia.

Landman and colleagues described renal parenchymal hypothermia using retrograde ureteral access during laparoscopic partial nephrectomy in a pig model [20]. A 12/14 ureteral access sheath was advanced to the ureteropelvic junction under fluoroscopic guidance followed by placement of a 7.1F pigtail catheter within the access sheath. After clamping the renal artery and vein, ice-cold saline was circulated through the access sheath and drained via the 7.1F pigtail catheter. Renal cortical and medullary parenchymal temperatures, measured with thermocouples, were noted to be 27.3 °C and 21.3 °C, respectively. When this technique was applied in a patient undergoing open partial nephrectomy, the renal cortical and medullary temperatures were decreased to 24 °C and 21 °C, respectively [21]. A potential drawback of this technique relates to incisional entry into the collecting system that occurs within 1–2 min of initiating tumor resection for an infiltrating tumor. This would lead to leakage of the transureteral cold perfusate or necessitate temporary discontinuation, potentially compromising continued core hypothermia for most of the procedure.

Janetschek and colleagues described laparoscopic partial nephrectomy with cold ischemia achieved by renal artery perfusion [22]. Fifteen patients with a mean tumor size of 2.7 cm (range, 1.5–4 cm) were studied. Cold ischemia was achieved by continuous perfusion of cold Ringer's lactate (4 °C) at a rate of 50 ml per minute through an angiocatheter that was passed into the main renal artery via a percutaneous femoral puncture. To diminish the risk of catheter dislodgement, the procedure was performed in the operating room by an interventional radiologist. The renal hilum was dissected and the artery occluded with a tourniquet, allowing tumor excision in a bloodless field. Mean operative time was 185 min (range, 135–220 min). Mean ischemia time was 40 min (range, 27–101 min), and renal parenchymal temperatures were 25 °C. Although feasible, this technique has the potential for renal arterial intimal injury and thrombosis, femoral artery puncture site sequelae, and catheter slippage. Furthermore, the need to involve an interventional radiologist, and the inability to use this technique in the presence of atherosclerotic, multiple, aberrant, or small-diameter renal arteries may limit its application.

Hemostatic Aids

Although various techniques of parenchymal hemostasis have been reported [23–25], their lack of reliability has prompted us to employ intracorporeal suturing exclusively. Physical means of circumferentially compressing the kidney include renal parenchymal tourniquets and cable tie devices that have been tested to achieve vascular control during a polar partial nephrectomy [26–28]. Although effective in the experimental setting of a smaller porcine kidney, these devices are clinically unreliable in the larger human kidney.

Fibrin sealants have been studied for a variety of urological applications [29]. The basic mechanism of action is to facilitate fibrinogen to fibrin conversion. Thereafter the soluble fibrin monomers are cross-linked to form insoluble fibrin that seals transected vessels. Concerns with this technology include single-donor cryoprecipitate-derived fibrinogen, which does not entirely eliminate the risk of viral disease transmission, bovine-derived thrombin (allergic reaction and potential transmission of prion diseases), and lastly these products often require two components to be mixed and/or sequentially applied, placing further demands on the surgeon in the laparoscopic arena.

A more readily applicable and user-friendly sealant, FloSeal has been incorporated into our current technique and applied in the most recent 50 patients. It is a highly effective adjunct in maintaining hemostasis. It is easily prepared within minutes and immediately effective. The gelatin matrix thrombin composite in FloSeal mechanically slows down bleeding and provides exposure to a high thrombin concentration, which accelerates long-term hemostasis by clot formation [30]. FloSeal has been used to achieve hemostasis during open and laparoscopic partial nephrectomy for exophytic tumors that did not require closure of the collecting system [30, 31]. In the future, we believe that potent bioadhesives will assume a primary rather than adjunctive role in obtaining renal parenchymal hemostasis during laparoscopic partial nephrectomy.

Conclusions

Laparoscopic partial nephrectomy is an evolving technique indicated in select patients who are candidates for nephron-sparing surgery. Experience with laparoscopic partial nephrectomy continues to grow and issues of renal ischemia and hemostasis are being addressed in the laboratory. Although the short-term oncological adequacy of laparoscopic partial nephrectomy is equivalent to open partial nephrectomy, long-term data are required.

Laparoscopic partial nephrectomy is a technically advanced procedure that requires application of the complete laparoscopic skill-set in a time-sensitive environment. However, it is the only form of minimally invasive treatment for localized renal cell carcinoma (RCC) that replicates the steps of open partial nephrectomy, the current gold standard of care. Thus, until the true therapeutic efficacy of energy ablative techniques is established, laparoscopic partial nephrectomy should be considered the primary form of minimally invasive NSS for localized RCC.

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3.2 Cryoablation and Other Invasive and Noninvasive Ablative Renal Procedures

Patrick S. Lowry, Stephen Y. Nakada

Contents

Introduction

The calendar year 2002 brought 31,800 new cases of cancer of the kidney accompanied by 11,500 deaths [1]. Historically, a large percentage of new renal cancer cases were discovered with metastasis, and even now one-third of renal cell carcinoma patients present with metastatic disease [2]. Due primarily to the widespread use of CT scanning, MRI, and ultrasound, contemporary series show increased rates of early discovery of renal tumors; over 50% of renal cell carcinomas (RCCs) now present as incidental findings [2, 3].

Effective control of renal cancer has historically been only by open surgery, with radical nephrectomy [4]. As a result of the trend towards early diagnosis of incidentally discovered small renal masses, modern surgical treatment has evolved. Partial nephrectomy, originally a procedure for patients with solitary kidneys or compromised renal function, emerged as the treatment of choice for renal masses smaller than 4 cm, even in patients with normal contralateral kidneys. Outcomes for cancer control and renal function after partial nephrectomy has been equivalent to results of radical nephrectomy [5, 6]. Numerous nephron-sparing options now exist to complement open partial nephrectomy, including laparoscopic partial nephrectomy and tissue ablative techniques such as cryoablation, radiofrequency (RF) ablation, high-intensity focused ultrasound (HIFU), microwave thermotherapy, interstitial laser therapy, and Cyberknife technology.

Of the tissue ablative options, the most clinical data exist on cryoablation. RF has been shown to be effective in the treatment of liver lesions, and clinical results are coming forth regarding its potential in the treatment of renal lesions. HIFU, microwave thermotherapy, interstitial laser therapy, and Cyberknife technology exhibit potential for future application in the treatment of renal cancer, but still warrant further investigation.

Mechanisms of Tissue Ablation

Cryoablation

Although mechanisms of tissue destruction are not completely characterized, it is postulated that cryoablation destroys tissue in both an immediate and a delayed manner [7]. Initially, rapid freezing forms cytotoxic intracellular ice crystals. The freezing process also causes extracellular ice crystal formation, increasing the extracellular osmotic concentration. As water follows the gradient into the extracellular space, the intracellular space becomes hyperosmotic, resulting in pH changes and protein denaturing. When the temperature falls further, extracellular ice crystal formation mechanically disrupts cellular membranes. Ensuing freezing of the cell physically damages the membranes, proteins, and cellular organelles. Damage to the vasculature within the ice-ball causes hyperpermeability of the microcirculation, resulting in thrombosis, vascular occlusion, regional tissue ischemia, and edema, leading to delayed cell death [8, 9]. Initial reports indicated that the critical temperature to ensure cell death is –40 °C [7]; however, subsequent studies, using a single-freeze cycle and monitoring tissue with thermosensors, have shown complete cell death at temperatures below –19.4 °C [10]. Canine studies show that the ice-ball must extend at least 3.1 cm beyond tumor margins in order for the margin to achieve the necessary –20 °C [11]. To ensure adequate treatment of the margins in clinical use, some recommend the ice-ball be extended 1 cm beyond tumor margin [12].

Although elements of tissue destruction are achieved with both the freeze and thaw processes, continued investigation remains to be performed to determine the optimal cycle of therapy (number of freezes, length of freeze, type of thaw [active vs passive]). Some studies show no difference in renal tissue ablation when comparing single vs double-freeze or active vs passive thaw [13, 14]. Others recommend a double-freeze cycle to improve cell death at margins [12, 15, 16]. Renal technique is largely based on available treatment data of hepatic tumors, primarily utilizing double-freeze cycles [17–19]. Single-freeze cycles effectively ablate normal renal parenchyma [20], but tumor models have not been developed to corroborate the minimum number and type of freeze/thaw cycles necessary for complete cell death. Double-freezing in an animal model results in a larger area of central liquefaction necrosis [14, 21]. Investigators have also found that with a double-freeze, passive thawing had no advantage over an active thaw [13, 21]. However, contrasting studies suggest that passive thawing does maximize tissue destruction [16]. While cell death is certain in the central area of liquefaction necrosis, the tumor margin is the area of concern. The dual-freeze technique increases physical damage to tumor cells, and a passive thaw may help to maximize tumor destruction. Unless new experimental results dictate otherwise, we believe double-freeze cycles with either active or passive thawing is adequate for renal cryoablation.

Radiofrequency Ablation, HIFU, Microwave Thermotherapy, Interstitial Laser Therapy

Radiofrequency, HIFU, microwave thermotherapy, and interstitial laser therapy all induce thermal tissue damage. The pathophysiology of thermal ablation has been well characterized [22]. When exposed to temperatures above 45 °C, cells undergo irreversible injury. At temperatures above 60 °C, instantaneous cell death occurs due to coagulation of proteins, cellular structures, and nucleic acids within the cell. The coagulation necrosis from the treated area is reabsorbed, with resultant formation of fibrosis.

Radiofrequency Ablation

Radiofrequency ablation employs electrical current around its probe tips to use heat to destroy tissue. When absorbed by tissue, the electrical current causes agitation of ions, resulting in molecular friction and heat up to 100 °C. RF ablation may be performed in several different ways, including conventional (dry) RF, saline augmented (wet) RF, cooled-tip RF, and bipolar RF.

During conventional RF ablation, the electrical current can be impeded by desiccated tissue that may collect on the probe tips, resulting in smaller lesions and areas of incomplete treatment, or skip lesions [23–25]. Conversely, other groups have described consistent successful treatments with conventional RF [26], suggesting that different RF units and/or individual surgeon technique may impact outcome.

In wet RF ablation, an electrically conductive medium, hypertonic saline, is infused in the treatment area. Theoretically, this prevents collection of charred tissue on the RF probes, allowing the electrical energy to be more evenly dispersed, for potentially larger, more consistently treated areas [27], although consistency remains a problem [23]. As with conventional RF ablation, areas of viable tissue, or skip lesions, within wet RF lesions have been described [23]. The cause for the viable tissue may be the pathology of the RF lesions. Two types of necrosis are seen with RF: a blanched necrotic lesion, and a predominantly

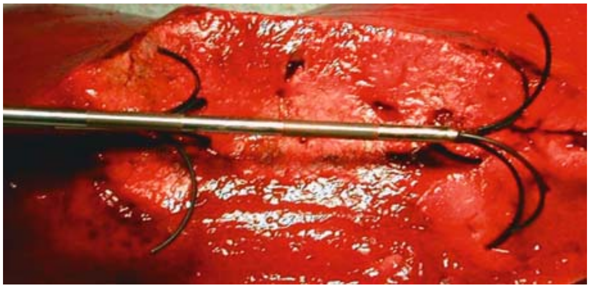

Fig. 1. Photo of prototypical bipolar radiofrequency probe. (Courtesy of Fred T. Lee, Jr.)

hemorrhagic necrotic lesion [28]. These hemorrhagic lesions may contain rare living and regenerating cells [28].

During cooled-tip RF ablation, an additional unit cools the probe tip, allowing the treatment to proceed without heat-induced charring and the subsequent undesired effects [29]. Cooled-tip RF ablation appears to have durable results in the short to intermediate time range, but it must be noted that no pathological examination of specimens was done to evaluate for skip lesions.

All monopolar RF units use the patient as the grounding source, and some uncontrolled thermal dispersion is a theoretical concern. Prototype bipolar RF units with two probes exist, allowing the electrical current to flow from one probe to another. Bipolar RF has been described in an animal model, and the experimental data show larger areas of tissue ablation, more uniform cell death, and improved monitoring of the lesion because the lesion can be framed within the bipolar needles [28] (Fig. 1).

At this time, RF technology is evolving rapidly. Published reports are not uniform with regard to the type of RF technology used, intraoperative monitoring, and treatment success. The use of RF for the treatment of select renal lesions at certain institutions has been successful in the intermediate time frame. As RF technology becomes more advanced, uniform treatment can be expected at all treatment locations.

HIFU

High-intensity focused ultrasound is a noninvasive method for delivery of heat energy to treat malignant lesions. Ultrasound waves are focused by a parabolic reflector into a small, finite area. The focused, high-intensity ultrasound waves are absorbed by the tissue, producing heat to 90 °C and resulting in tissue ablation only in the area of focused energy [30, 31]. At this time, HIFU shows capability as an energy source for the ablation of renal tumors, but must be regarded as an investigational treatment until further progress has been achieved. Certainly, if effective, HIFU is the least invasive treatment available at present.

Microwave Thermotherapy

Transmitted through probes inserted into tissue, microwaves of 300–3,000 Hz generate heat by oscillation of the electromagnetic field, with subsequent coagulation necrosis of the targeted tissue. The pattern of tissue ablation has several zones of destruction [32]. Forty-eight hours after microwave thermotherapy, in vivo and in vitro, H&E stains show that closest to the microwave probe there is a complete ablative zone, characterized by preservation of the renal architecture. Adjacent to the complete ablative zone is a partial ablative zone characterized by coagulation necrosis. In vivo, immediate H&E staining reveals two zones: adjacent to the microwave probe there is a red zone of capillary congestion and red blood cell damage. Outside of this red zone, an irregular shaped pink zone extends in which proteinaceous fluid is seen in the tubular lumen. At the cellular level, the red zone surrounds an area of complete necrosis, with a zone of partial necrosis extending further into the pink zone. At this time, microwave thermotherapy for treatment of renal tumors remains investigational, but this mechanism for tissue destruction merits further investigation.

Interstitial Laser Thermotherapy

After placement of appropriate laser fiber (Diode, Nd:YAG) into the tissue to be treated, activation of the laser creates appropriately high temperatures resulting in coagulation necrosis [33]. A preliminary study involving patients who were not surgical candidates exhibited the ability of the interstitial laser therapy (ILT) to ablate tumor via a percutaneous approach. Although tumor volume was not significantly decreased, enhancing tumor volume was reduced by 45% [34]. While ILT shows the potential for minimally invasive treatment of renal lesions, it remains investigational at this time.

Cyberknife Technology

Although not classically needle ablation, the Cyberknife is a radiosurgical device [35]. Radiotherapy kills cells by inducing DNA strand breaks (single- and double-strand breaks), interfering with cell replication and resulting in apoptosis. In addition, high-dose radiation can directly kill cells. The Cyberknife, similar to the Gamma Knife used in neurosurgery, takes 1,200 separate beams of radiation, and focuses them into an intense dose of radiation in a more discrete area than conventional radiation therapy. The individual 1,200 radiation beams have low levels of radiation, and induce very little effect on tissue, but high-radiation doses are delivered to the focal point, destroying target tissue while sparing surrounding structures.

Indications and Contraindications

Minimally invasive therapies are generally not recommended for lesions larger than 4 cm in size. Tumor margins and adequate cell death are the area of most concern from a standpoint of oncological treatment, and larger lesions are more likely to have incompletely treated margins. Minimally invasive therapies are well suited for patients with multiple masses (Von Hippel-Lindau), bilateral masses, solitary renal units, or chronic renal insufficiency due to the renal-sparing nature of these treatments. Exophytic lesions are the most straightforward to treat; they are the easiest to identify, and may be treated with minimal risk to hilar structures and the collecting system. Coagulopathy is an absolute contraindication, because of the risk of acute or delayed hemorrhage.

Hilar lesions should be avoided; placement of probes as well as activation of the energy system could cause bleeding from large hilar vessels. Furthermore, impingement on the collecting system, likely during treatment of hilar lesions, risks postoperative urine leak. In addition, hilar lesions pose an additional problem for cryoablation. The blood flow through the larger vessels creates a heat sink in the area adjacent to the vessel, interfering with progression of the cryolesion.

Ideally, masses to be treated with these therapies would enhance on CT or MRI. In addition to a higher likelihood of being benign, the nonenhancing quality negatively impacts the quality of the surveillance. As no tissue is formally removed, the treated area is expected to form a scarred lesion, which should be nonenhancing and either stable or decreasing in size on follow-up imaging. An increase in size or development of an enhancing area would be indication for retreatment or surgical removal of the lesion.

It should be noted that at this time, these minimally invasive treatments have not had long-term follow-up, and consequently must not be considered as durable a therapy as partial nephrectomy.

The role of operative renal biopsy with needle ablation is often debated. While there are clear benefits in follow-up plans and a potential treatment plan, many investigators choose not to perform a renal biopsy at the time of treatment. Certainly, in most cases, the biopsy data have little effect on the treatment plan, as many focus on the radiographic follow-up. In time, as more potential surgical candidates or younger patients elect needle ablative techniques, renal biopsy will gain renewed interest.

Preoperative Planning

The standard workup of a renal mass should be complete before deciding on the surgical approach. Therefore, the evaluation should be the same as for an open radical nephrectomy. Renal function should be evaluated with a serum creatinine. If the creatinine is elevated, or if the radiological imaging reveals an abnormal contralateral kidney, a differential renal scan may be considered. A metastatic survey should include an abdominal CT scan, a PA and lateral chest X-ray or chest CT, and a serum calcium and alkaline phosphatase. A bone scan is advised for patients with elevated calcium, elevated alkaline phosphatase, or a recent onset of symptomatic bone pain [2].

Patients should undergo bowel prep the night before surgery with the agent of choice so that in the case of inadvertent injury to the bowel, primary repair may be performed. For tissue ablation, most use one bottle of magnesium citrate.

Techniques

Cryoablation, RF, and microwave thermotherapy could potentially be performed via laparoscopic access [12, 24]. Cryoablation, RF, and interstitial laser thermotherapy have been described through percutaneous access [34, 36, 37]. Although still experimental in nature, HIFU and the Cyberknife deliver energy transcutaneously, potentially representing the least invasive treatment modalities.

Equipment

Cryoablation is delivered via cryoprobes, which are insulated instruments that are supercooled at the tip using either liquid argon (−187 °C) or liquid nitrogen (−195 °C). The supercooled tip forms a cryolesion, or ice-ball, around the tumor. Cryoprobes are available in various diameters to tailor therapy for varying situations. Cryoprobes can be advanced through laparoscopic ports or placed percutaneously. Laparoscopic intraoperative ultrasound monitors probe placement and ice-ball progression.

Radiofrequency requires RF probes and the generator to supply the electrical current that supplies heat for tissue ablation. Laparoscopic ultrasound can be used for placement of the probe, but may not show accurate progression of the treatment. Experimental treatments such as microwave thermotherapy, interstitial laser treatments, HIFU, and Cyberknife technology require their delivery systems and energy generators.

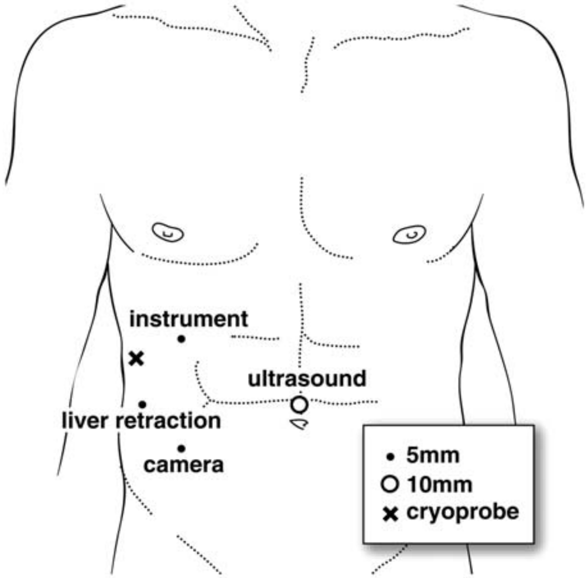

Fig. 2. Schematic for transperitoneal cryoablation, port configuration

Laparoscopic Positioning

For anterior and anterolateral lesions, the authors employ a transcutaneous laparoscopically-assisted access. The patient is positioned in a modified flank position. Although the table may be rotated to more of a flank during the case to allow the bowel to fall away and facilitate dissection, initial positioning consists of a modified flank position with the abdomen aimed slightly more anteriorly (Fig. 2). For posterior or posterolateral lesions, the patient is placed in the full flank position to facilitate retroperitoneal access (Fig. 3). The kidney rest is raised sparingly to avoid neurological or pressure injuries, and the table is minimally flexed (15–20°). The downward leg is flexed, and the knee and ankle are well padded with foam or gel pads. The upward leg is straight and well supported with pillows. The lower arm is well padded at the elbow and wrist, and an axillary roll is placed. The upper arm is placed on enough pillows to keep it in a relaxed position. The patient is carefully examined to ensure that no points of excess pressure exist. Areas of concern should receive additional padding or change of position. Wide cloth tape affixed to the bed and placed over the shoulder and greater trochanter

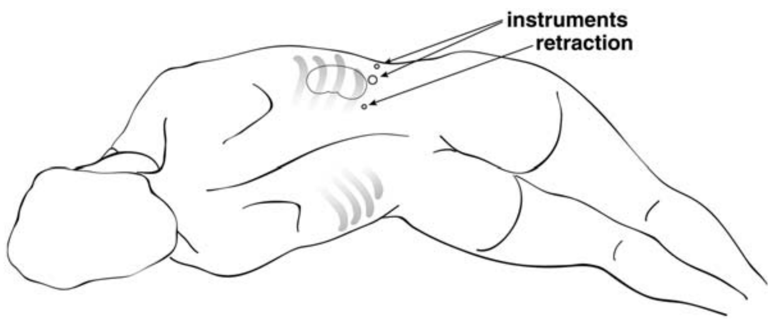

Fig. 3. Schematic for retroperitoneal cryoablation, with patient positioning and port position

increase stability. Tape blisters are avoided by placing towels or Tegaderm between the cloth tape and the skin. The patient's entire abdomen and flank is then prepped and draped.

Intraoperative Monitoring

Accurate monitoring of laparoscopic cryolesions is accomplished with intraoperative laparoscopic ultrasound probes. The cryolesion may be monitored with real-time sonography performed by a radiologist experienced in laparoscopic ultrasound, which we believe better confirms adequate treatment of the margin. The authors use a laparoscopic high-resolution linear ultrasound transducer (Lap L9-5, HDI 5000, Bothell, WA) that fits through a 10-mm port. The tip of the transducer probe deflects in the anterior-posterior and medial-lateral directions to allow viewing of the advancing cryolesion from different angles (Fig. 4). Investigators who perform cryoablation via percutaneous methods usually monitor the cryolesion with MRI [37].

Monitoring of the RF-induced lesion has proven more difficult. The RF interferes with the ultrasound probe, preventing the outermost extent of the RF lesion from being accurately monitored [23, 24]. CT scanning has been used for monitoring of RF during percutaneous treatment [36, 38], but is not available for use during laparoscopic exposure. Accurate monitoring of the lesions caused by RF is important, because the lesions are not as uniform or consistent as those created during cryoablation [23]. Bipolar RF may prove to have advantages with monitoring, as the needle may be used to frame the lesion to be ablated [28].

Wisconsin Technique for Laparoscopic Cryoablation of Renal Tumors

Laparoscopy is utilized for exposure of the renal mass. Three trocars are placed for either approach; a fourth 5-mm port is sometimes employed for liver retraction. Cryoablation is performed using an argon gas-based

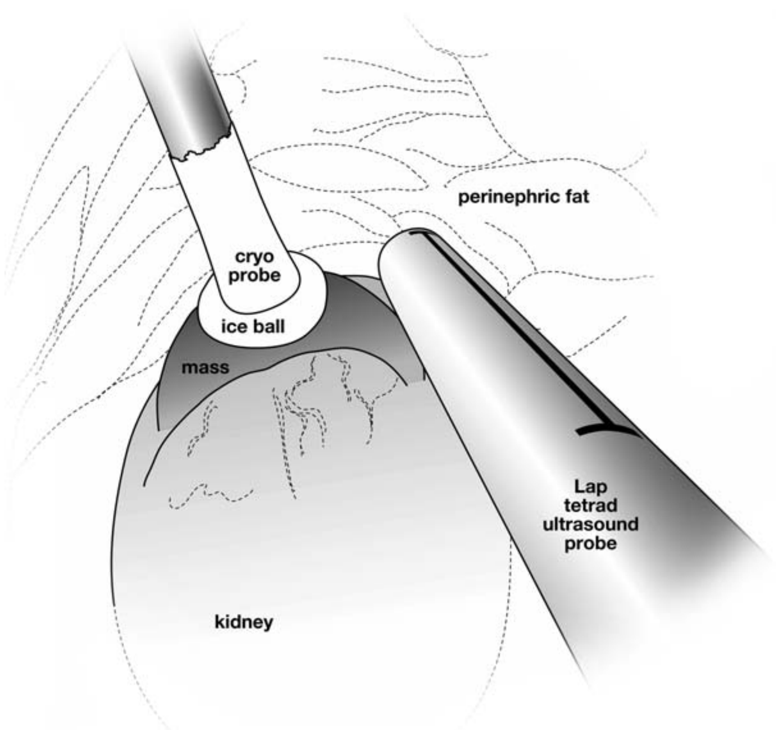

Fig. 4. Intraoperative monitoring schema, with ultrasound probe and cryolesion visible transperitoneally

system that operates on the Joule-Thompson principle (Accuprobe, Endocare, Irvine, CA). Cryoprobes are available in diameters of 2.4 mm (sharp tip), 3.0 mm (blunt), and 5.0 mm (blunt). The number and size of cryoprobes used in individual cases vary because of differences in tumor size and location. The smaller cryoprobes (2.4, 3.0 mm) are often passed percutaneously because of the relatively short shaft length; the 5.0-mm probe has more flexibility for placement given the longer shaft, and may be placed laparoscopically or percutaneously. After ultrasound confirms proper probe placement, cryoablation is initiated

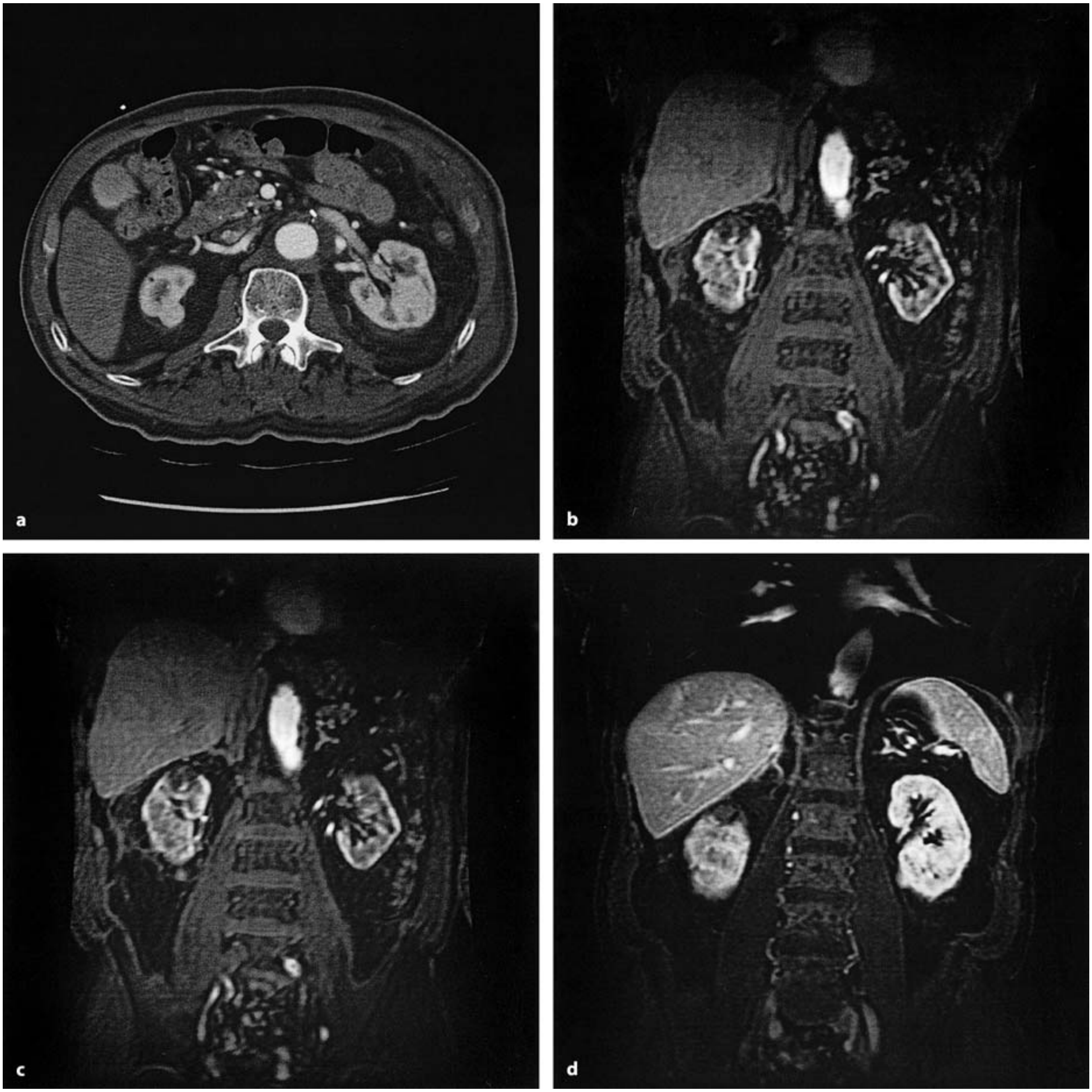

Fig. 5. a CT of 2-cm renal lesion, untreated. **b** One month follow-up MRI. **c** Three month follow-up MRI: note minimal enhancement. **d** Seven month follow-up MRI, with no enhancement and lesion contraction

using two 10-min freeze cycles followed by passive thaws. The freeze cycles continue until the ice-ball edge is 1 cm beyond the tumor margin. When probes are placed percutaneously, the abdominal wall is protected from cryoinjury by placing red rubber catheter tubing over the probe. The skin is protected by dripping saline onto the skin at the probe entry site. The probes are not removed from the cryolesion until they are released spontaneously during passive thawing. After careful probe removal, a small piece of rolled up Surgicel can be placed in the defect of the cryoprobe and held with direct pressure for 10 min. With the insufflation pressure decreased, the cryolesion is observed for 15 min to confirm hemostasis. Additionally, fibrin glue may be injected into the cryoprobe defect to control venous bleeding.

Postoperatively, serial serum hematocrits are obtained for 24 h. MRI is obtained on postoperative day 1, and at 3, 6, 9, and 12 months, then yearly; if a lesion does not shrink appropriately, more diligent follow-up is required (Fig. 5 A–D). We obtain MRI scans with T_1-weighted, T_2-weighted, and gradient echo images performed before, during, and after gadolinium-based intravenous contrast.

Complications

Complications of minimally invasive therapy are similar to those of partial nephrectomy, but special considerations should be made to avoid unnecessary morbidity. Using open cryoablation, Rukstalis et al. described a renal laceration in the cryoablated area that required sutures for hemostasis, and several capsular tears managed with direct pressure in open cryoablation [39]. To minimize trauma, cryoprobe removal should be done passively after the cryolesion has thawed adequately to release the probe [12, 23]. To stop bleeding, direct pressure with hemostatic agents is applied to the cryoprobe defect for 10 min, followed by observation for 10–15 min (under reduced insufflation pressure) [12]. In one percutaneous cryoablation series, small perinephric hemorrhages were seen in 20% of the patients ($n = 20$) [37], and 25% of the patients ($n = 4$) in another percutaneous cryoablation series [40]. Although these were managed conservatively without need for transfusion, they illustrate the potential of serious bleeds with cryoablation, especially in percutaneous procedures, where bleeding cannot be visually monitored. Furthermore, a chronically anemic patient from a laparoscopic series [15] experienced a drop in hemoglobin (11.6 to 9.2) resulting in atrial fibrillation and requiring transfusion. Laceration of the liver caused by a fan retractor has been described; the patient was managed conservatively without transfusion [12].

To avoid inadvertent contact and subsequent injury, adjacent organs need protection from the cryolesion. Pancreatic injury [15], ureteropelvic junction stricture [11, 29], and complete bowel obstruction [41] have been reported. Results of cryolesion involvement with the collecting system are unclear. Animal studies with intentional impingement of the cryolesion on the collecting system revealed minimal scarring of the lamina propria and smooth muscle and regrowth of overlying urothelium [42]. However, an earlier study by the same group described a death in an animal due to urinary extravasation [41]. Involvement of the ice-ball with the collecting system was also described in an open human series, and in animal models, no urinary leak was seen [11, 39].

RF, as well as other ablative mechanisms delivered laparoscopically, have similar complication profiles related to the laparoscopic exposure of the renal lesion, the potential for bleeding, and the possibility of damage to adjacent organs. A series of 37 RF treatments had eight small, contained, clinically insignificant hematomas and one inadvertent burn of the liver; no patient required transfusion or had delayed hemorrhage [36]. In another series outlining complications during RF treatment of liver lesions, it was noted that 0.6% experienced dispersive pad burn [43].

HIFU also adds the potential for skin burns, which should be avoidable with proper coupling of the water cushion [30]. As clinical experience is very limited with HIFU, the potential for additional complications remains to be clarified.

Interstitial laser therapy, microwave thermotherapy, and the Cyberknife technology also have too limited experience to suggest particular potential complications.

The Cyberknife is a variation of radiation therapy, and one might speculate that complications from radiation toxicity may be localized to the treated area. Since the Cyberknife concentrates the treating radiation onto a focal area, toxicity to surrounding organs may be minimized.

No adverse systemic effects have been noted after any of the minimally invasive treatments. During cryoablation, systemic hypothermia has not been noted, and monitoring of renal artery and renal vein temperatures showed no evidence of hypothermia [44]. In a porcine model, esophageal temperature decreased by only 1–3 °F [41]. Clinically, patient core temperature was unchanged [41].

Experimental Studies

Cryoablation of small tumors does not compromise renal function in patients with normal baseline function. A canine model with solitary kidneys showed a temporary elevation of creatinine compared to baseline [11]. Bilateral cryoablation in a porcine study also showed transient elevation of creatinine [41]. In humans undergoing renal cryoablation, postprocedure creatinine was not significantly elevated [40, 45]; however, patients with existing renal insufficiency may have deterioration of renal function [39]. Also, blood pressure monitoring has found no significant differences in preoperative and postoperative blood pressure levels, even in patients with solitary kidneys [45].

Postoperative Imaging

Postoperatively, lesions require close monitoring to ensure tumor regression. The renal mass may not completely disappear for a number of months, as it is replaced with fibrosis, but it should progressively decrease in size or become stable. Furthermore, these fibrotic scars are not expected to show areas of enhancement. Failure to decrease in size after 6 months or the persistence of enhancing areas should mandate consideration for renal biopsy, repeat treatment, or radical/partial nephrectomy. While no set algorithm exists for postprocedure monitoring, all patients need close follow-up (every 3–6 months) for 12–18 months, followed by long-term surveillance, yearly or every other year, to identify any recurrences.

Results

The laparoscopic approach offers the renal sparing benefits of open exposure, yet with less morbidity. The kidney is generally approached transperitoneally for anterior and lateral tumors, or retroperitoneally for posterior tumors. After kidney mobilization and adequate tumor exposure, cryoprobes are placed into the tumor through the laparoscopic trocars or transcutaneously. Placement of the cryoprobes is monitored visually and via laparoscopic ultrasound probes. End-firing ultrasound has also been used for monitoring probe placement and subsequent therapy [46]. One published series includes 32 patients with a maximum tumor size of 4 cm treated with a double-freeze technique [12]. The hospital stay was 1.8 days (average), and time to full recovery was 2 weeks (median). Twenty patients had follow-up MRI at 1 year; five had no evidence of disease, and 15 had lesions that decreased in size by an average of 66%. Overall, average follow-up was 16 months (range, 7–23), with no recurrence. Twenty-three underwent postprocedure biopsy of the small residual mass, which were all negative. Laparoscopic cryoablation offers excellent exposure, accurate ultrasound monitoring, and nephron-sparing potential while remaining minimally invasive. Currently, available intermediate results appear durable, but longer follow-up is needed. Our series to date at Wisconsin includes 31 patients treated laparoscopically, with one recurrence and mirrors other experiences.

RF ablation has neither as many clinical series nor the length of follow-up when compared to cryoablation. One study includes 34 high-risk patients who underwent percutaneous RF treatments for 42 tumors [29]. Although this series appears to show successful treatment of exophytic lesions, other studies have shown incomplete tissue ablation in the target area [23, 25, 47]. The reason for the failures is not known. Some believe that incomplete tumor treatment is due to the shortfalls of dry RF, and that saline-augmented treatments will prove superior. However, wet RF creates lesions that are irregular in shape and variable in size [23]. With irregularity of lesions preventing predictable treatment areas, the difficulty obtaining accurate radiologic monitoring is of paramount concern. Monitoring of temperature in adjacent renal tissue to follow the RF lesion has been described in an experimental model and may help characterize how the RF lesion progresses [48]. RF treatment failures may have occurred as a result of inadequate treatment caused by limited operative monitoring.

Comparison of Cryoablation and RF

Both cryoablation and RF are potential additions to the treatment armamentarium for renal masses. Intermediate data of cryoablation is promising, and data of treatment with RF is emerging. At this point, cryoablation appears to have advantages over RF. At this time, larger studies with longer follow-up give more credence for treatment with cryoablation. Cryoablation is easily monitored intraoperatively with ultrasound, yet RF presents a challenge in attempting to monitor progression of treatment. Lesions created with cryoablation are predictable, with homogenous destruction of tissue within the cryolesion; RF has not yet been refined to produce regular, predictable lesions, and potential viability of treated tissue remains a concern. Cryolesions produce an area with predictable tumor destruction, with only the margin being of concern.

Longer follow-up of patients treated with RF will answer questions regarding the adequacy and durability of RF ablation. Benefits of RF include the outpatient nature of the treatment, and further support its role in patients who are not good candidates for surgery or anesthesia. Undoubtedly, with time, RF or other thermal ablative techniques will prevail for many patients. In the future, carefully controlled clinical trials will be necessary to confirm their efficacy, as well as to establish their role compared to surgical resection, the current standard of care.

Conclusion

As five-year follow-up nears, urologists will soon be able to confirm the durability of renal cryoablation. Nevertheless, investigators must delineate methods that will ensure cell death at margins of the cryolesion, and to further determine the margin for safety around the collecting system and other vital structures. The use of radiofrequency ablation continues to become more widespread, but with varying energy sources, current results are variable. Further investigation is required to develop more uniform and predictable patterns of ablation. Additionally, improved intraoperative monitoring of RF ablation will be required to ensure that lesions are treated completely. Microwave thermotherapy and interstitial laser therapy remain investigational, but have tissue ablative capabilities that need further study. HIFU and Cyberknife technology are potentially the ideal minimally invasive ablative therapy, but still require further characterization. Improved renal cancer tumor models and lines are needed, particularly for in vivo studies; this is especially relevant with the Cyberknife since renal cell carcinoma is commonly radiation resistant. Furthermore, one must take care when analyzing results of clinical series of small lesions that have never been biopsied; the data may not extrapolate to treatment results of slightly larger renal cell carcinomas as smaller lesions more commonly are benign lesions or less aggressive cancers. While the potential of minimally invasive ablative techniques are boundless, the future lies in the options of cryoablation, radiofrequency ablation, and various extirpative techniques.

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4 Laparoscopic Radical Nephroureterectomy for Upper Tract Transitional Cell Carcinoma

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Humberto Villavicencio

Contents

Introduction

The standard treatment for most patients with upper tract transitional cell carcinoma (TCC) is open complete nephroureterectomy (NU) with excision of a cuff of the bladder and intact removal of the entire specimen [1]. This usually requires one long incision or two separate incisions resulting in significant morbidity and prolonged convalescence [2–8].

Currently minimally invasive techniques allow for other management options. In selected cases, such as in solitary kidney, renal insufficiency, bilateral tumours or in patients with high anaesthetic risk, antegrade or retrograde nephroscopy/ureteroscopy with excision and ablation of the tumour can be an option [9–15]. Most patients, however, require nephroureterectomy. It was Clayman et al. [16] who in 1991 described the technique of laparoscopic nephroureterectomy (LNU). In that time it was a very long surgery with concerns about the oncological outcome.

After more than a decade, progressive acceptance and apprenticeship of laparoscopy in different centres all over the world have led to several publications (Tables 2–4). Transperitoneal (TP) or retroperitoneal (RP) laparoscopic or laparoscopic hand-assisted (HA) nephroureterectomy has become another minimally invasive option for the definitive surgical management of upper tract TCC [2, 3, 17–21]. Compared with open nephroureterectomy, this approach results in decreased morbidity, better hospital recovery, and briefer convalescence [2–8].

Indications and Contraindications

The indications for laparoscopic and laparoscopic-assisted NU are the same as those for an open procedure. TCC of the renal collecting system or the ureter is the most common indication. In patients at risk for renal failure following nephrectomy and with an early-stage and low-grade TCC, one should consider a renal-sparing approach. An uncorrected bleeding diathesis is the only absolute contraindication to the procedure. Chronic renal inflammation is a relative contraindication, since risk of complication and conversion is potentially increased.

Previous major open abdominal surgery can be better managed by the RP approach, and therefore is no longer a contraindication.

In patients with previous pelvic surgery, one should better proceed to laparoscopy of the kidney and then an open approach to the lower ureter.

Preoperative Preparation

The diagnoses of upper tract TCC should be confirmed by urography or a computed tomography scan or, as an alternative, by ureteroscopic evaluation and biopsy. Concomitant TCC should be excluded with cystoscopy and radiographic evaluation of the contralateral collecting system. In high-grade lesions, depending on the clinical extension, further staging can include chest radiography, computed tomography scan of the abdomen, bone scan and liver function tests.

When there is a risk of renal failure after nephrectomy, a preoperative nephrological evaluation will favour the postoperative management and eventual dialysis. A mechanical bowel preparation is not necessary in most patients. Prophylactic antibiotics should be given.

Patient Positioning and Operating Room Configuration

The intervention consists of two parts in our centre. In the first part, the management of the distal ureter, the patient is placed in a dorsal lithotomy position. In the second part, the NU itself, the patient is placed in a semilateral decubitus position (60° oblique position) with the operative table flexed. Pressure points are padded. The patient is secured to the table at the chest, lower hip, and knee level with wide cloth tape to ensure that no patient movement will occur during the procedure. The bottom leg is flexed and bent while the top leg is kept straight. Pneumatic stockings are placed on both legs.

The semilateral decubitus position, with the ipsilateral shoulder and hip rotated approximately 20–30° upwards, allows for the patient to be rotated from the flank position to a modified supine position without having to be repositioned on the table when initiating an eventual open distal ureterectomy.

Prior to insufflation, all patients are put under general endotracheal controlled anaesthesia, a nasogastric tube and, after a cystoscopic component, if necessary, a three-way Dufour catheter is inserted.

In a TP approach, the surgeon and his assistant stand on the contralateral side to the tumour. The scrub nurse with the instrument table is positioned on the ipsilateral side at the end of the table. Alternatively, an AESOP robot (Computer Motion, Santa Barbara, CA, USA) can be fixed to the ipsilateral side at the head of the operating table to hold the camera.

In the RP approach, the patient is placed on the operative table in a standard flank position with the pathology side facing up. The surgeon and the assistant are positioned facing the patient's back. The scrub nurse stands on the opposite side at the end of the table.

Two monitors, one on both sides of the patient, allow the operative team to view the procedure.

Access and Trocar Placement

In our institution, a TP approach with four trocars is utilized. Intraperitoneal access is initially obtained with the placement of a 10/12-mm trocar using the open-access technique at the level of the umbilicus but lateral to the rectus fascia depending on the obesity of the patient. A pneumoperitoneum is created by applying 10–15 mmHg of CO_2 pressure. Then two 10/12-mm trocars, one just above the iliac crest in the midclavicular line and another at the level of the umbilicus in the anterior axillary line, and a 5-mm trocar, subcostal in the midclavicular line, are inserted under view. Additional trocars may be placed as needed for retraction of the liver, colon, ureter or kidney.

Surgical Technique

Management of the Lower Ureter

The development of endoscopic techniques (pluck or intussusception) at first allowed an improvement in the management of the lower ureter in open radical surgery [22, 23]. The incorporation of laparoscopic surgery in the radical treatment of TCC of the upper urinary tract has led to the new approaches in order to improve technical and oncological results [24–26]. Long-term comparative outcomes will ultimately solve the dilemma of the distal ureter [27] (Table 1).

Table 1. Management of the lower ureter: advantages and disadvantages of the different techniques

Technique		Advantages	Disadvantages
Open surgery		One of the most reliable	Possible contralateral ureteral compromise
		Advised in tumours of the distal ureter and intramural ureter, and in the bladder	Possible inadequate total distal excision (obese patients)
		Advised in previous pelvic radiotherapy	Compromise of contralateral orifice
Pluck procedure	Simple	Easy and simple technique	Contraindicated for tumours of the distal ureter and intramural ureter, and in the bladder
		No learning curve	Contraindicated in previous pelvic radiotherapy
		Less distal laparoscopic dissection	Distal ureter unoccluded (potential extravesical tumour seeding)
			Risk of leaving a fragment of the ureter
	With balloon occlusion	Easy and simple technique	Contraindicated for tumours of the distal ureter and intramural ureter, and in the bladder
		No learning curve	Contraindicated in previous pelvic radiotherapy
		Minimal risk of extravesical seeding	Risk of leaving a fragment of the ureter
		Less distal laparoscopic dissection	
	With transvesical ligation technique	Controlled occlusion	Learning curve
		No risk of extravesical seeding	Contraindicated for tumours of the distal ureter and intramural ureter, and in the bladder
		Less distal laparoscopic dissection	Contraindicated in previous pelvic radiotherapy
			Prolonged procedure
			Additional ports
Laparoscopic stapling		Controlled occlusion	Potential to leave viable urothelial tissue within the staple line
		No risk of extravesical seeding	Staples visible at cytoscopy
			Contraindicated for tumours of the distal ureter and intramural ureter, and in perimeatal bladder tumours
			Extensive distal laparoscopic dissection
			Risk of operative injury of the contralateral ureteral orifice
			Fluoroscopy required
Intussusception		Less distal laparoscopic dissection	Two surgical specimens
		Moderate difficulty	Extensive transurethral manipulation
			Not always successful intussusception of the ureter
			Contraindicated in tumours of the ureter

The Open Method

The distal ureter with bladder cuff is resected through an open lower abdominal incision at the end of the procedure. This may be accomplished through a standard Gibson, Pfannenstiel or lower midline incision. We normally prolong the incision of the lower port.

This procedure is used when there is a tumour of the distal ureter and/or in association with synchronous bladder tumour, and also in patients with previous surgery or radiotherapy of the pelvis.

The Pluck Procedure

Different variations of this technique have been described:

1. Simple
2. With balloon occlusion
3. With transvesical ligation.

Simple

This is the method of choice in our centre and it consists of an endoscopic resection of the ureteral meatus and its intramural tract until perivesical fat is visualized around the resected ureter. Careful coagulation of the resected area and ureteral stump is done, and an indwelling urethral catheter is placed (Fig. 1). During laparoscopic nephrectomy the ureter is clipped distal to the tumour site prior to manipulation of the kidney. This quick procedure facilitates the laparoscopic dissection of the distal ureter and its release from the bladder wall is reasonably easily obtained [28, 29].

A modification of this technique has been described, which consists of meatal circumcision with a hook electrode or Collins knife until perivesical fat is visualized, until the ureter is freed of all perivesical attachments [30] (Fig. 2). Lin et al. [31] proposed to do first the nephrectomy and then the transurethral pluck procedure. This timing may decrease the risk of cell seeding, since the pluck procedure is the last step of the surgery. This is how Wong et al. [32] proceed after TP HA NU, as do Kawauchi et al. [7] after the same RP procedure. Operative time is decreased, since there is no repositioning on the operating table.

Balloon Occlusion

A ureteral catheter is inserted and endoscopic resection of the intramural portion is done.

Once the ureter is detached from the bladder with the pluck procedure, the ureteral catheter is exchanged for a 7F occlusion balloon catheter. The balloon is inserted in the renal pelvis (or below a proximal ureteral tumour if present) and snugged down to isolate the tumour-bearing portion of the collecting system. The balloon is left inflated until the distal ureter is "plucked" from the bladder laparoscopically after the nephrectomy [6].

Transvesical Ligation

The most complicated approach to the lower ureter uses a transurethral Collins knife and two transvesical needlescopic instruments for the dissection of the ureteric orifice, with placement of a loop suture around the ureteric stump [24]. The patient is placed in the lithotomy position. Under cytoscopic control, the 2.2-mm needlescopic ports are inserted suprapubically into the bladder (Fig. 3). The ureteral origin is grasped and with a 24-F resectoscope is circumferen-

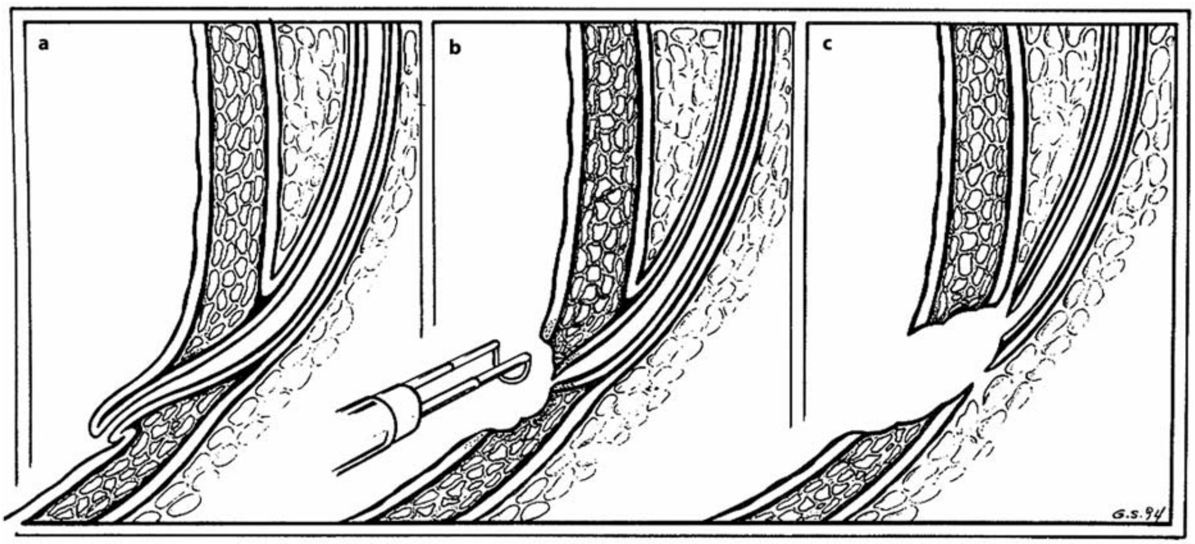


Fig. 1 a–c. Cross-section of intramural portion of ureter (**a**) in pluck simple technique (**b**) after partial resection of the intramural portion and the complete resection (**c**)

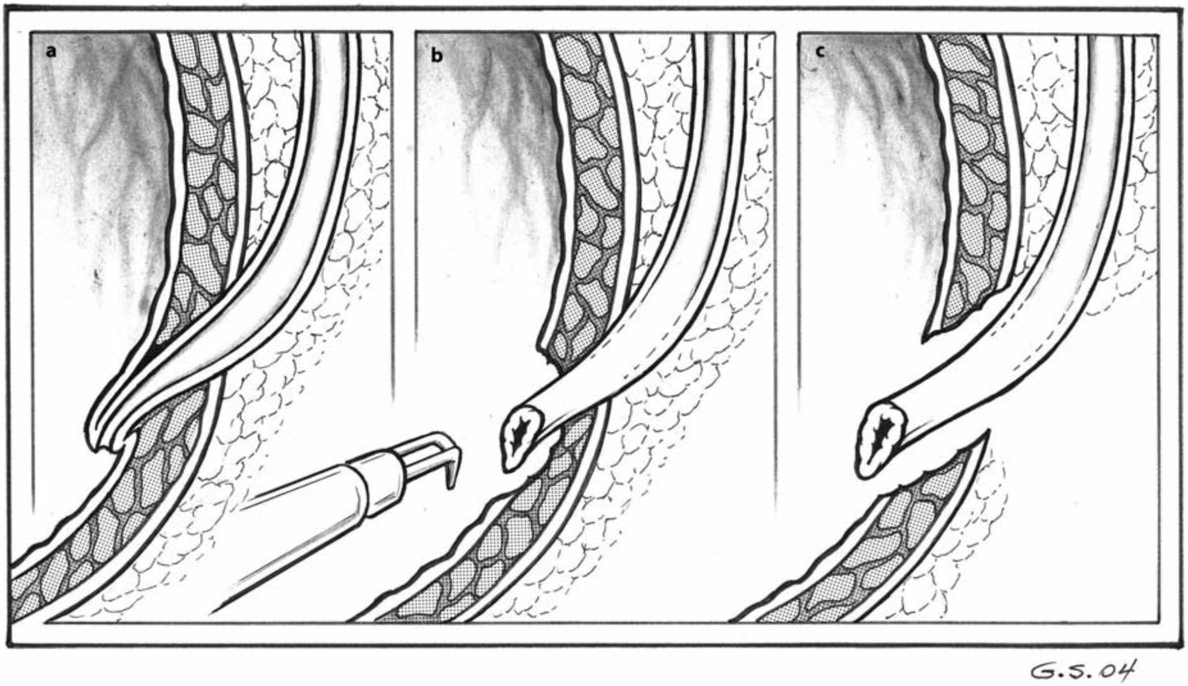


Fig. 2 a–c. Cross-section of intramural portion of ureter (**a**) in pluck simple technique with circumferential incision after partial (**b**) and complete incision (**c**)

tially detached with an adequate bladder cuff. Extravesical fibrofatty attachments of the juxtavesical ureter are released. Then the ureter is occluded by cinching down the endoloop. A 22-F urethral Foley catheter is left indwelling. Then the patient is repositioned in the ipsilateral standard flank position for the kidney procedure.

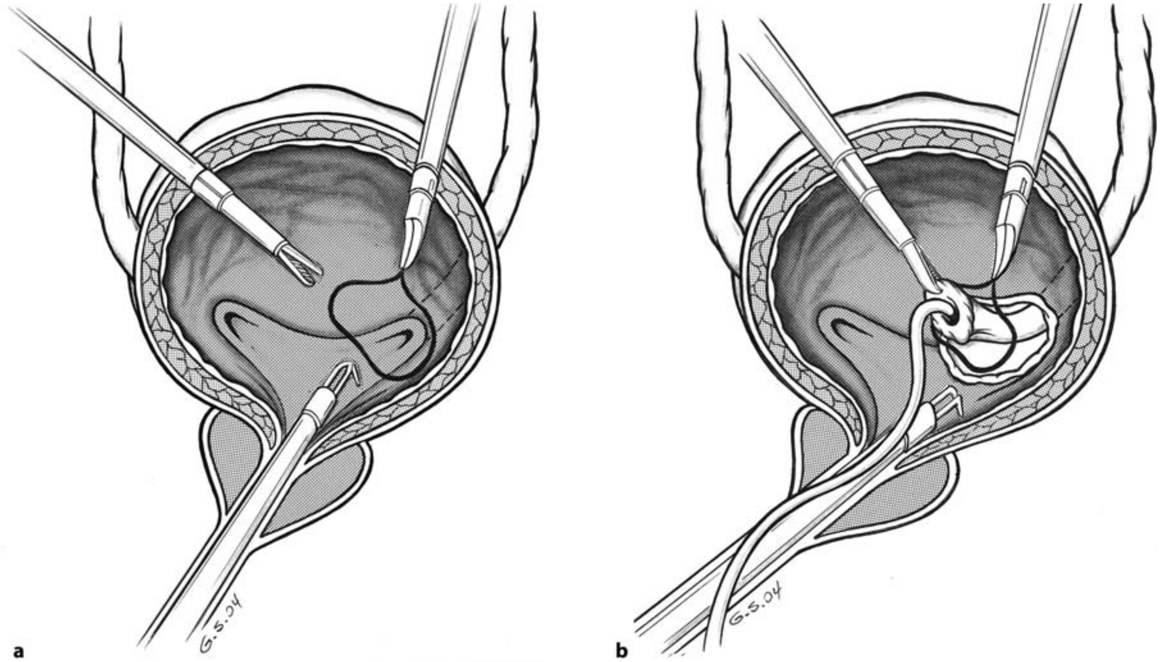
As an alternative, during hand-assisted LNU, a single 10/12-mm bladder trocar can be used to introduce a 24-F offset nephroscope. With a Collins knife advanced through its working channel, the ureteral orifice is circumferentially incised; the HA port allows tactile manipulation [25]. This variation avoids transurethral instrumentation and repositioning of the patient (Fig. 4).

Extravesical Stapling

Initially, a ureteral dilating balloon catheter is inserted into the affected ureter over a fluoroscopically positioned Bentson guidewire. The balloon is inflated to less than 1 atm of pressure and left in position. Using a 24F resectoscope equipped with an Orandi electrosurgical knife, the ureteral orifice and ureteral tunnel are incised anteriorly, exposing the underlying surface of the inflated balloon. The edge of the incision is fulgurated with a ball electrode to maintain hemostasis. After deflation and removal of the dilating balloon catheter, an occlusion balloon catheter is advanced fluoroscopically over the Bentson guidewire into the renal pelvis. The balloon is inflated and positioned at the ureteropelvic junction. With the ball electrode, the interior of the now opened ureteral orifice and ureteral tunnel is completely fulgurated. The Bentson guidewire is then replaced with an Amplatz super stiff guidewire. A sidearm adaptor, passed over this guidewire, is fixed to the end of the occlusion balloon catheter for drainage. Alongside this catheter, a Foley urethral catheter is inserted. Both catheters are firmly joined and placed in a sterile bag.

The rest of the procedure related to the distal ureter is continued after the nephrectomy.

Landman et al. [33] proposed first doing the NU and stapling and after termination of the laparoscopic



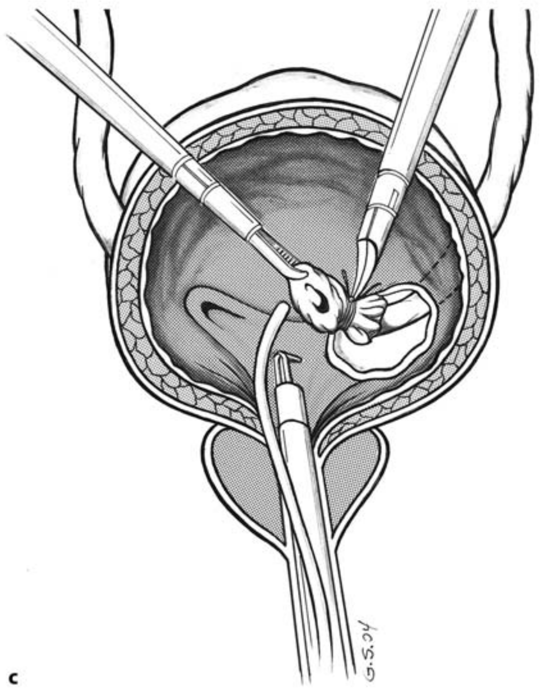


Fig. 3 a–c. Pluck transvesical ligation technique: **a** needlescopic ports with endoloop, **b** circumferential attachment of bladder cuff with Collins knife, **c** endoloop cinched down occluding the ureter

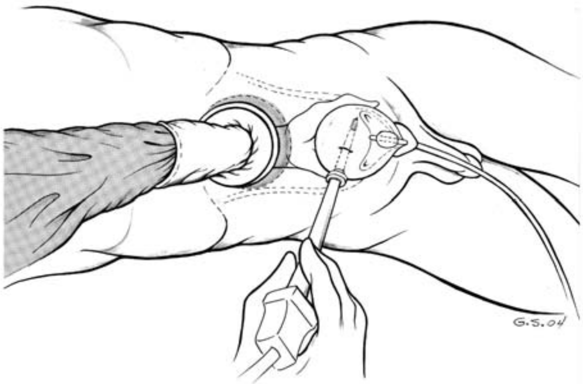


Fig. 4. Pluck transvesical ligation technique modified: one of the surgeon's hands elevates the hemitrigone and the other, through one transvesical port, the bladder cuff is resected

part, they perform cytoscopy and unroofing of the ureteral orifice using an Orandi or Collings resectoscope electrosurgical knife until the staples are visualized.

Intussusception

Intussusception consists of removing the kidney first and a proximal ligature and section of the proximal ureter. Then the upper portion of the distal ureter is dissected and a ligature is placed just above the tip of the Chevassu catheter and another one just below the bulb of it. The flank incision is closed.

The Chevassu catheter is pulled out and under direct cytoscopic vision, an invagination of the ureter down into the pelvis and into the bladder is obtained. The resectoscope or Collins knife is inserted into the bladder and a circumferential section of the ureter and its attachments to the bladder is performed [39, 60–62] (Fig. 5). The ureter is extracted through the bladder and urethra. In 10% of cases, it is not possible to complete intussusception and conversion to open surgery is needed [38].

A complication rate of 10% has been described: catheter breakage, the impossibility of urethral progression, anchorage of the pelvic ureter, and urethral stricture [38].

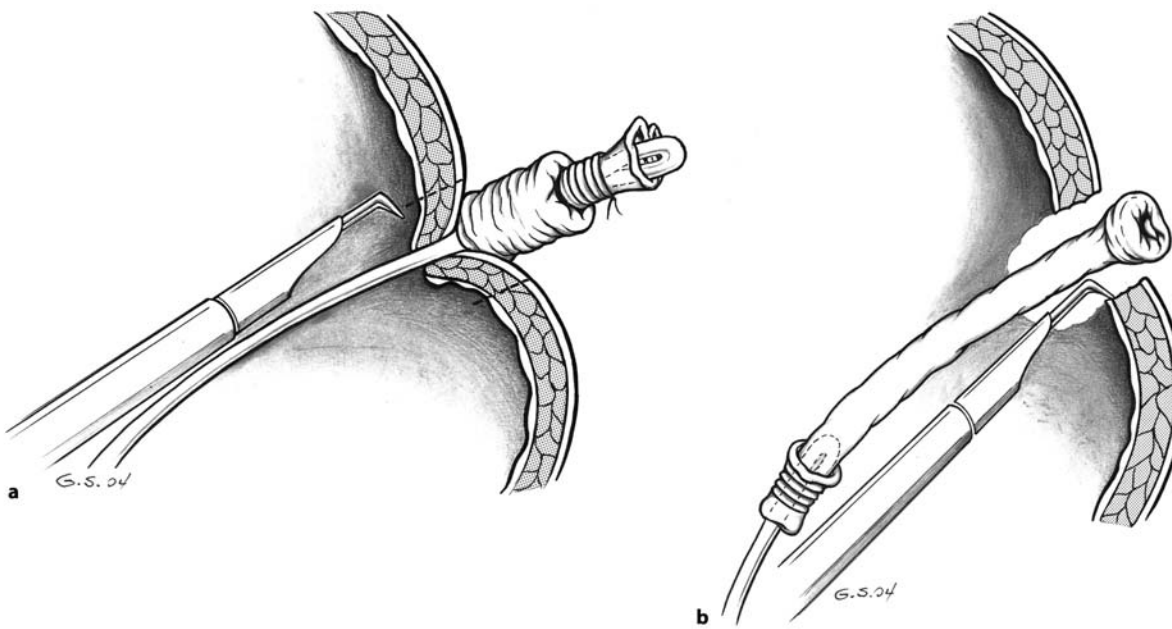


Fig. 5 a, b. Intussusception technique: after transection of the ureter during nephrectomy, the ureter is tractioned (**a**) and then the intramural portion is excised (**b**)

Laparoscopic Nephrectomy

Three laparoscopic techniques exist to perform nephrectomy. We will only mention the different possibilities, since the techniques are described in detail in other chapters.

Pure Laparoscopic Transperitoneal Approach

The renal part of the laparoscopic dissection is identical to a laparoscopic TP extrafascial total nephrectomy, except the ureter is clipped distal to the tumour site and left intact. The adrenal gland is routinely spared, provided that previous imaging showed no obvious signs of disease. The procedure may include RP lymph node dissection. Usually dissection begins with incision of the line of Toldt from the hepatic or splenic flexure down into the pelvis across the iliac vessels (Table 2).

After identification of the ureter and clipping it distal to the tumour site, the gonadal vessels are divided. Then the hilum is dissected and the renal artery transected between clips. The renal vein is divided with an endovascular gastrointestinal anastomosis (GIA) stapler. With vascular control ensured, the kidney and proximal ureter are dissected free.

Hand-assisted Transperitoneal Approach

After pneumoperitoneum is achieved, the hand-assistance device is positioned in a 7–8-cm periumbilical midline incision or in the lower quadrant according to the surgeon's preference. With this device, the surgeon's hand can be used for retraction and blunt dissection, thus taking advantage of the incision required for intact removal of the specimen. HA seems to reduce the operative time and to shorten the learning curve for laparoscopic nephrectomy [33] (Table 3).

Retroperitoneal Approach

RP access is initially obtained via the open Hasson technique. A 1.5-cm incision is made under the 12th rib on the posterior axillary line in front of the sacroiliac muscles. The RP space can be developed by blunt digital dissection and consequent balloon dissection. Trocar-mounted balloons are available, allowing direct visualization while the space posterior to Gerota's fascia is dissected. Then, three to five RP trocars can be placed. The pneumoretroperitoneum is created by applying 10–15 mmHg of CO_2 pressure. The posterior face of the kidney is further dissected along the psoas muscle until the renal pedicle is identified. In this approach the renal artery is dissected, clipped and cut before control of the renal vein (Table 4).

The ureter is dissected as far as possible towards the pelvis. Subsequent dissection includes the perirenal fat and Gerota's fascia. The kidney is left in the RP cavity.

Lymphadenectomy Technique

We do not perform lymphadenectomy (LDN) routinely. Klinger et al. [8] advise doing it as a staging procedure and they include all hilar and ventral caval (right side) or ventral aortic (left side) lymph nodes.

Ending of the Procedure and Extraction of the Specimen

The alternatives depend on the chosen preparation of the intramural ureter and the approach used in the nephrectomy.

Whatever technique is used, intact specimen retrieval is preferred. If a total laparoscopic or retroperitoneoscopic technique was used, the intact specimen is placed in a retrieval bag and extracted through a small midline incision incorporating a trocar site. After using the laparoscopic HA or open approach to the distal ureter, the specimen can be removed by the surgeon's hand.

The specimen can be removed with different incisions according to the surgeons preference (lower midline, Pfannenstiel, lower quadrant, flank incision) (Fig. 6).

The Open Method

The patient is repositioned in a supine position or sometimes it is enough just rotating the operating table 30–40°, thus allowing the surgery to be done with the patient in slight lateralization. Via a short iliac ipsilateral muscle-splitting incision (Gibson incision) or a lower midline incision, the entire distal ureter with a small bladder cuff is dissected and secured, as in open surgery. The Gibson incision is preferred if the distal ureter could not be freed laparoscopically to the level of the iliac vessels. In this option, there is no need for any transurethral preparation. The bladder can be closed with reabsorbable sutures. The incision is closed in the standard fashion.

Table 2. Comparison of transperitoneal laparoscopic nephroureterectomy

Author	**Kerbl et al. [26]**	McDougall et al. [18]	Keeley and Tolley [21]	Shalhav et al. [51]	Mc Neill et al. [52]	Jarret et al.[a] [53]	Abou El Fettouh et al.[b] [17]	Landman et al. [3]	Fundació Puigvert	Valdivia et al. [54]	Klinger et al. [8]
Journal	Eur Urol	J Urol	J Urol	J Urol	BJU Int	Urology	Eur Urol	J Urol	Not published	Arch Esp Urol	Eur Urol
Year	1993	1995	1998	2000	2000	2001	2002	2002	2003	2004	2003
Number of patients	6	10	22	25	25	25	116	11	23	15	19
Distal ureter	Stapled	Stapled	Pluck	Stapled	Pluck Open	Stapled Open	40 Pluck transvesical 12 Pluck simple 31 TUR and stapling 33 open	Stapling	19 Pluck simple 3 Open 1 Complete laparoscopic	Pluck and coagulation	Open
Time (hours)	7.29	8.3	2.6	7.7	2.7	5.5	No data	6.1	3.4	5.0	3.3
Mean blood loss (ml)	180	100–400	No data	190	No data	440	No data	190	345	250	282
Mean hospital stay (days)	4.6	5	5.5	6.1	5	4	No data	3.3	6	No data	8.1
Morbidity (%)	16	10	27	48	16	36	No data	45	6.2	20	0
Open conversion (%)	0	10	18	0	4	4	4	0	12.5	0	0
Global recurrence (%)	No data	40	9	52	16	68	34.7	36.6	No data	13.3	10.5
Bladder(%)		30	0	23	No data	48	24	30		0	5.3
Local (%)		10	5	15.3	No data	4	1.7	0		0	0
Distant metastasis (%)		10	5	15.3	16	16	9.4	18.1		13.3	5.3
Follow-up (months)	No data	25	No data	39	35	24.2	25	27.4	12	No data	22.1
Lymphadenectomy	Not explained	Not done	Not explained	Not explained	Not explained	Not explained	Not explained	Not explained	Not done	Not explained	Yes
Positive nodes	0	0	No	1	0	1	2	0	0	0	4

[a] Transperitoneal and hand-assisted transperitoneal
[b] 51 cases transperitoneal and 65 Transperitoneal (TP) or retroperitoneal

Table 3. Comparison of transperitoneal hand-assisted nephroureterectomy

Author	Stifelman et al. [55]	Chen et al. [56]	Seifman et al. [6]	Landman et al. [33]	Uozomi et al.[a] [57]	Chueh et al. [20]	Kawauchi et al. [7]
Journal	Urology	Urology	Urology	J Urol	J Endourol	J Urol	J Urol
Year	2000	2001	2001	2002	2002	2002	2003
Number of patients	22	7	16	16	10	7 (14 kidneys)	34
Distal ureter	Transvesical	Open	1 Stapling 13 Pluck balloon 3 Open	Stapling	Open	Open (midline)	6 Intussusception 25 Pluck 3 Open
Time (hours)	4.5	3.7	5.3	4.9	7.6	5	3.9
Mean blood loss (ml)	180	140	557	201	462	218	236
Hospital stay (days)	4.5	7.3	3.9	4.5	No data	8.8	13
Morbidity (%)	5	0	38	31	40	14.3	12
Open conversion (%)	0	0	6.2	6	0	0	3
Global recurrence (%)	27	14.3	18.7	31.1	No data	0	12
Bladder	18	14.3	18.7	27		0	6
Local	0	0	0	0		0	0
Distant metastasis	9	0	0	18.7		0	6
Follow-up (months)	13	6	19	9.6	No data	5.6	13.1
Lymphadenectomy	Not explained	Not explained	Not explained	Not explained	Not explained	Not explained	Not explained
Positive nodes	0	0	0	0	0	0	0

[a] Retroperitoneal hand-assisted

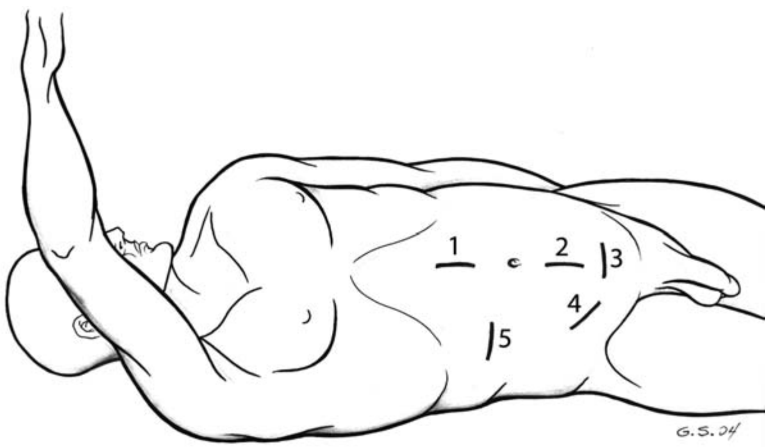


Fig. 6. The most common incisions used in NU laparoscopy: *1, 2* midline supra- and infraumbilical, *3* Pfannenstiel, *4* lower quadrant/Gibson, *5* flank incision

Table 4. Comparison of retroperitoneal nephroureterectomy

Author	Chung et al. [58]	Hsu et al. [5]	Salomon et al. [59]	Gill et al. [3]	Goel et al. [4]	Matsui et al. [48]	Yoshino et al. [60]
Journal	Minim Invasive Ther	Urology	J Urol		World J Urol	Urology	Urology
Year	1996	1999	1999	2000	2002	2002	2003
Number of patients	7	5	4	42	9	17	23
Distal ureter	Open	Transvesical	Open	Transvesical	Open	Open	Stapler
Time (hours)	4.6	5.6	5.7	3.9	3.1	4.78	4.8
Mean blood loss (ml)	No data	150	220	242	275	151.1	304
Hospital stay (days)	9	2	5.7	2.3	5.1	2.7	No data
Morbidity (%)	14	0	0	12	0	11.7	0
Open conversion (%)	14	0	0	5	11.1	0	0
Global recurrence (%)	14	No data	25	26	22.2	35	26.1
Bladder	14		0	19	0	29	17.4
Local	0		25	0	0	6	0
Distant metastasis	0		0	7	22.2	0	8.7
Follow-up (months)	12.6	9	19	11.1	15	8.8	15
Lymphadenectomy	Not explained	Not explained	No data	Not explained	Not explained	Some cases	Yes
Positive nodes	0	0	1	2	0	0	2

The Pluck Procedure

Because the ureter was previously completely detached from the bladder, the laparoscopic dissection of the ureter need only be continued down to the level of the iliac vessels. Gently pulling the ureter cephalad, while dissecting around it distally, eventually results in its release from the bladder. Recognition of the coagulated distal ureter stump or previously placed loop suture confirms complete resection. The small opening in the bladder is not closed.

We normally remove the specimen in a retrieval bag through a prolongation of the lower-port incision.

Extravesical Stapling

In the first step, the ureter has been unroofed. The ureter is laparoscopically dissected caudal into the pelvis. When crossing it, the superior vesical artery, the vas deferens or round ligament and the medial umbilical ligament are clipped and transected.

When the detrusor muscle fibres are identified at the ureterovesical junction, an area of bladder adventitia around it is cleared. With a grasping forceps the ureter is retracted superior and laterally, thereby tenting up the bladder wall at the ureterovesical junction. After withdrawing the ureteral occlusion balloon catheter and supra stiff guidewire, the bladder cuff is secured by firing a 12-mm laparoscopic GIA tissue stapler. Filling the bladder can be done to role out any extravasation (Fig. 7).

Postoperative Considerations

Postoperative care for the NU patient is essentially the same as that for the nephrectomy patient. However, the bladder catheter is maintained for 5 to 7 days postoperatively, at which time a cystogram can be performed to confirm satisfactory bladder closure with no urinary extravasation. In our institution, the postoperative follow-up protocol includes urine cytology studies and cystoscopy every 3 months for the first

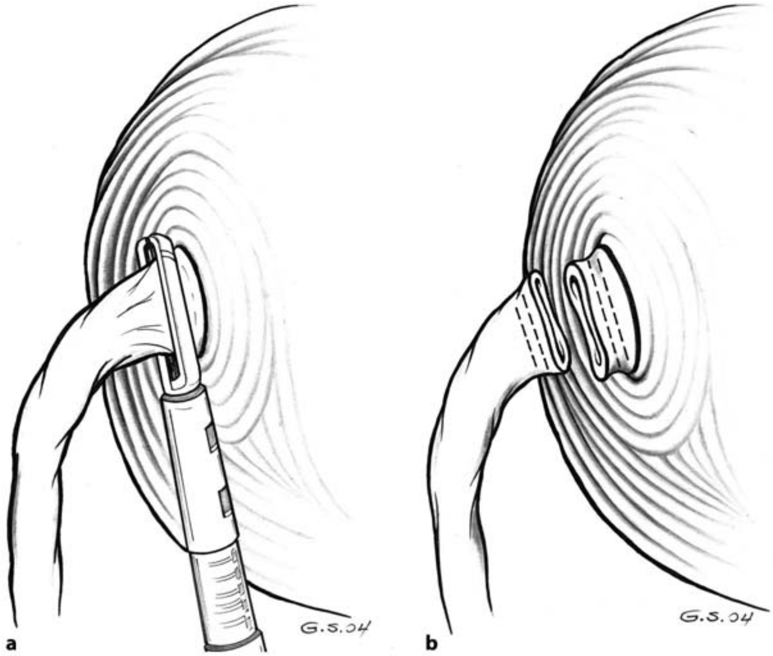


Fig. 7 a, b. Extravesical stapling technique: the lower ureter is dissected and with cephalad traction, a GIA stapler is placed (**a**) and fired (**b**)

2 years and every 6 months thereafter, as well as yearly excretory urography and abdominal computerized tomography scan.

General Comments

Surgical Procedure

Approach

The LNU can be performed through the peritoneal cavity or the retroperitoneum with or without hand assistance [39–41].

The comparison of the techniques is presented in detail in other chapters. It has been mentioned that the TP approach has the potential for intraperitoneal contamination with cancer cells and the RT approach allows early control of the renal artery without manipulation of the bowel. From the practical point of view and facing the global results (Tables 2–4), there is an important variation in the parameters. They appear to be more related to the preferences of urologists, probably due to apprenticeship, and also to the management of the lower ureter.

Management of the Distal Ureter

Open surgery and the pluck technique, simple and with balloon occlusion, are the easiest and fastest methods. The transvesical approach requires a learning period and is more complex to perform. The laparoscopic stapling leads to an extensive laparoscopic dissection of the pelvis and paravesical space. These last two methods are more difficult and time-consuming (Table 1).

In the series examining the TP approach (Table 2), it is evident that in the centres using the stapling technique, the surgeries last more than 5.5 h, even though the differences were reduced in the RP approach (Table 4).

The intussusception technique is no longer used in centres dedicated to laparoscopic surgery. This may be because the ureter needs to be divided, it is difficult to obtain good attachment of the catheter, and in 10% of the patients the technique fails [38].

A few case reports of invasive extravesical recurrence have been reported, attributed to the simple pluck technique. We therefore are very careful in its management. It is important to clip or ligate the ureter early below the tumour site when doing the laparoscopic nephrectomy. With more than 50 patients

Table 5. Extravesical implantation at the site of ureteral resection in the pluck procedure

Author	Jones and Mosey [43]	Hetherington et al. [61]	Abercrombie et al. [44]	Arango et al. [62]	Fernandez Gómez et al. [45]	Regueiro et al. [63]
Journal, year	Br J Urol, 1993	Br J Urol, 1986	Br J Urol, 1988	J Urol, 1997	Arch Esp Urol, 1998	Actas Urol Esp, 2003
Pathology	Poorly diff	Poorly diff Well diff	Mod diff	Well diff	Poorly diff	Mod diff
Margin of the ureter	Positive	Negative Negative	Negative	Negative	Negative (multifocality in ureter)	Negative (dysplasia)
Time elapsed	3 months	4 months 9 months	4 years	7 months		9 months
Early ligature of the ureter	Not mentioned	Not mentioned Not mentioned	Yes	Yes	Not mentioned	Not mentioned
Attributed to the technique	No	Yes Yes	No	Yes	Yes	Yes

treated with this technique at our centre, we have not had any extravesical recurrence [42]. Table 5 shows the local recurrence in seven patients that may be attributed to this technique, but only in five cases is there a consistent relation. Only two reports mentioned that early control of the ureter with ligature or clip was done (an important step with this technique). In two different cases, the local recurrence is probably more related to persistence of the disease because of a positive margin [43] and multifocal disease in the ureter [44]. In another patient, a local recurrence at 4 years of follow-up can hardly be attributed to cell seeding [45].

Lymphadenectomy

The importance of LDN in LNU is as controversial as it has been in open NU. There are no clear data on the benefit of performing a wide LDN in these patients. Komatsu et al. [46] reported that LDN may provide therapeutic benefit in patients with low volume nodal disease. Miyake et al. [47] presented in their series examining open NU that the presence of lymph vessel invasion is more important.

In the series published on laparoscopy, only Klinger et al. [8] explained the technique, and Matsui et al. [48] performed it in some cases. The remaining series (Tables 2–4) do not mention it, although some found some positive nodes.

Klinger et al. [8] performed local LDN in 73.7% of their patients and a mean of 8.7 nodes per patient were obtained; two patients had positive nodes at frozen section and two additional patients had micrometastasis. They conclude that LDN may procure a better staging and therefore make patients more amenable for a radical oncological treatment.

Extraction of the Specimen

The presence of tumour in the lower ureter and/or bladder precludes the utilization of endoscopic techniques. In these cases, open surgery, preferably through a Gibson or midline incision, should be performed.

In patients where the ureter is plucked or stapled, the simple access is to prolong the lower port incision, normally in the lower abdominal quadrant; alternatively using a suprapubic, midline or pararectal incision. In the RP approach a flank incision may be used.

The general consensus is in favour of intact specimen extraction, to provide knowledge on surgical margin status, and pathological stage and grade.

Morbidity

The mean blood loss ranges from 140 to 557 ml, but most of the series report blood loss below 250 cc.

Open conversion ranges from 0% to 18%, results mostly from vascular problems and bleeding, and sometimes can be attributed to technical difficulties in an advanced local stage of the tumour.

There is a large variability in morbidity among centres (0%–48%). This variability may be related to the criteria used, the limited number of patients included in the study and the centre's learning curve. The hospital stay varies between an average of 2 and 13 days and differences depend more on the centres and countries. The hospital stay nearly always is shorter than in open surgery.

Oncological Follow-up

Globally all series have a short follow-up. Of the 25 series, including 517 patients (Tables 2–4), seven have a follow-up of less than 12 months, and only in six have a follow-up of more than 24 months. Bladder recurrence ranges from 0% to 48% and is clearly related to time of follow-up; the incidence is similar to open series [42, 44]. Also some port site metastases were described [49] (see Chap. 9).

Summary

Laparoscopic or retroperitoneoscopic NU using pure laparoscopic or hand-assisted techniques is no longer an investigational or experimental procedure; it will have to be accepted and become the standard practice in medical centres [50].

These different approaches encounter different problems, but it is important to consider that radical surgery remains the main goal.

Long-term comparative studies are needed to elucidate the best approach of the distal ureter in upper tract urothelial tumours. Several oncological principles that have to be followed to guarantee good results:

- Complete and en bloc excision
- Controlled occlusion
- Non-touch, with preservation of Gerota's fascia [8]
- Organ bag for retrieval

Which is the best technique? Regarding all the aspects mentioned in the LNU, one should consider which approach could better accomplish the following:

- Good oncological control
- No risk of cell seeding
- No repositioning of the patient
- No added cost

The experience gained in reference centres and longer follow-up will allow further refinements of the LNU technique and should confirm the good oncological results.

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5.1 Laparoscopic Radical Cystectomy and Intracorporeally Constructed Sigma-Rectum Pouch (Mainz Pouch II)

Ingolf Tuerk

Contents

Radical cystectomy with a type of urinary diversion remains the gold standard treatment for muscle-invasive bladder carcinoma. Constant advances in anesthesiology and surgical technique, and more sophisticated postoperative care have decreased the risk of such major surgery. However, radical cystectomy remains an aggressive procedure with significant morbidity and mortality. The complication rate in the early postoperative period after radical cystectomy and urinary diversion is still 25%–35% [1]. This remaining morbidity of open cystectomy has stimulated interest in treatment alternatives with less morbidity without compromising the oncological outcome.

Advances in laparoscopic surgery have resulted in a notable decrease in patient morbidity with speedier recovery and a shorter hospital stay. Since the first report of a laparoscopic nephrectomy by Clayman and co-workers in 1991 [2], the role of laparoscopy in urology has been rapidly expanding. Laparoscopic radical nephrectomy has been established in the last 5 years with reports of equivalent oncological results, and the traditional benefits of less postoperative pain, improved cosmesis, shorter hospital stay, and faster return to full activity [3, 4]. Recently, laparoscopic radical prostatectomy seems to be as efficacious as the open procedure. Early oncological data look similar to open series, but only short-term observation is available. However, new benefits are evident with the laparoscopic approach: improved visualization of the operative field with more surgical precision, and significantly less blood loss [5–7].

The next logical step is the utilization of laparoscopic approach for the surgical treatment of muscle-invasive bladder cancer. Laparoscopic application in the field of cystectomy started in 1992 when Parra et al. [8] reported a laparoscopic simple cystectomy in a 27-year-old female with symptomatic pyocystitis of a retained bladder after previous urinary diversion. The operating time was 130 min, the blood loss was 115 ml and the hospital stay was 5 days. In 1993, de Badajoz was the first to use the laparoscopic approach to cystectomy for invasive cancer in a 64-year-old female [9]. OR time was 8 h, blood loss was minimal, and the postoperative course was free of complications. Puppo et al. performed laparoscopically assisted transvaginal radical cystectomy in five female patients with bladder cancer [10]. Operating times were between 6 and 9 h. Four of five patients were discharged from hospital free of complications on days 7–11. The largest report on laparoscopic radical cystectomy was published by an Egyptian group. Denewer et al. reported ten patients with invasive bladder cancer who underwent laparoscopically assisted cystectomy and urinary diversion [11]. They demonstrated that the laparoscopic access involves less morbidity and earlier recovery as well as a short hospital stay.

Technique of Laparoscopic Radical Cystectomy

Preoperative preparation includes a bowel preparation of clear liquids only starting preoperative day 2, 3 l of mechanical bowel preparation fluid preoperative day 1, and a cephalosporin and metronidazole on call to the OR. Lower extremity compressive devices are applied before induction of anesthesia. The patient is placed in supine position, a nasogastric tube is inserted, and a 16-F Foley catheter is placed to drain the bladder.

As in the open procedure, the right-handed surgeon stands to the patient's left. Camera monitors are positioned at the patient's feet. In our experience, the surgeon's dissection is best accomplished via laparoscopic scissors attached to monopolar cautery in one hand, and graspers attached to bipolar cautery in the other. The first assistant utilizes suction in one hand and graspers for retraction in the other. We commonly utilize the Aesop robotic arm and voice recognition to give control of the camera to the surgeon. However, if the first assistant is being instructed, it is best to have a second assistant operate the camera.

Pneumoperitoneum is obtained with a Veress needle. A primary 10-mm laparoscopic trocar is placed at the level of the umbilicus. After inspection of the abdominal cavity, the other four trocars are placed in a fan-shape fashion. Two 10-mm trocars are placed under laparoscopic control on the lateral pararectal lines about 10 cm above the symphysis pubis. Two 5-mm trocars are positioned 2–3 cm medial to the anterior-superior iliac spine bilaterally (Fig. 1).

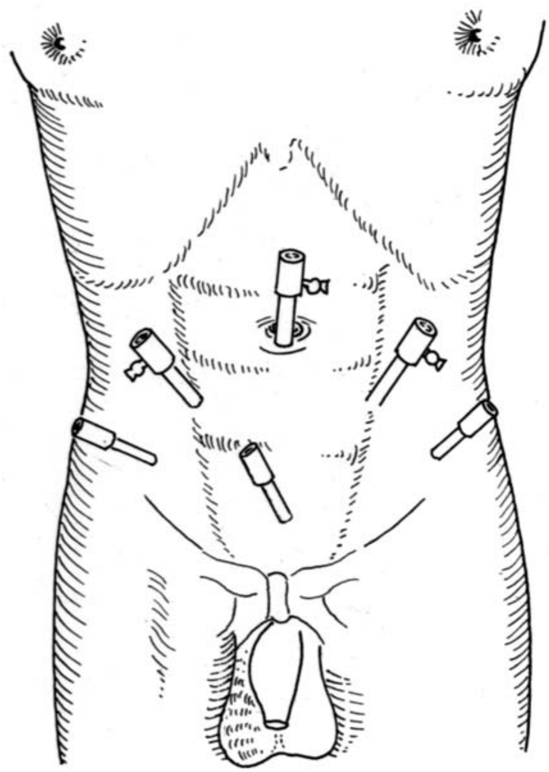

Fig. 1. Number and placement of the trocars

The peritoneum is incised at the level of the Douglas pouch. The tips of the seminal vesicles are dissected to expose Denonvilliers fascia. The fascia is incised in the midline to expose the perirectal fat. The fibers of the rectum are bluntly pushed posteriorly away from the prostate. This dissection is carried down as far as the apex of the prostate. Complete mobilization of the rectum is fundamental to better define the prostatic and vesical pedicles and to prevent rectal injuries.

Incision of the peritoneum is carried out along the external iliac artery and extended distally to the abdominal wall lateral to the umbilical ligaments, and proximally to the common iliac artery.

At the level of the pubic bone, the bladder and perivesical fat are dissected off the pelvic wall with exposure of the endopelvic fascia. The fascia is incised bilaterally and the fibers of the levator muscle carefully dissected. This maneuver greatly facilitates the identification of the lateral aspect of the vesicoprostatic pedicles.

The ureters are found at the crossing over the common iliac artery. The ureters are dissected down to the bladder wall with care to preserve their vascular supply. The ureters are clipped distally, divided and the distal ureteral margins sent for frozen section. Two 4-0 Vicryl holding sutures of different colors are placed at the distal end of the ureters. The dissected distal ureters are positioned above the level of iliac vessels.

After the previously described complete mobilization of the rectum and lateral dissection of the bladder off the pelvic wall, the vascular pedicles of the bladder and prostate are already well defined. It is important to note that the bladder is purposely left attached to the anterior abdominal wall in the midline to facilitate the exposure of the vascular pedicles. The vascular pedicles of the bladder and prostate are divided using Endo-GIA laparoscopic vascular staplers. Three or four reloads are necessary to completely divide the pedicle in each side (Fig. 2).

The umbilical ligaments and urachus are incised to enter the Retzius space. The bladder is dissected from the abdominal wall to expose the anterior aspect of the prostate and the endopelvic fascia. The incision of the endopelvic fascia is completed toward the puboprostatic ligaments. Because it was previously decided not to perform an orthotopic neo-bladder, the ligaments are sharply divided to expose the apex and the dorsal venous complex of the prostate. Once the membranous urethra and the dorsal venous complex are exposed, the complex is suture ligated with 0-Vicryl on a CT-1 needle and divided. The urethra and the apex of the prostate are fully dissected. The urethra is transected at the level of the pelvic floor muscle. After transection of the dorsal wall of the urethra, it is important to close it at the prostatic apex to avoid urine spillage in the peritoneal cavity. The closure is performed with a figure-eight 2-0 Vicryl suture. The rectourethralis muscle is divided and radical cystoprostatectomy completed.

In men, the remaining attachments are divided to completely free the specimen (bladder, prostate and seminal vesicles), and it is secured in an endobag for later removal through the rectum during the urinary diversion. In women, the bladder with the anterior wall of the vagina are removed to complete the dissection, and the specimen immediately entrapped in an endobag for immediate removal through the vaginal opening. The vagina is then closed by a running 0-Vicryl suture.

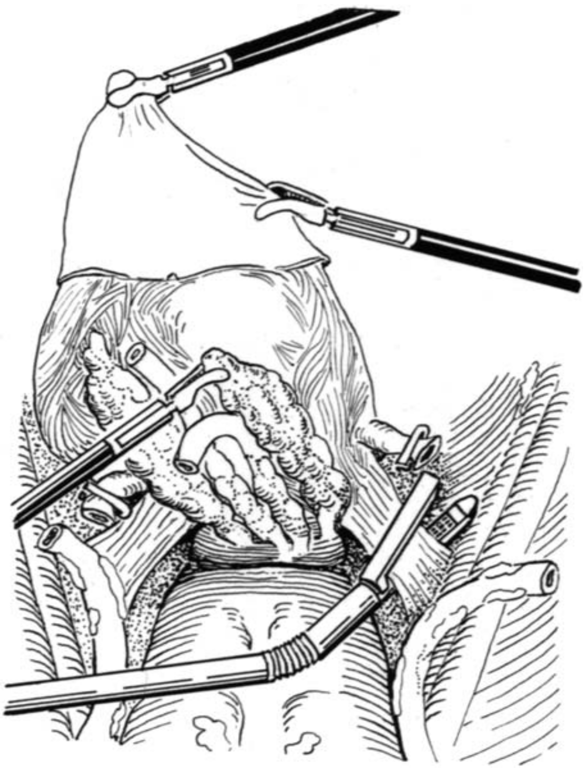

Fig. 2. Transection of the bladder pedicles with Endo-GIA

An extended bilateral pelvic lymph node dissection is performed. The limits of the dissection are the pubic bone caudally, the aortic bifurcation cranially, the genitofemoral nerve anteriorly, and the internal iliac artery posteriorly. The removal of the lymph nodes is performed using a small endobag.

Urinary Diversion

Once laparoscopic radical prostatectomy has been mastered, radical cystectomy only involves the additional simple steps of taking down the lateral pedicles with the Endo-GIA stapler. The challenge is the urinary diversion.

The ileal loop urinary diversion has been the standard type of urinary diversion since it was described by Bricker in 1950 [12].

The first laparoscopic ileal loop urinary conduit was reported by Kozminski and Partamian [13]. Their procedure did not include a cystectomy. A total of five port sites were used, one of which served as the stoma site. Laparoscopically, both ureters were mobilized and transected. The bowel anastomosis was performed extracorporally by gently elevating a small loop of ileum through a port site. The initial operation took 6 hours h and 20 min. De Badajoz and Puppo provided their patients with an ileal conduit after laparoscopic cystectomy as described before [9, 10].

To date, most authors perform a laparotomy after lap cystectomy to remove the specimen and construct the urinary diversion (ileal conduit). However, Gill et al. have recently reported successful ileal conduit urinary diversion by laparoscopy alone, performed in two men [14]. The surgical time of the complete procedure (laparoscopic cystectomy and ileal conduit) was 11.5 and 10 h, and blood loss was 1,200 and 1,000 ml, respectively. However, most patients motivated and healthy enough to undergo a 10-h laparoscopic procedure will also be the type of patients desiring the long-term quality of life benefits of a continent urinary diversion as well as the short-term recovery benefits of a laparoscopic approach.

Most patients willing to undergo the lengthier operative times required for a laparoscopic approach will also desire a continent urinary diversion because of the better quality of life and cosmesis.

The first experimental laparoscopic ureterosigmoidostomy for urinary diversion using pigs was reported by Trinchieri et al. [15]. Anderson et al. published their experience constructing a laparoscopically assisted sigma rectum pouch as a continent urinary diversion in an animal model (pig) [16]. The laparoscopically mobilized sigma was extracorporeally positioned via a laparotomy. The pouch was formed by side-to-side anastomosis of the opened bowel segment with a stapler, and the ureterocolonic anastomoses were done extracorporally. Postoperative function of the pouch was good. However, in 44% of the cases, the formation of stones was diagnosed in the area of titanium clips, and in 33% stenosis of the ureterocolic anastomosis occurred. Denewer et al. used the same technique in 1999 for continent urinary diversion after laparoscopic cystectomy in their ten patients [11]. An 8-cm-long incision in the lower abdomen was required to construct the sigma-rectum pouch extracorporeally using a stapling technique, and the ureters were implanted in an antireflux fashion. No postoperative follow-up information was provided regarding stone formation.

The most noticeable benefit of the sigma-rectum pouch diversion is the easy construction and the nearly 100% day and night time continence of properly selected patients. The rectum sigma pouch is a modification of the ureterosigmoidostomy and was first described by Fisch et al. as an alternative continent urinary diversion [17]. Several authors reported excellent functional results of this continent urine reservoir after open radical cystectomy [18–20].

To our knowledge, we performed in April 2000 the first continent urinary diversion completely laparoscopically using the Mainz-pouch II technique [21]. Another issue of the laparoscopic procedure is how to remove the cystectomy specimen. Until now laparoscopists have made a mini-laparotomy incision for specimen removal. The opening of the sigmoid and rectum or the vagina also makes it possible to remove the specimen without enlarging any of the abdominal port sites.

Technique – Laparoscopic Mainz II Pouch (Rectum-Sigma Pouch)

Prior to surgery, patients undergo outpatient sigmoidoscopy to exclude diverticulosis.

Further selection criteria included a competent anal sphincter, assessed by the ability to hold a 200–300 ml water enema for 2 h, and adequate renal function (serum creatinine < 1.5).

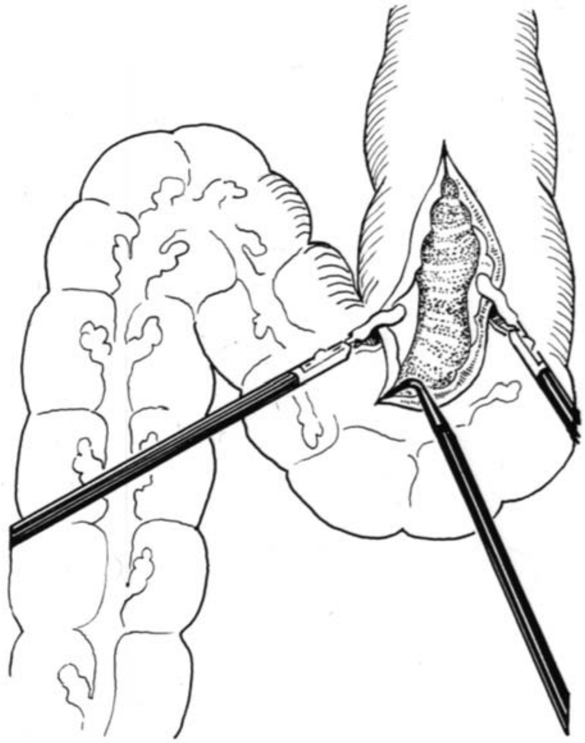

Fig. 3. Opening of the sigmoid intestine (antemesenterically) with electric hook

An antemesenteric enterotomy is made with an electric hook at the rectosigmoid junction and extended 10 cm proximally and 10 cm distally (Fig. 3). In men, this allows for transanal removal of the specimen (Fig. 4). The posterior walls of the rectum and sigmoid are then anastomosed side-to-side with a running 3-0 Maxon suture to form the posterior wall of the pouch (Fig. 5). Nonrefluxing ureteral anastomoses are formed by preparing a 3-cm submucosal bed in the posterior plate of the pouch, and then drawing the mobilized ureters through the pouch plate and securing with 3–4 sutures in this previously formed bed. After insertion of 8-F monopigtail ureteral catheters (via the opened rectum) the submucosal tunnels are completed by suturing the mucosa over the ureters (Fig. 6). The ureteral stents are brought out of the anus and the pouch is drained with a transanal 26-F Nelaton catheter. The anterior wall of the pouch is closed with a running 3-0 Maxon (Fig. 7). The pelvis is drained with a single Jackson-Pratt (JP) through one of the lateral 5-mm trocar incisions. Hemostasis

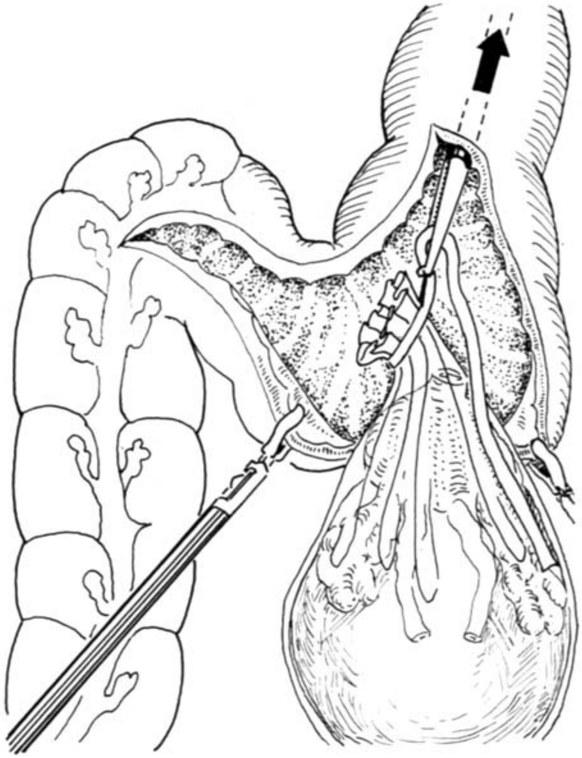

Fig. 4. Removal of the specimen in the endo-bag via the opened rectum

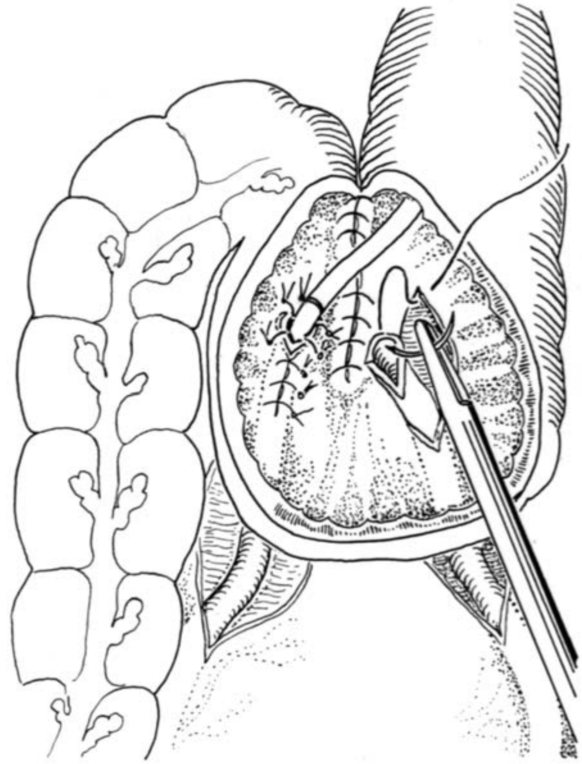

Fig. 5. Side-to-side anastomoses of rectum and sigmoid to form the posterior wall of the pouch

is checked, all trocars are removed under vision, and the trocar sites closed with running sutures.

Results

From April 2000 until March 2003, 15 patients (seven male, eight female) diagnosed with clinical T2N0M0 transitional cell carcinoma (TCC) of the bladder were selectively offered laparoscopic radical cystectomy with continent urinary diversion – the Mainz II sigma-rectum pouch. Prior to initiating this laparoscopic approach, 36 open cystectomies with Mainz II pouch diversions had been performed at Charité Hospital in Berlin. The mean age was 64.7 years (range, 58–69). The Mainz II diversion was selected for males with tumors infiltrating the prostatic urethra (orthotopic neo-bladder therefore contraindicated) or because they preferred this procedure over the open-type alternatives. In females the Mainz II pouch was already our preferred kind of continent urinary diversion before we started with the laparoscopic approach.

All 15 procedures were completed laparoscopically without intraoperative complications. Conversion to open surgery was not required in any case. The median operating time was 6.3 h (range, 5.5–7.9). The median estimate blood loss was 220 cc (range, 150–300 ml, 0 transfusions), and approximately 1,500 ml of combined crystalloid/colloid intravenous fluids were required per the discretion of the anesthesiologist. In general, liquids were tolerated on postoperative day (POD) 2, the JP drain was removed POD 4, the ureteral stents were removed on POD 8, and the pouch drain was removed on POD 9. On POD 10, IVPs were performed, demonstrating normal upper tracts and no leakage from the pouch. Patients were discharged on POD 10–12 (median, 11), significantly earlier than patients after comparable open surgery. Of 15 patients, 14 are fully continent (day/night) of urine and stool. One patient experienced a postoperative pouch leak at 3 weeks follow-up, re-

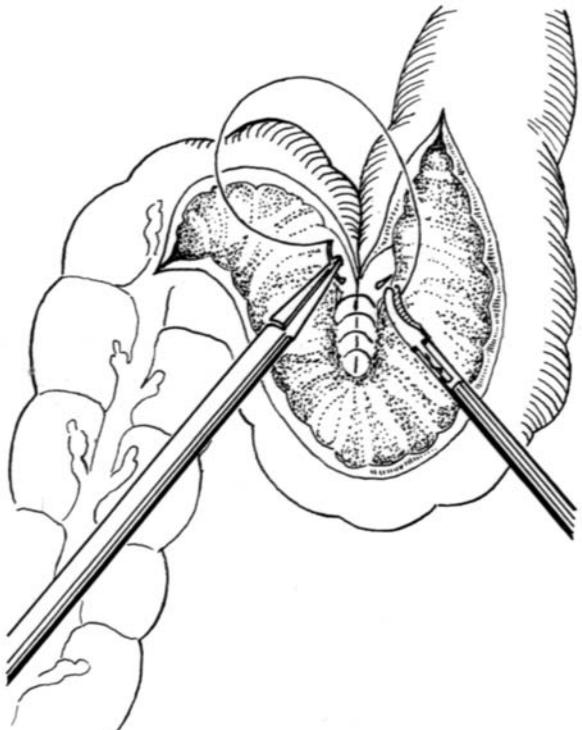

Fig. 6. Suturing of the mucosa of the sigmoid over the already implanted ureter to create the submucosal tunnel (nonrefluxing anastomoses)

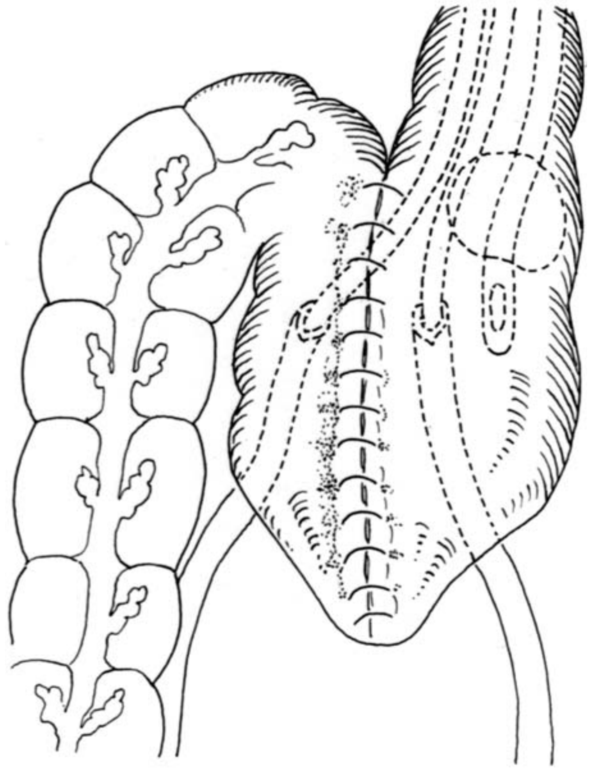

Fig. 7. The anterior wall of the pouch is closed with running suture (Maxon 3×0) and both ureters were stented with 8-F ureteral catheters and the pouch was drained with a 26-F Nelaton catheter

paired by open suturing. In another patient, a rectovaginal fistula was established 4 weeks after surgery, which required open repair as well. Histopathological examination of the specimens revealed transitional cell carcinoma: pT1 G3 + CIS ($n=1$), pT2b G2–3 ($n=5$), pT3a G3 ($n=6$), and pT3b G3 ($n=3$). The resection margins were free of tumor in all specimens. Positive lymph nodes were revealed in one patient, who was treated with adjuvant chemotherapy. Follow-up ranges from 14 to 48 months and has shown no local recurrence, but one patient with systemic recurrence. This patient developed bone metastasis 3 years after laparoscopic radical cystectomy. With regard to the upper urinary tract, two patients developed a stricture of the ureteral-intestinal anastomosis. In both cases an open re-anastomosis was necessary to solve the problem. In all other patients, the upper urinary tract is still well preserved without any evidence of hydronephrosis. The renal function is normal and mild hyperchloremic acidosis compensated with oral sodium bicarbonate was required in 11 out of 13 cases.

In our experience, the laparoscopic sigma-rectum pouch has significant technical advantages as a first-step continent urinary diversion. The sigmoid and rectum have posterior attachments that keep them still and facilitate laparoscopic suturing. The length of suture lines is also significantly less than for an ileal neo-bladder. The rectum has a capacity of approximately 400 cc, and therefore only a 20-cm opening is needed along the sigmoid and rectal surface to form a detubularized, low-pressure pouch. While endostapler devices could be used to speed up the bowel closure, we only use absorbable sutures to minimize the chances of future stone formation.

It is important to emphasize that the sigma-rectum pouch is not a traditional ureterosigmoidostomy, nor should it be associated with the significant complications and secondary cancers associated with that abandoned procedure. Gumus et al. have demonstrated by filling cystometry that the sigma-rectum pouch holds 400 cc of urine without reflux into the descending colon or ureters [22]. In reports of the classic ureterosigmoidoscopy, urine and stool were stored together in the rectum, and it was thought that urine frequently refluxed up the colon causing frequent contractions that led to frequent defecations of fecaluria. Chronic irritation of the ureteral anastomoses with fecal material was thought to predispose future cancer growths [23].

The sigma-rectum pouch provides the fixation of the left descending colon to the rectal ampulla in order to keep the colon in line with the rectum. The result is that the majority of our patients reported separately passing urine and feces at convenient intervals and with good anal control. Since urine and stool were not constantly mixed and since the ureteral anastomosis is away from the stool path, it has been proposed that the risk of carcinogenesis should be significantly less [24]. Nevertheless, long-term follow-up to determine the incidence of colonic carcinogenesis and ureteral strictures is limited.

Regardless of the form of laparoscopic diversion, the relatively low IV fluid requirements during these procedures (1,500 ml combined crystalloid/colloid) suggests the intriguing possibility that with fewer fluid shifts, electrolyte loss and overall cardiovascular stress to the patient is reduced, and is another potentially benefit that needs further study.

Summery

Clearly, the last decade has seen promising advances in laparoscopic urologic surgery. What once was thought technically impossible is now becoming a reality. Earlier, laparoscopy was mostly used for ablation of diseased tissue, but this has changed and laparoscopy has now become a tool for reconstruction as well. While reconstructive laparoscopy still remains challenging, advances in clip and suture technology have been of great benefit. These advances made it possible for radical cystectomy and construction of a continent urinary diversion to be performed by the laparoscopic approach alone, while maintaining established oncological and reconstructive principles. However, laparoscopic cystectomy and urinary diversion is still in its infancy. A number of problems will need to be addressed before such complicated procedures become commonplace. The future will surely see further improvements in instruments for reconstruction plus the application of novel energy sources to achieve more rapid, yet accurate approximation of tissue.

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5.2 Laparoscopic Radical Cystectomy with Orthotopic Bladder Replacement

Roland F. van Velthoven, Jens Rassweiler

Contents

The American Cancer Society estimates that 57,400 new cases of bladder cancer will be diagnosed in the United States this year, and 12,500 people will die of the disease. Radical cystectomy remains the gold standard for muscle-invasive bladder cancer and high-risk superficial tumors resistant to intravesical therapy [1]; moreover, open cystoprostatectomy with urinary diversion remains a major procedure, which may be demanding for patients.

Although cystectomy performed through a laparoscopic approach was first described in 1992 [2], this indication remained very controversial and was still considered recently as experimental for the treatment of bladder cancer [3]. During the last decade, the greatest impact shown by the laparoscopic approach in urology was undoubtedly shown on patients with genitourinary malignancies. Although only pelvic lymph node dissection and occasionally nephrectomy were initially considered as oncologically feasible, several other approaches such as laparoscopic adrenalectomy and radical nephrectomy are today considered as standards of care, not only at centers of excellence but even in the general community. Maturing data with laparoscopic radical prostatectomy suggest excellent continence rates and equivalent oncologic results based on pathological surrogates of cure [4].

The laparoscopic approach for advanced disease such as cytoreductive nephrectomy has also been found to be feasible for selected patients with metastatic renal cell carcinoma. Other novel therapies, such as laparoscopic radical cystectomy with urinary diversion and laparoscopic retroperitoneal lymph node dissection, hold great promise of benefit for patients with urologic malignancies [5].

Beyond initial reports on feasibility, controversy persisted regarding the risk of cell spillage or port metastases in transitional cell carcinoma; yet the strict observation of oncological safety rules such as the respect of closed urinary cavities has increased the acceptance of laparoscopic nephroureterectomy [5]; hence radical cystectomy should become more and more accepted if the same rules are carefully observed [6]. Moreover, animal and clinical experimental work has demonstrated that laparoscopy may be less immunodepressant than its open counterpart [7]; this additional theoretical advantage could play a positive role in favor of radical cystectomy made by the laparoscopic approach.

Although laparoscopic cystectomy with different urinary diversions has already been described and has shown to provide intraoperative and postoperative advantages vs open surgery [8–10], the laparoscopic cystoprostatectomy has rarely been well codified and illustrated [11]. Having set up an experience in radical prostatectomy since 1999, our groups started to perform laparoscopic radical cystectomy 1 year later, in spring 2000. Since then until June 2004, 30 and 8 patients were operated on in Brussels and in Heilbronn, respectively.

As elegantly shown in another recent review [12], all technical steps of an open-surgery radical cystectomy with urinary diversion have been translated into equivalent laparoscopic maneuvers.

The potential advantages of doing the procedure laparoscopically are the smaller incisions, hence decreased pain and quicker recovery time, implying a shortened hospital stay, decreased blood loss and fluid imbalance compared with the open technique. If transfusion is usual during open surgery, it is infrequent with laparoscopy. A stepwise protocol is actually established, with minor alternative variations between centers [9, 11, 12, 38].

Patient Preparation

Preoperatively, the bowel is prepared by oral self-administration of 2 l of electrolyte lavage solution over 2 days before the surgical procedure. Antibiotic prophylaxis with a cephalosporin is performed from day 1 to 5 and low-molecular-weight heparin (4,000 units) is administered preoperatively and until the postoperative day 15. Compression stockings are applied as the patient is placed in the supine position with the legs apart to allow free access to the perineal space. The table is set to a 30° Trendelenburg position. An 18F Foley catheter is inserted to drain the bladder and a nasogastric tube is positioned. As the lower limbs are carefully strapped to the table without compressions, no shoulder pads are necessary.

Equipment

The technique is challenging, requiring considerable laparoscopic infrastructure and expertise. Using a five- or six-port transperitoneal approach, the radical cystectomy and pelvic lymph node dissection are performed first. Standard laparoscopic surgical equipment with few special instruments are required (Table 1).

Table 1. Equipment for laparoscopic radical cystoprostatectomy

Standard laparoscopic equipment	
■ High-flow insufflator	
■ 300 W Xe light fountain	
■ 3CCD camera	
■ 10-mm 0° endoscope	1 (30° endoscope optional)
Trocars	
■ 10- to 12-mm trocars	2–3
■ 5-mm trocars	3
Instruments	
■ Laparoscopic Metzenbaum scissors	1
■ Laparoscopic bipolar forceps	1
■ Laparoscopic atraumatic prehension forceps	2
■ Laparoscopic suction irrigation cannula	1
■ Laparoscopy bags (optional)	
■ Harmonic scalpel or Ligasure (Tyco Healthcare) 5- to 10-mm forceps	
■ Surgical endoscopy 5- to 10-mm clip applicators	

Trocar Placement

The patient is in the supine position, with the lower limbs slightly (15°) abducted. A 30° flexion is given to the knees, to define accordingly the value of the Trendelenburg position. Extension of the hips should be avoided to prevent any backache (Fig. 1).

A five-port diamond or fan-shaped transperitoneal approach is used (Fig. 2). The first 10-mm trocar is placed 1 cm above the umbilicus; an open technique through a mini-laparotomy is optional at this level. This trocar is reserved for the 0° laparoscope. The remaining four ports are placed under endoscopic control after classical establishment of the pneumoperitoneum (12–14 mmHg) with or without the use of a Veress needle.

At the left McBurney point, a 12-mm trocar is placed; this diameter is chosen to ease the retrieval of pelvic lymph nodes after dissection. At the true McBurney point, a 10-mm trocar is placed to accept a 10-mm instrument if necessary.

On the midline, a 5-mm trocar is placed, one span below the umbilical trocar. A fifth 5-mm trocar is placed at the horizontal level of the navel, on the vertical line of the right lateral trocar.

The abdomen and pelvis are inspected; eventual adhesions of the sigmoid loop in the left fossa are released by blunt and sharp dissection.

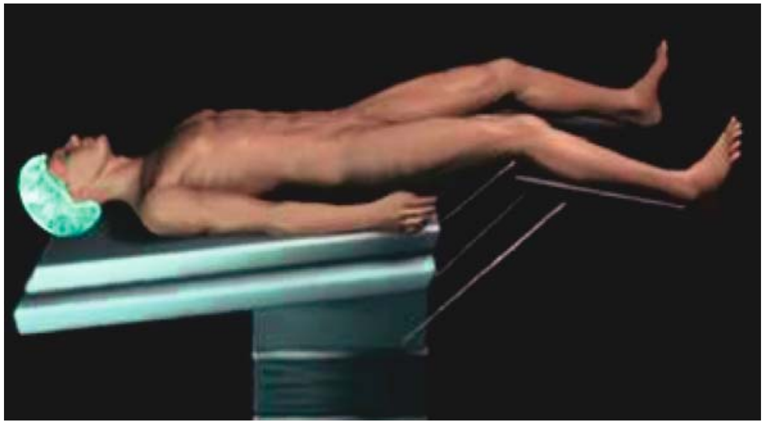

Fig. 1. Patient positioning. The patient is in the Supine position, with the lower limbs slightly (15°) abducted. A 30° flexion is given to the knees, to define accordingly the value of Trendelenburg position. Extension of the hips should be avoided

Laparoscopic Cystoprostatectomy in the Male

Dissection of the Retrovesical Space

In a male patient, the operation starts by dissection of the plane behind the seminal vesicles; the dissection is started at the level of the Douglas pouch. The posterior wall of the bladder is lifted vertically by means of a fenestrated forceps held by the second assistant. A horizontal 6- to 8-cm incision is made on the peritoneum, two fingers above the bottom of the Douglas pouch (Fig. 3).

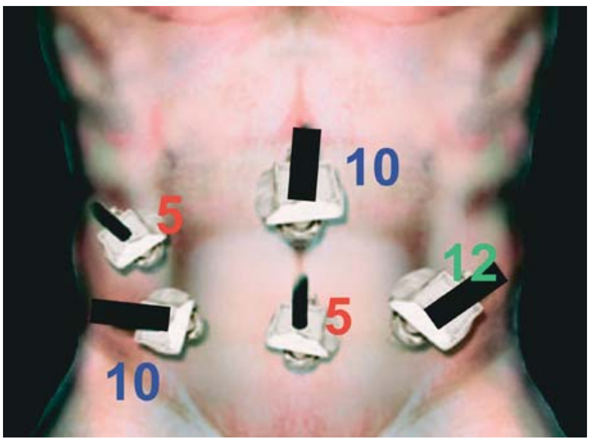

Fig. 2. Trocar placement. The first 10-mm trocar is placed 1 cm above the umbilicus, for the 0° laparoscope. At the left McBurney point a 12-mm trocar is placed to ease the retrieval of pelvic lymph nodes after dissection. At the true McBurney point, a 10-mm trocar is placed to accept a 10-mm instrument. On the midline, a 5-mm trocar is placed, one span below the umbilical trocar. A fifth 5-mm trocar is placed at the horizontal level of the navel, on the vertical line of the right lateral trocar

Ampullae and seminal vesicles are exposed but not dissected from the bladder, to which they remain attached throughout the procedure. If necessary, the posterior aspect of Denonvilliers fascia is exposed and incised horizontally to open the perirectal fatty space. When started high enough, the dissection is able to leave the Denonvilliers posterior sheet covering the seminal vesicles.

The dissection is continued bluntly on each side and on the anterior aspect of the rectum towards the apical area of the prostate.

The vascular supplies of the vesicles are recognized laterally, but not divided so far.

A tunnel is created between the rectum and the prostate with the vesical and prostatic fibrovascular pedicles laterally.

Lateral Dissection of the Bladder

The umbilical arteries are identified close to the abdominal inguinal ring and the peritoneum is incised just laterally to them. From the internal inguinal ring caudally, a vertical incision of the peritoneum follows the medial aspect of the external iliac artery until the crossing of the ipsilateral ureter. The vas is divided at the level of the inguinal ring and retracted medially to open the space medial to the external iliac vessels (Fig. 4).

The classical or extended ilio-obturator lymph node dissection [13, 14] can be carried out at this moment;

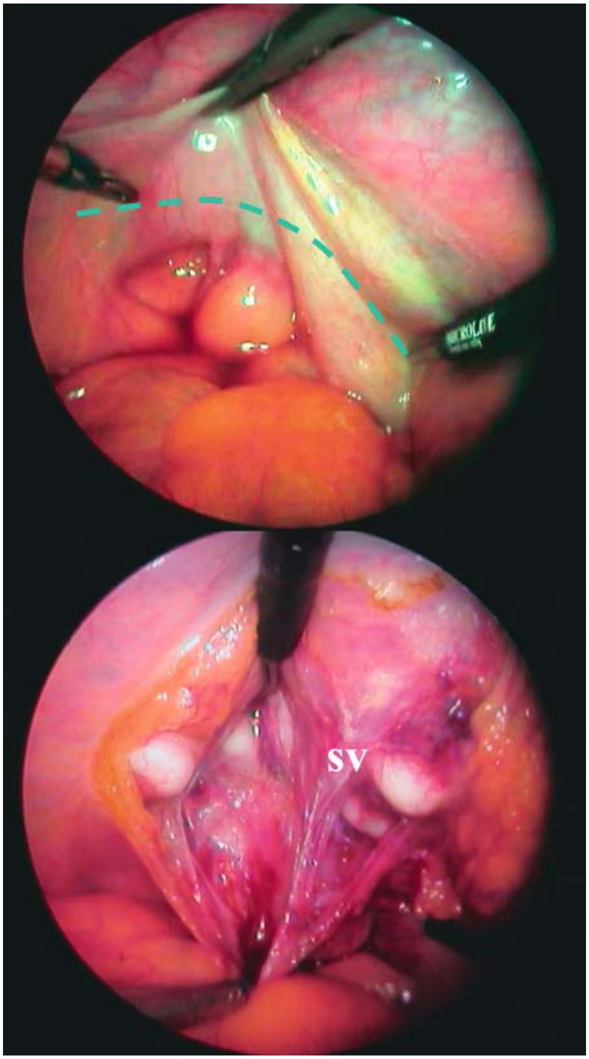

Fig. 3. Posterior dissection. The dissection is started at the level of the Douglas pouch. The posterior wall of the bladder is lifted vertically by means of a fenestrated forceps held by the second assistant. A horizontal 6- to 8-cm incision is made on the peritoneum, two fingers above the bottom of the Douglas pouch. Ampullae and seminal vesicles (*sv*) are exposed but not dissected from the bladder. The posterior aspect of Denonvilliers fascia is exposed and incised horizontally to open the perirectal fatty space

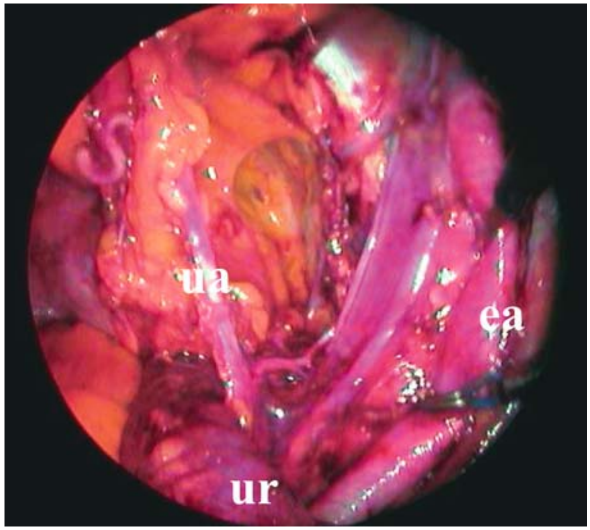

Fig. 4. Lateral dissection. The umbilical arteries (*ua*) are identified and the peritoneum is incised just laterally to them. A vertical incision of the peritoneum follows the medial aspect of the external iliac artery (*ea*) until the crossing of the ipsilateral ureter (*ur*). The vas is divided at the level of the inguinal ring and retracted medially. The classical or extended ilio-obturator lymph node dissection is carried out at this time

sampling of the nodes in view of frozen sections can be extended to external and/or internal node groups.

The peritoneal incision is then extended cranially, at the anterior aspect of the ureter, beyond the crossing of iliac vessels. This makes it possible to prepare an adequate length of free ureter in view of their anterior reimplantation. Careful hemostasis of the arteriolar supply to the iliac portion of ureters should be ensured to avoid potentially neglected bleeding.

The superior vesical artery is divided at its origin. This can be accomplished by means of a 10-mm Ligasure (Tyco Healthcare, Mansfield, MA, USA) forceps or by section between laparoscopic clips.

The ureter is then further followed, completely dissected and divided between clips, close to its intramural portion. The last centimeter is resected and properly oriented for frozen section to exclude dysplasia of the lower ureter.

The inferior vesical artery and vesicoprostatic artery are then divided as described above. Their division is carried out in close vision of the lateral aspect of the seminal vesicle to which they provide arterial supply (Fig. 5). The division of the successive pedicles is temporarily interrupted at the upper lateral edge of the prostate, on each side, in order to preserve temporarily the emergence of the neurovascular bundles.

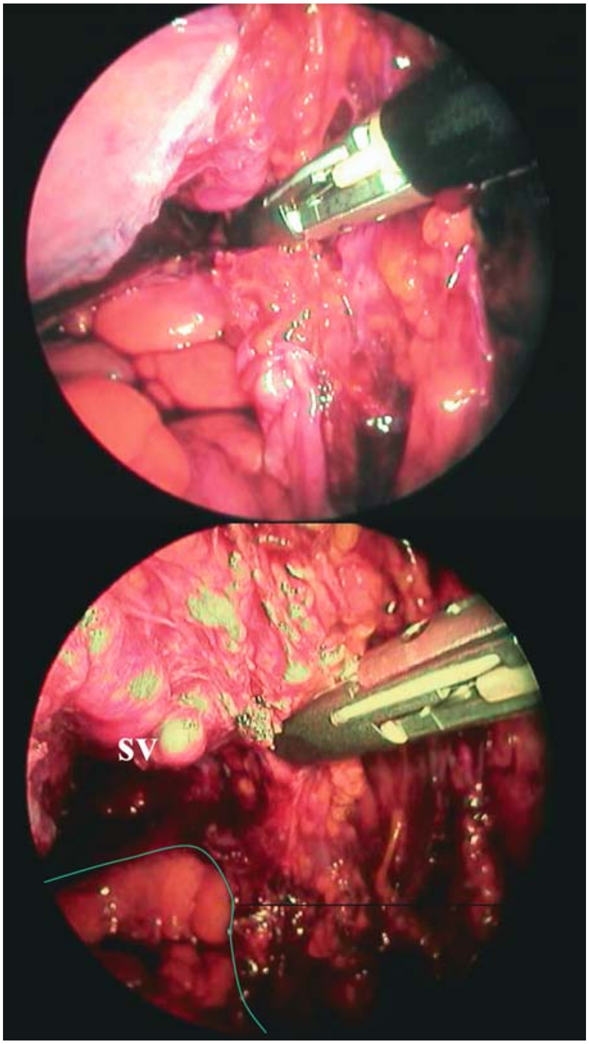

Fig. 5. Antegrade dissection. The superior vesical artery is divided at its origin, here by means of a 10-mm Ligasure (Tyco Healthcare). The inferior vesical artery and vesiculo-prostatic artery are then divided as described above. They are divided in close vision of the lateral aspect of the seminal vesicle (*sv*)

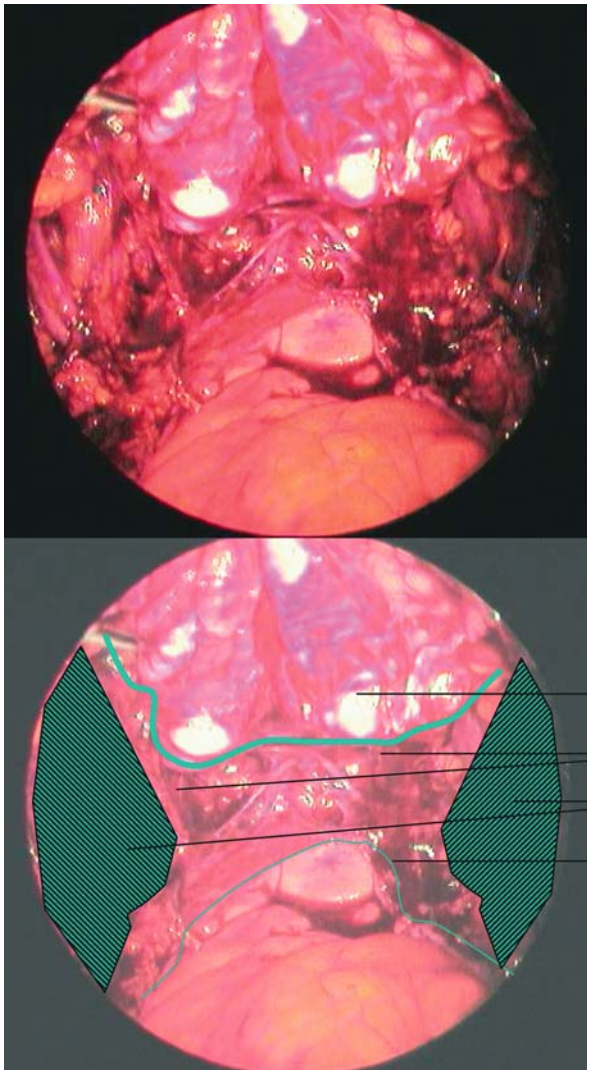

Fig. 6. Posterior dissection completed. The division of the successive pedicles is temporarily interrupted at the upper lateral edge of the prostate, on each side, in order to preserve temporarily the emergence of the neurovascular bundles. So far, the bladder remains suspended through its anterior attachments and the Retzius space is kept closed except for its lateral aspects

So far, the bladder remains suspended through its anterior attachments and the Retzius space is kept closed except for its lateral aspects (Fig. 6).

Anterior Dissection of the Bladder

When the antegrade dissection and division of the bladder's upper vascular elements are achieved, the umbilical ligaments are sectioned and the Retzius space is then opened. The high section of umbilical ligaments is made possible by the supraumbilical position of the telescope, by the working position of the scissors in the upper right trocar and by an hemostatic forceps working in the left lateral trocar.

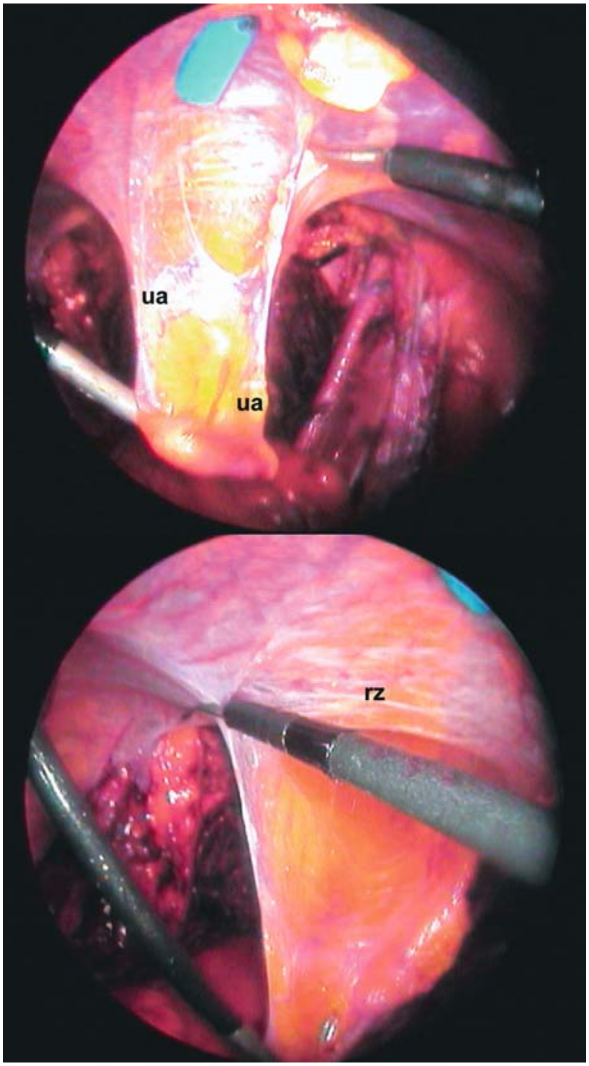

Fig. 7. Anterior dissection of the bladder. The umbilical ligaments (*ua*) are sectioned and the Retzius space (*rz*) is then opened. The high section of umbilical ligaments is made possible by the supraumbilical position of the telescope, by the working position of the scissors in the upper right trocar, using a hemostatic forceps working in the left lateral trocar. The low midline trocar is visible in the upper part of the picture. In the back, the right iliac artery and the posterior dissection planes. At this point the anterior peritoneum is incised lateral to the umbilical arteries from the umbilicus to the inguinal ring. The prevesical space is entirely opened and the bladder is dissected from the anterior abdominal wall

At this point the anterior peritoneum is incised lateral to the umbilical arteries from the umbilicus to the inguinal ring (Fig. 7). The prevesical space is entirely opened and the bladder is dissected from the anterior abdominal wall. With a combination of sharp and blunt dissection, the space between the lateral wall of the bladder and the pelvic side wall is developed until reaching the endopelvic fascia on both sides. The superficial dorsal vein is then divided on the anterior aspect of the prostate and the endopelvic fascia is opened on its line of reflexion; the lateral surface of the prostate is separated from the levator ani muscle to carefully isolate the dorsal vein complex and the prostatic apex.

Nerve Sparing Dissection of the Vesicoprostatic Complex

At this time, the lateral aspect of the prostate is exposed by the first assistant exerting a traction on the vesicoprostatic junction in the opposite direction. This maneuver exposes the superior vesicoprostatic pedicle left intact so far (Fig. 8). In the meantime, the rectum is pushed downwards with the suction cannula, in order to expose the medial aspect of the vesicoprostatic pedicle.

Descending the pelvis, the visceral fascia is opened on the lateral aspect of the prostate and the branches of the ipsilateral neurovascular bundle to the prostate are divided successively towards the apex of the prostate, on each side, using a harmonic scalpel, a 5–10 Ligasure or a bipolar forceps.

Apical Dissection

At this point the vesicoprostatic complex is still attached to the pelvic floor by the deep dorsal vein complex and the urethra. The Santorini plexus is divided after ligation or by means of the Ligasure forceps.

The anterior aspect of the urethra is exposed as close as possible to the prostatic parenchyma in order to maintain the puboprostatic ligaments intact as well as an adequate urethral stump, if an orthotopic neobladder is planned.

From the points reached by the division of the visceral fascia, the lateral and posterior aspects of the urethra are then dissected with a right-angle Maryland forceps (5 or 10 mm). When free, the urethra is ligated with an intracorporeal knot or clamped by a 10-mm Hem-o-Lok clip and divided after removal of the indwelling catheter (Fig. 9).

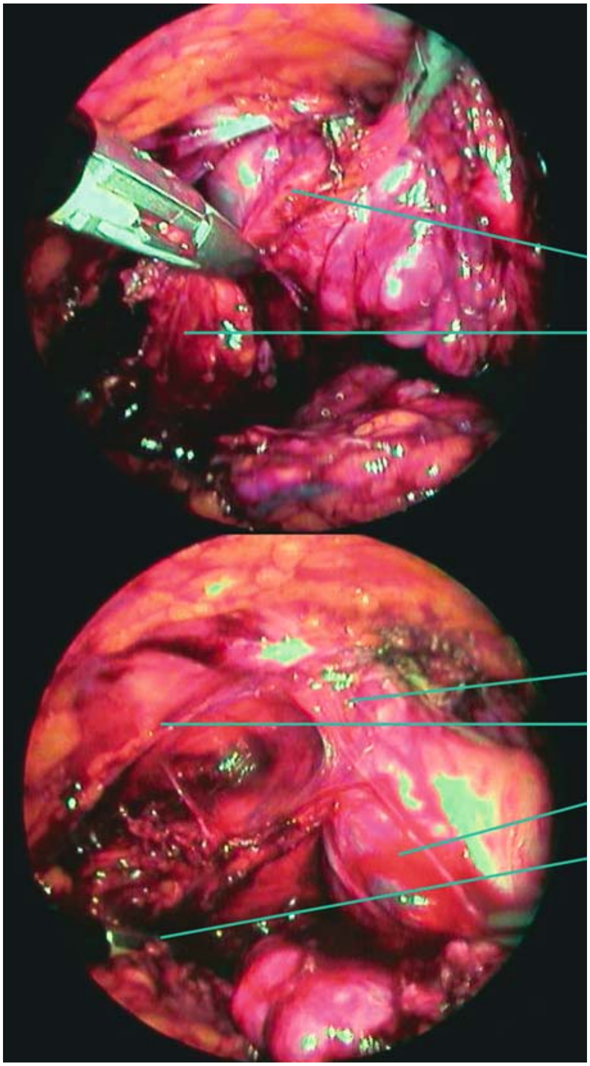

Fig. 8. Neurovascular bundle dissection. The lateral aspect of the prostate is exposed by the first assistant exerting a traction on the vesicoprostatic junction in the opposite direction. This maneuver exposes the superior vesicoprostatic pedicle left intact thus far. Descending the pelvis, the visceral fascia is opened on the lateral aspect of the prostate and the branches of the ipsilateral neurovascular bundle to the prostate are divided successively towards the apex of the prostate, on each side, using a harmonic scalpel, a 5- to 10-Ligasure or bipolar forceps

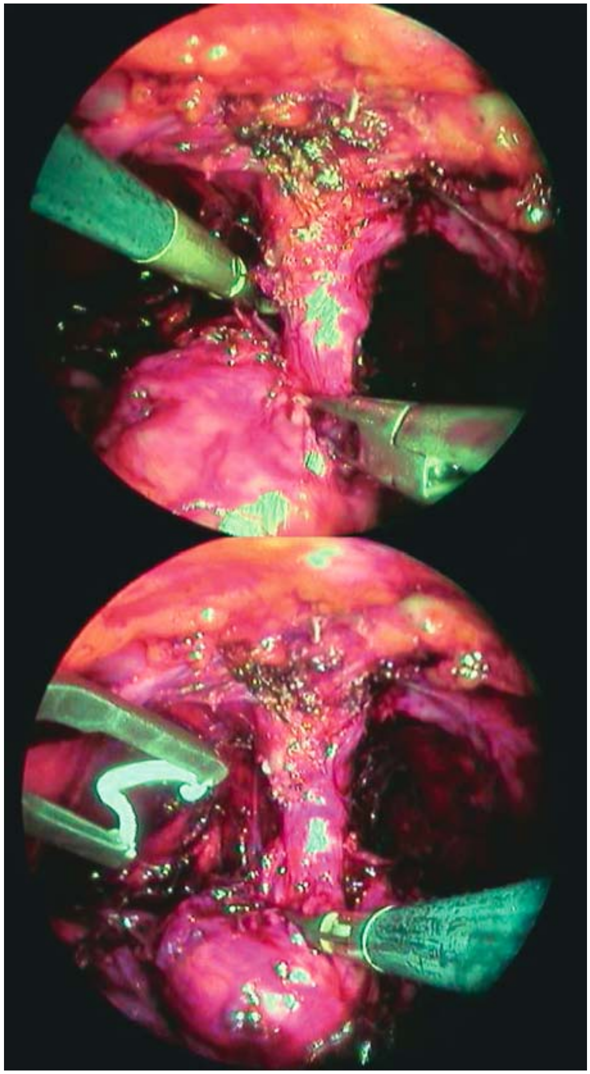

Fig. 9. Apical dissection section of urethra. The anterior aspect of the urethra is exposed as close as possible to the prostatic parenchyma in order to maintain the puboprostatic intact ligaments as well as an adequate urethral stump if an orthotopic neobladder is planned. The lateral and posterior aspects of the urethra are then dissected with right angle Maryland forceps (5 or 10 mm). The urethra is ligated with an intracorporeal knot or clamped by a 10-mm Hem-o-Lok clip and divided

The urinary lumen is never opened by this means in order to avoid any cell spillage. The terminal plate and the distal insertions of Denonvilliers fascia are incised, releasing the specimen completely.

If the available length of both ureters is considered too short by the surgeon, the former dissection is continued cranially. The left ureter is tunnelized behind the sigmoid loop to join the right ureter in the retroperitoneal space; a fenestrated atraumatic forceps is passed through the upper right trocar, lifting the posterior peritoneum caudally to the aortoiliac bifurcation, and bluntly dissecting the sigmoid mesentery to allow the passage of the left ureter to the opposite side.

After a last overview of the main hemostatic controls, the pneumoperitoneum is temporarily deflated; lateral trocars remain as they are placed.

In case of an orthotopic bladder replacement, a mid-line laparotomy incision is made, unifying the two medial trocar holes. These trocars are temporarily removed.

The vesicoprostatic specimen is removed en bloc through the incision, its entrapment into a bag is optional.

Laparoscopic Cystectomy in the Female

The posterior dissection starts at the level of the rectovaginal space.

As described in laparoscopic surgery for prolapse [15], the posterior vaginal bottom is lifted by the second assistant with a curved metal retractor, exposing immediately the rectovaginal space to blunt and sharp dissection. This dissection is extended laterally to the ischiorectal fossae. The peritoneal incision is then continued cranially at the level of the first peritoneal fold to find and dissect the ureters.

The lateral incisions of the parietal peritoneum are started at the internal inguinal ring, both ligamenta teres are divided and retracted medially to expose the medial aspect of the external iliac vessels. Pelvic lymph node dissection is done on each side, as already described in view of frozen sections. The subsequent dissection and antegrade division of the ureters and upper vesical pedicles are then carried out as in males.

The umbilical ligaments and urachus are divided and the prevesical space is opened and bluntly dissected to expose the anterior aspect of the bladder to the bladder neck, urethra and anterior wall of the vagina. Opening of the endopelvic fascia allows the dissection to be continued until the lateral aspects of the urethra, which is dissected completely, secured between clips and transected. If an orthotopic bladder replacement is planned, a maximal urethral stump is then preserved in view of the anastomosis. Depending on patient's age and expectations, cystectomy may be carried out with vaginal and uterine preservation [16]. More often, according to the tumor burden and stage, the uterus and part of the vagina may need to be taken with the bladder.

The metal retractor is moved to the anterior vaginal bottom to enable the dissection of the urethrovaginal space, which is developed in a retrograde way after section of the urethra. The vaginal anterior wall is sectioned using the retractor, giving a flat horizontal shape to the vagina; the gas leak during section of the vagina is prevented by packing the vagina, eventually with Vaseline gauze.

The vagina is repaired and closed with O-woven PGA sutures, after retrieval of the specimen.

Laparoscopically Assisted Orthotopic Bladder Replacement

The orthotopic neobladder pouch is created by suturing the opened small bowel together to form a new bladder. As usual, a 55- to 60-cm segment of ileum located 15 cm away from the ileocecal junction is isolated and detubularized, leaving intact a proximal 10-cm isoperistaltic afferent Studer limb segment. Depending on the surgeon's skills or preferences, a Hautmann ileal bladder can be built as well and the bowel prepared accordingly. The continuity of the small bowel is restored outside the body through the incision made for specimen retrieval; a spherical neobladder is constructed extracorporeally as well. A termino-terminal ureteroileal anastomosis is then performed through the same incision, using the Wallace or Bricker technique.

Ureters are intubated with 8F smooth catheters temporarily attached to the posterior wall of the pouch with rapid adsorbable sutures (Vicryl rapid 2/0).

Both catheters are exteriorized through the anterior wall of the pouch, and subsequently will be passed through the abdominal wall.

The anterior wall of the reservoir is closed by a running Connel-Mayo PGA 3/0 suture; the caudal part

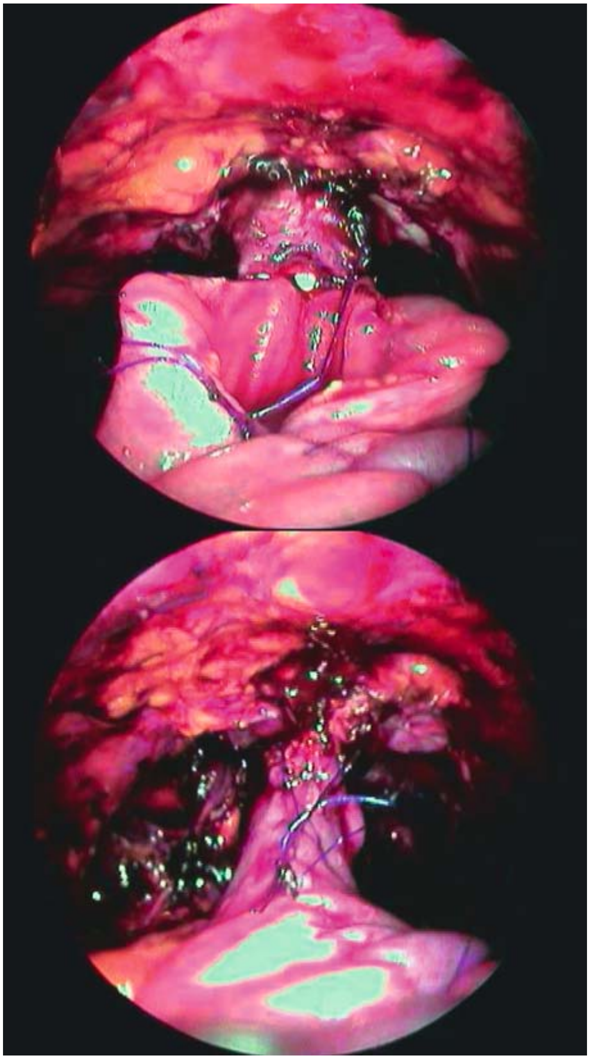

Fig. 10. Vesicourethral anastomosis. The posterior aspect of the anastomotic suture is completed. The caudal aspect of the anterior closing suture of the ileal neobladder is left open. After completion of the anterior aspects of the two hemicircle running sutures, the intracorporeal knot is made at twelve o'clock. The anterior aspect of the bladder is then closed

of this closure is left open in view of the vesicourethral anastomosis.

When the pouch is ready, it is placed in the abdomen and the mini-laparotomy is closed classically. The 10-mm trocar is replaced for the lens, in an infraumbilical position and the pneumoperitoneum reinsufflated.

After appropriate positioning of the ileal neobladder in its orthotopic position, a vesicourethral anastomosis is started between the ileal orifice left open and the urethral stump.

This technique has been described elsewhere [17]; it has now been widely adopted for the reconstructive part of radical prostatectomy. Briefly, the suture is started at six o'clock on the ileal edge of the suture; two 6- to 7-in. pieces of 2/0 PGA monolayer threads knotted together are used; two hemirunning sutures are then built up to twelve o'clock, where the only knot tied intracorporeally is made (Fig. 10).

When this suture is completed, a Jackson-Pratt drainage is placed in the pelvis. The tube is exteriorized through a trocar hole in the right fossa. Fascial incisions of 10 mm are closed with interrupted 0 sutures. The skin is closed with surgical staples.

This stepwise protocol and its alternative options are summarized in Table 2.

Other Technical Options of Urinary Diversion

Depending on the gender and age of the patient as well as on the specific indications, the following types and techniques of urinary diversion have been performed.

Ileal Conduit

For male patients, the ileal conduit is usually made with laparoscopic assistance. The extended sub- or supraumbilical minilaparotomy incision for retrieval of the specimen is used for the isolation of the 20-cm segment of the distal ileum in an open technique. The ileoileal anastomosis is performed by interrupted seromuscular stitches, and the ileum is brought back into the abdominal cavity. Subsequently, the 10-mm trocar incision in the right lower abdomen is used as ileostoma.

As an alternative option, the incision at this level can be enlarged, the rectus fascia incised to a size allowing for specimen retrieval and ileoileal anastomosis. The distal end of the ileal conduit is then pulled through the wound and sutured to the skin, at the upper end of the incision. After placement of two single J-stents, the ileal segment is manipulated back into the abdominal cavity, the subumbilical or pararectal incision is closed and the pneumoperitoneum re-established. Finally, the left ureter is transposed retro-

Table 2. Laparoscopic radical cystectomy – technical steps and options

Operative Step	Options	Comments
Positioning of patient	Deflected supine Lithotomy	 For female patients
Trocar arrangement	Semilunar W-shaped	In case of ileal conduit One port = urostoma
Transperitoneal access	None	Similar to open surgery
Incision of Douglas pouch and retrovesical dissection	None	None
Pelvic lymph node dissection	Standard extended	Depending on surgeon
Division of ureters	None	None
Division of ovarian and uterine vessels	Endo-clips	For female patients
Division of umbilical ligaments and pedicles	Endo-GIA Hem-o-Lok Ligasure	Depending on surgeon
Suturing of dorsal vein	None	None
Division of urethra	Closed by catheter Closed by clip	Depending on technique
Incision of anterior vagina	None	In female patients
Division of prostate pedicles	Radical Nerve-sparing	Depending on indication Depending on indication
Entrapment of specimen	Organ bag intra-abdominally Transrectally	
Retrieval of specimen	Mini-laparotomy Transvaginal Transrectal	Periumbilical, mid-line Pararectal

peritoneally behind the sigmoid and both ureters are sutured, stented and sutured to the ileal conduit using interrupted sutures.

In the female patient, following transvaginal extraction of the specimen, the formation of an ileal conduit can be carried out completely laparoscopically. For this purpose a 20-cm ileal segment is isolated using an endoscopic stapler. The ileoileal anastomosis is made with antemesenteric side-to-side stapling and closure of the remaining opening by endoscopic suturing. Then, the distal end of the ileal segment is pulled out via an enlarged trocar incision in the right lower abdomen and sutured to the skin. Via the thus created urostoma, single J-stents can be introduced and both ureters are stented and sutured to the ileal conduit in a modified Wallace-type technique or individually using interrupted sutures, according to Bricker's technique.

Rectosigmoid Neobladder

Some authors feel that a sigmoid neobladder can be reconstructed relatively easily in a complete laparoscopic manner, mainly because of the anatomical localization of the sigmoid in the pelvis [18, 19]. This allows for a very stepwise construction of the reservoir from the back to the front of the sigmoid loop. After its identification and proper orientation, the sigmoid segment is incised antemesenterically and the posterior wall created by a U-shape anastomosis of the posterior wall using a continuous suturing technique. Now both ureters are implanted in a serous-lined tunnel included in the posterior wall suture, stitched by interrupted sutures and stented by use of Mono-J-catheters, which are exteriorized through the rectal catheter. Finally the anterior wall is closed completely.

Other Types of Urinary Diversion

Additionally, in the literature the formation of an orthotopic sigmoid pouch [20], a continent ileal pouch [21], and a prostatoenterocystoplasty after prostate- and seminal vesicle-sparing cystectomy [22, 23] has been described.

In the case of a pouch with continent catheterizable stoma, the pouch is created outside the body, the ureters are connected to the pouch, then the pouch is dropped back into the abdomen, and the stoma is created on the skin.

Postoperative Management

In the first night, all patients are monitored in the intensive care unit for vital parameters and adequate pain management. Parenteral nutrition was continued until complete oral feeding. The drains are removed after reduction of secretion below 50 ml. On day 10, the ureteral stents are removed without cystogram. The urethral catheter of neobladders is removed on postoperative day 18, after 48 h of intermittent clamping every 2 h.

Discussion

The Concept of Laparoscopic Cystectomy

The successful introduction of laparoscopic radical prostatectomy at the end of the last decade pioneered by European urologists was a major step in the technical development of minimally invasive surgery [24–26]. It was demonstrated that even complex ablative-reconstructive interventions in the pelvis could be performed laparoscopically. Moreover, some studies showed that despite initially longer operating times, such procedures provided significant advantages for the patient when compared to the open counterpart [27, 28].

Therefore it seemed to be no more than a logical step that at the beginning of this century the first centers reported their initial experience with laparoscopic radical cystectomy [29, 30]. Similar to radical prostatectomy, there were early reports in the 1990s showing significant technical difficulties and therefore preventing the clinical introduction [31–33]. In the meantime, an increasing number of urologists, including various international centers, published their experiences with laparoscopic radical cystectomy (Table 3).

As for the radical treatment of localized prostate cancer, radical cystectomy deals with an initially ablative procedure followed by a major reconstructive procedure in cases of laparoscopic assistance to urinary diversion. Moreover, it also needs to be adapted to a disease present in both genders, whether for malignant indications or not.

In contrast to laparoscopic radical prostatectomy, the numbers of the different series are still limited. On the other hand, due to the disease, various technical procedures have been described concerning both the radical cystectomy (i.e., anterior exenteration, radical cystoprostatectomy, prostate-sparing cystectomy) as well as the type of urinary diversion (i.e., ileal conduit, continent pouch, neobladder) (Table 4).

Open radical cystectomy requires an abdominal incision with prolonged retraction of the abdominal wall. This maneuver leads to a high level of postopera-

Table 3. Laparoscopic radical cystectomy with ileal conduit

Year	Author	No.	OR time (hours)	Laparoscopically assisted	Reoperation	Complications	Reference
1995	Puppo	4	6–8	Yes	None	None	[31]
1995	Sanchez de Badajoz	1	8	Yes	None	Nerve (1)	[32]
2002	Gill	12	7–8	No	2	Ileus (1), sepsis (1)	[12]
2002	Peterson	1	7	Yes	None	None	[35]
2003	Popken	5	5–6	Yes/no	None	None	[36]
2003	Rassweiler	4	6–7	Yes/no	None	Urine leak (1)	[37]
2003	Hoepffner	10	6	Yes/no	None	Sepsis (1)	[52]
2004	Van Velthoven	13	5–7	Yes	None	Rectum (1)	[38]
2004	Sakakibara	11	7–9	Yes	None	Ileus (4), leak (2)	[39]
	Total	62			2/62 (3%)	11/62 (17.7%)	

Table 4. Laparoscopic radical cystectomy with bladder replacement

Year	Author	No.	Operating time (hours)	Diversion type	Laparoscopic assistance	Reoperation	Complication	Reference
1999	Denewer	10	8–10	Mainz II	Yes	NA	NA	[29]
2002	Abdel-Hakim	8	7–12	Ileal	Yes	0	Thrombosis (1)	[42]
2002	Chiu	1	8.5	Ileal	Yes	0	None	[43]
2002	Türk	11	7–8	Mainz II	No	1	Pouch fistula (2)	[19]
2003	Gaboardi	6	6–8	Ileal	Yes	0	None	[40]
2003	Gill	3	8–12	Ileal	No	0	Vaginal fistula (1) GI bleeding (1)	[41]
2003	Paulhac	1	7.5	Ileal	Yes	0	Urine leak (1)	[21]
2003	Hoepffner	25	7	Ileal	Yes	1	Cutaneous fistula (1)	[52]
2003	Goharderakhshan	25	NA	Ileal	Yes	3	Bleeding (2), sepsis (3), urine leak (3)	[44]
2003	Vallancien	20	NA	Ileal	Yes	NA	NA	[22]
2003	Popken	4	6–7	Ileal	Yes	0	None	[36]
		1	7	Mainz II	No	0		
2003	Guazzoni	3	7–8	Ileal	Yes	0	None	[23]
2003	Liu	5	7	Sigmoid	Yes	0	NA	[20]
2003	van Velthoven	15	7–9	Ileal	Yes/no	0	Ileus (3)	[38]
		2	7–8	Mainz II	Yes/no		Acute retention (1)	
2003	Rassweiler	1	8	Ileal	Yes	1	Bleeding (1)	[37]
2004		3	9–11	Sigmoid	No	0	UTI (1), ureteral stenosis (1)	
	Total	144				4.1%	15.3%	

Perioperative complication rate: 22/144 (15.3%); reoperation (open) rate: 6/144 (4.1%)

tive pain, often requiring narcotic administration for several days. Consequently patients remain hospitalized with continuous nursing needs for a long time and normal activity is regained only slowly.

The main apparent advantage of the laparoscopic radical cystectomy consists in less postoperative pain, due in part to the smaller incisions made. No large metal retractors are needed to keep the incision open, which contributes also to reduced pain. In the laparoscopic approach there is also usually less blood loss, thus minimizing the chances for blood transfusion. Subsequently, patients are encouraged to be out of bed and ambulate sooner. With quicker ambulation, many patients also experience quicker return of bowel function. The diet is advanced from clear liquids to regular diet as the patient's bowel function recovers, sometimes at day 2 postoperatively. Once patients can tolerate regular food and are walking about freely, they are discharged home. In addition to these advantages, the laparoscopic approach also offers a better cosmetic result due to the small and almost negligible incisional scars over time.

Although there have been few studies that have addressed the effect of age and comorbid disease on outcomes after laparoscopic urological procedures, candidates for the laparoscopic procedure are the same as for the open procedure – patients with organ-confined, muscle-invasive bladder cancer who need cystectomy whether or not they have a usable urethra.

In major laparoscopic procedures, the only variable associated with increased risk of postoperative complications in the univariate analysis was estimated blood loss. There was a trend toward increased postoperative complications in patients with increased comorbidity, but this did not reach statistical significance.

At the recent World Congress of Endourology, in arguing against widespread use of the minimally invasive procedure, deVere White cited recent research suggesting that even traditional cystectomy appears to be too demanding for many surgeons. A study presented at a recent meeting of the American Society of Clinical Oncology and reported in *Urology Times* in August 2003 evaluated 268 cystectomies performed by 106 surgeons at 109 institutions between 1987 and

1998. In up to 62% of the cases, the surgeons removed fewer than ten lymph nodes, increasing the risk for recurrence. The study was conducted by Harry W. Herr, a bladder cancer specialist at Memorial Sloan-Kettering Cancer Center in New York.

Patients face more than a fivefold increased risk that their cancer will recur, despite cystectomy, if fewer than ten lymph nodes are removed. When the cancer does recur, the survival rate is grim – less than 10% of these patients live 5 years. The surgeons in the study who did the fewest procedures had the worst track record. But even the highest-volume surgeons removed too few lymph nodes in one-third of their cases.

"Based on how well even traditional cystectomy, an operation that has been taught for 50 years, is being performed, and based on the skill required to perform laparoscopic cystectomy, widespread adoption of the laparoscopic technique would be unwise," deVere White said.

With regard to such conservative concepts, the initial European experience showed the feasibility and safety of the technique, including all variations of urinary diversion. Our goal was to translate the technical steps routinely used in our open technique and to standardize a laparoscopic protocol. At no moment in our development in laparoscopy were we ready to accept compromising our oncological or functional results because of our surgical approach. Differences with the open access are the immediate transperitoneal approach, posterior dissection of the seminal vesicles, Denonvilliers fascia incision and lymphadenectomy possibly done after the cystoprostatectomy, for staging purposes.

Beyond the unavoidable learning or discovery curve, the mean laparoscopic operative time in our experience is 120–180 min, including the vesicoureteral anastomosis when performed laparoscopically; the average blood loss is below 500 cc. With regards node sampling, no doubt that the laparoscopic approach enable surgeons to perform extended lymph node dissection yielding more than ten lymphatic nodes; this skill is inherited not only from conventional ilio-obturator dissection but also from the modified retroperitoneal templates performed laparoscopically.

Technical Difficulties of the Procedure

Although the first laparoscopic cystectomy was performed in 1992, very few surgeons adopted the technique during the rest of that decade. Although it could be demonstrated that the ablative part of the procedure does not cause major problems for experienced surgeons, on the other hand, even for centers of expertise, urinary diversion, particularly if performed intracorporeally, is a challenging operation. Over the last 3 years, however, more and more urologists have reported performing laparoscopic cystectomy.

A significant number of reports are only available as abstracts presented at the 2003 European Urology Association, American Urological Association and World Congress of Endourology meeting (Tables 3, 4). Therefore a detailed analysis remains difficult. However, most of the reports do not differ significantly with respect to operating time and the type and frequency of the observed complications. In the meantime, apart from the gastric pouch, all contemporary types of urinary diversions have been realized either with laparoscopic assistance or even completely intracorporeally. It is evident that the OR time mainly depends on the type and technique of urinary diversion. We were able to collect 206 reported cases worldwide. The incidence of complications (15.3%–17.7%) as well as the reintervention rate (3.4%–4.1%) reflect the technical difficulties of the procedure even in the hands of laparoscopically experienced surgeons. On the other hand, it is obvious that such problems are largely linked to the learning curve of the techniques and mainly concern the reconstruction of the urinary diversion (i.e., urinary leakage, urine fistula, ileus) rather than the radical cystectomy itself, which requires usually only 2–3 h.

The main questions raised of course concern the respect of oncological bases of radical cystectomy and the risk of transitional cell spillage during the procedure.

Transitional cell carcinoma is much more aggressive than, for instance, adenocarcinoma of the prostate, both in terms of the development of local recurrence and progressive metastatic disease. There have already been reports of disease-specific mortality after a short-term follow-up [6, 34]. Although recent studies could not reveal any specific risk factors for the development of port-site metastases related to the laparoscopic technique, most of the reported trocar metastases, in the field of urology, have been observed in cases of transitional cell carcinoma [37, 45]. Such issues require further prospective long-term studies.

Moreover, there have been oral reports on unusual abdominal metastases observed after laparoscopic cystectomy. These cases exclusively concern cystectomies associated with prostate apex preservation in view of performing optimal nerve-sparing laparoscopic cystectomy [22]. Indeed, beyond the specific risk of incidental prostate cancer [46], this technique also implies a wide opening of the bladder neck in the presence of possible residual tumor material in the bladder lumen. We strongly believe, as do others [11, 12], that the bladder should be removed remaining strictly closed and that the urinary pathway should be divided only after securing by clips or ligations. Moreover, with respect to the same risk of transitional cell spillage, the lack of tactile control and the risk of dysplasia of the upper tract or of the urethra make frozen sections of these organs mandatory.

Sticking also to the rules of classical radical cystectomy [47] implies performing the procedure through a strict transperitoneal approach, allowing for the removal of the peritoneal coverage of the bladder. This explains our choice of a systematic supraumbilical trocar on the midline for the lens as well as the relatively high position of the upper right trocar, at the horizontal level of the former one. This latter position allows the scissors held in the surgeon's right hand to perform a high, juxtaumbilical section of urachus and of umbilical ligaments. This maneuver allows the opening of the Retzius space, avoiding an excessively long way into the perivesical fat as well as useless maneuvers to improve the visibility on bladder limits. Tactical reasons related to the size of the specimen delay this anterior exposure until the moment where the posterior dissection is completely achieved, releasing the specimen from the prerectal space and dividing the upper pedicles and the ureters.

The same logical features of an antegrade procedure explain the stepwise progression, following the ureters from the crossing with the iliac vessels, performing an extended pelvic lymph node dissection and securing successively the superior, the inferior vesical arteries as well as the vesicoprostatic arteries in the male [11]. Attention should nevertheless be paid to avoid premature division of the pedicles adjacent to the seminal vesicles, in view of an optimal preservation of the neurovascular bundles. This dissection should be delayed until the anterior attachments of the bladder are released and the endopelvic fasciae are opened on each side of the prostate. Lifting the entire specimen towards the upper opposite side then allows the antegrade dissection of the neurovascular bundles with the appropriate tools. For the same reasons, the use of blind wide diathermy or of endoscopic staplers should be prohibited.

So far, it is illustrated here that even for the experienced surgeon, laparoscopic radical cystectomy with urinary diversion is a technically challenging procedure. We believe that this technique is here to stay yet easily reproducible and therefore also indicated for patients affected by clinically organ-confined invasive bladder cancer, as long as we continue to carefully respect the rules of oncologic surgery for TCC, it may become a standard of care even in the elderly.

Extracorporeal, Hand-assisted or Intracorporeal Creation of Urinary Diversion

There is no doubt that the actual reported operative techniques require further standardization. Some authors emphasize their completely intracorporeal procedure [9], whereas others focus on the advantages of a laparoscopically assisted or even hand-assisted technique [11, 35]. We feel that an entirely laparoscopic approach should only be performed if the retrieval of the specimen can be accomplished without an additional incision (i.e., transvaginally, transrectally) or if the urinary reservoir cannot be reconstructed via a mini-incision as in case of rectosigmoid pouch or of sigmoid neobladder.

With regard to the possibility of hand-assisted laparoscopic cystectomy, as stated by Moinzadeh et al. [12], we believe that the presence of the operator's hand may actually compromise exposure during pelvic surgery dealing with a large specimen in a reduced workspace. Moreover, skilled surgeons generally have an extensive experience with laparoscopic prostatectomy before starting cystectomy; it is therefore unlikely they will require hand assistance for an easier procedure.

In cases of the ileal conduit in male patients, the extended paraumbilical trocar incision can be used subsequently for the retrieval of the specimen, the formation of the ileal conduit, the ileoileal anastomosis, the creation of the ileostoma and the placement of the ureteral stents. Therefore any type of intracorporeal technique seems to represent an unnecessary prolongation of the operating time, without true benefit to the patient. Already laparoscopic radical nephrectomy and living donor nephrectomy have shown that a 5- to 8-cm mini-incision does not increase the access morbidity significantly. In case of urinary diversion, the combined technique leads to a significant reduction in the operating time.

Table 5. Laparoscopic urinary diversion – technical steps and options

Operative Step	Options	Comments
Transposition of ureter	None	Not for sigmoid-neobladder or neopouch
Creation of reservoir	Intracorporeally	Sigmoid neobladder
		Sigmoid pouch
		Ileal conduit in females
	Extracorporeally	Ileal conduit in males
	(laparoscopically assisted)	Ileal neobladder
Ileal pouch		
Ureteral anastomosis	Intracorporeally	Sigmoid neobladder
		Sigmoid pouch
		Ileal conduit
	Extracorporeally	Ileal neobladder
		Ileal pouch
Urethral anastomosis	Intracorporeally	All continent diversions

In cases of orthotopic bladder replacement, the advantages of the laparoscopic vesicourethral anastomosis are to be considered in terms of immediate watertightness to increase early continence and avoid any subsequent stenoses.

The various options available for urinary diversion are summarized in Table 5.

Involvement of Robotics in the Field of Laparoscopic Radical Cystectomy

Two groups recently reported their early experience with the use of Da Vinci telemanipulators in the field of laparoscopic radical cystectomy [48] followed by intracorporeal creation of an ileal bladder [49]. The role of the robotic arms was essentially limited to the nerve-sparing dissection during the ablative time and to the vesicourethral anastomosis, in cases of neobladders. This adds to the catalogue of urologic procedures already described with robotic assistance [50, 51]. Further functional results are still awaited to evaluate the true return of this investment in the fields of reduced operative times, improved erectile function and optimal neobladder.

Perspectives of Laparoscopic Radical Cystectomy

Radical cystectomy remains the gold standard for muscle-invasive bladder cancer and high-risk superficial tumors resistant to intravesical therapy, and a laparoscopic approach can reproduce open surgery. Operative times for these radical procedures, however, remain longer than those for open surgery. Blood loss is less and patients recover more quickly.

The learning curve of laparoscopic radical cystectomy may take several years to final perfection, as already realized with laparoscopic radical prostatectomy. One reason is the significantly lower incidence of the procedure.

The operating time obviously has to be reduced significantly to minimize the associated morbidity of the procedure. On the other hand, there are no principle technical obstacles and increasing experience may lead to a dramatic reduction of operating times in the near future. New trends in this field may concern the improvement of suturing devices or the availability of adsorbable staples to reduce the time devoted to building neobladders.

Furthermore, patients have to be followed carefully with respect to long-term functional and oncological results.

Laparoscopic cystoprostatectomy is a feasible, fast, safe and rather easy procedure, yet, at present, laparoscopic radical cystectomy is still an operation for pioneers, but in our opinion this procedure may be not strictly relegated to a few centers of expertise in the future. We are optimistic that laparoscopy is likely to play a viable role in the future management of muscle-invasive bladder cancer.

Patients treated with this technique benefit from all the advantages associated with laparoscopic surgery, which are not reduced by the external reconstruction of a urinary diversion performed through a mini-laparotomy.

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6.1 Laparoscopic Pelvic Lymph Node Dissection

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Contents

Introduction

Prostate cancer is one of the most common causes of cancer mortality in men [1, 2]. Only in cases of organ-confined disease will curative treatment strategies be possible. If pelvic lymph nodes metastases of prostate cancer are present, a radical treatment such as radical prostatectomy, internal or external radiotherapy will not influence the prognosis in a positive manner [3, 4]. With the advent of prostatic specific antigen (PSA) testing nowadays, most men with prostate carcinoma will have a low risk of pelvic lymph node involvement. Therefore, curative treatment strategies are routinely carried out without pelvic lymph node dissection. Although the risk of lymph node metastases can be estimated using a combination of serum PSA level, Gleason grade and clinical stage, 2%–30% of patients with presumed localized prostate cancer are still found to have lymph node metastasis [5, 6]. Improvements in detecting lymph node metastases for staging with all currently available imaging techniques, such as MRI, CT scan, ultrasonography and iliopelvic scintigraphy have so far been unsuccessful because of a low specificity and sensitivity [7–9]. These techniques are based on detecting enlarged lymph nodes, which results in a significant false-negative rate for lymph nodes that are not enlarged but do consist of metastases. Another possible approach is the combined use of CT and fine needle aspiration [10, 11]. It enhances the accuracy rate compared to imaging alone. Still, the practical role is limited to a select group of patients that are at very high risk for lymph node metastases.

Contrast-enhanced techniques in combination with MRI might improve the sensitivity because they can possibly detect metastatic deposition within the lymph nodes [12]. Laparoscopy for pelvic lymphadenectomy in prostate cancer was first described by Scheussler and associates [13]. So far, it has been proved that laparoscopic pelvic lymph node dissection (PLND) allows a more accurate staging in high-risk prostate cancer compared to MRI or CT [14].

Indications

Not all patients with a diagnosed prostate cancer will need a lymphadenectomy. Furthermore, improved detection of localized prostate cancer through the institution of screening protocols and early detection programs has decreased the number of patients presenting with lymph node involvement. Therefore, patients with a newly diagnosed prostate cancer have to be stratified into risk categories in order to estimate the risk of lymph node metastasis. Since 1992, several strategies have been developed in order to predict the change of lymph node metastases in prostatic carcino-

Table 1. Risk profiles for pelvic lymph node metastases in prostate cancer ()

Risk group (in %)	
Low (2%)	Gleason sum <7, and PSA <10, and clinical stage <T2c
Moderate (20%)	Gleason sum 7, or PSA 10, or clinical stage T2c
High (40%)	Gleason sum 7 and PSA 20 *or* Gleason sum 8 and PSA 10 *or* PSA 50

PSA in ng/ml

ma. In 1997, Partin et al. [5] published nomogram tables predicting pathological stage using clinical stage, Gleason score and PSA. This table was validated by Blute et al. in 2000 [15]. Also, other groups developed algorithms, nomograms and artificial networks. Although other factors such as the number of positive prostate biopsies and seminal vesical involvement at biopsy were introduced as independent predictors for risk of lymph node metastases, the Gleason score, PSA and clinical stage remain the best predictive factors [16–22]. All studies showed that patients can be stratified into risk groups. Patients with a serum PSA level of less than 10 ng/ml, a Gleason sum under 7 and clinical stage under T2c are defined as those who are at low risk for pelvic nodal metastatic involvement. For example, when in this group the prostate biopsy identifies a tumor with a Gleason grade of 4 or more, the risk for nodal metastases is less than 5% [22]. Based on PSA, the biopsy Gleason sum, and clinical stage, patients are stratified into low-, moderate- and high-risk groups (Table 1), with 2%, 20% and 40% risk for metastatic lymph nodes, respectively. The cutoff values for the risk factors are a serum PSA of 10 ng/ml, clinical stage T2c, and Gleason sum 7. This means that patients at low risk do not require a pelvic lymph node dissection. Those at moderate risk do need a lymphadenectomy prior to localized follow-up treatment such as brachytherapy and perineal radical prostatectomy. In this group, a lymph node dissection can be performed at the same session as open or laparoscopic radical prostatectomy. In patients who have a high risk for nodal metastatic involvement, the lymph node dissection should be performed in a separate operative session prior to definitive local therapy. Lymph node dissection is advised when men are considered for salvage therapy after biopsy-proven persistent or recurrent adenocarcinoma of the prostate.

Contraindications

In the field of urologic laparoscopic procedures, the pelvic lymphadenectomy is technically relatively less demanding, although for the less experienced laparoscopists it can still be more time-consuming than an open procedure [23].

Guazzoni et al. [24] showed that the accuracy of the laparoscopic dissection improved after the first 20 cases. In patients who underwent an open surgical revision of the dissection area at laparoscopic PLND, the number of lymph nodes left behind decreased as the laparoscopic experience increased.

For every procedure, we have to keep in mind that the main purpose is accurate staging of the prostatic carcinoma disease. Furthermore, the technique itself should be safe to perform and economically effective.

In general, the contraindications that apply for intraperitoneal laparoscopy will also be valid for the laparoscopic pelvic lymphadenectomy (Table 2). Absolute contraindications are a severe chronic pulmonary obstructive disease, a current peritonitis or intestinal obstruction, bleeding diatheses, infections of the abdominal wall, and suspected malignant ascites.

Table 2. Contraindications for laparoscopic pelvic lymph node dissection for staging in prostatic carcinoma

Absolute contraindications	Relative contraindications	Relative contraindications for extraperitoneal approach
■ Severe chronic pulmonary obstructive disease	■ Extensive prior abdominal surgery	■ Prior lower abdominal surgery
■ Current peritonitis	■ Organomegaly	■ Prior pelvic surgery
■ Intestinal obstruction	■ Pelvic fibrosis	■ Prior inguinal hernia surgical repair
■ Bleeding diatheses	■ Aneurysms of aorta or iliac arteries	
■ Infections of the abdominal wall	■ Ascites	
■ Malignant ascites	■ Morbid obesity	
	■ Severe hernia of diaphragm	

Relative contraindications are those conditions that can cause potential difficulties in performing a laparoscopic procedure. These cases will be more technically challenging and the risk for bleeding or causing damage to intra-abdominal organs will be increased. Morbid obesity is associated with a higher complication rate than in patients with a normal body habitus. Mendoza et al. [25] showed that the risk for one or more intraoperative or postoperative complications in morbidly obese patients is 30%. Extensive prior abdominal surgery, organomegaly, aneurysms of the aorta or iliac arteries and ascites will require close attention and a cautious approach in obtaining the pneumoperitoneum and placement of the trocars because of a higher risk of organ and vascular injury. It has been shown that peritoneal adhesions are most commonly caused by intraperitoneal or transperitoneal surgery [26]. Pelvic fibrosis due to previous pelvic surgery, radiation therapy or peritonitis can make it impossible to create the adjusted working space or to explore the target region of interest. Also, previous hip replacement surgery can cause a pelvic fibrosis and inflammation, especially of the obturator lymph node region, due to leakage of the sealant. A severe hernia of the diaphragm can give a possible leakage of CO_2 into the mediastinum and cause postoperative clinical complications. Obtaining access at sites of an existing hernia of the abdominal wall is not possible. This should be considered in preplanning of the port placement when laparoscopic surgery is intended.

Relative contraindications for the extraperitoneal approach are previous lower abdominal or extraperitoneal surgery or inguinal hernia surgery. In these cases it can be difficult to develop a working space. When attempting to create the working space, the peritoneal membrane will often tear. The possible leakage of carbon dioxide into the peritoneal cavity causes a collapse of the extraperitoneal working space and can make the dissection impossible.

Preoperative Preparation and Patient Positioning

A light meal is administered the evening prior to surgery. There is no strict need for prophylactic antibiotic medication or bowel preparation. Although some urologists prefer bowel enemas in case a difficult dissection is anticipated or a transperitoneal approach is used, or when the lymph node resection will precede

a

b

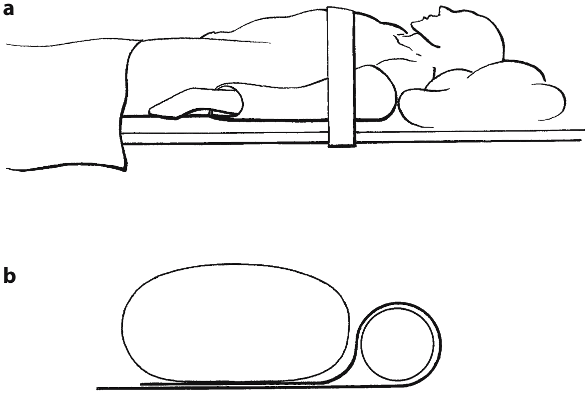


Fig. 1 a, b. Dorsal supine position of the patient with the arms padded and fixated alongside the body. **a** Lateral view and **b** transverse view at thoracic level

a laparoscopic radical prostatectomy. The use of one kind or a combination of antiembolic prophylactic preparations such as pneumatic stockings, elastic stockings or low-molecular-weight heparin drugs is advocated.

After general anesthesia is obtained, a transurethral Foley catheter is placed for bladder drainage, a nasogastric tube is placed in the stomach and the operative area is shaved. The patient is placed in the dorsal supine position. The arms are padded and fixated alongside the body with a blanket (Fig. 1 a, b). Special attention is needed for bolstering the intravenous catheters to prevent lacerations due to pressure. The surgeon will have more space to maneuver when the arms are tucked to the sides. The lower extremities will be spread at the hip joints with a 25°–30° angle, allowing free access to the perineum and rectum if needed. A sterile scrub is done from the xiphoid process to the pubis and from the left to right midaxillary line. Sterile drapes are placed. Furthermore, the video column with light-source and insufflator is placed between the legs (Fig. 2). At this position, the screen will be nearby and in a straight line with the surgeon's and the assistant's working position.

The operating surgeon stands at the contralateral side, whereas the assistant surgeon stands at the ipsilateral side of the lymph node dissection. The lower extremities are slightly bent to 15°–20° at the knee joints and are fixed with a knitted standard tubular 20-cm-wide bandage. This will prevent the patient from dislocation in the cranial direction when it is

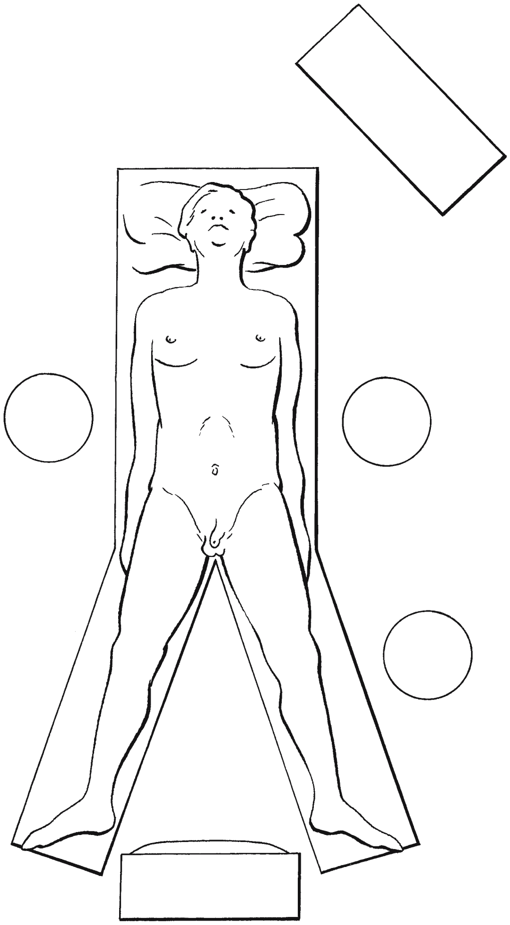


Fig. 2. Overview of position of the patient, surgeon, assistant surgeon, operating assistant and video column. The legs are spread 25°–30°

tilted towards a Trendelenburg position (Fig. 3). The angle of the Trendelenburg position (15°–25°) depends on the approach to the pelvis used: intraperitoneal or extraperitoneal. In order to prevent jeopardizing the vascularization, the fixating bandage should be not too tightly bound. A compartment syndrome can be caused due to excessive pressure in prolonged procedures. Some surgeons will also strap the chest to prevent the patient from sliding, when Trendelenburg or lateral rotation positioning is requested, and to avoid scapular pain related to pressure on shoulder rests [27].

Techniques

A laparoscopic pelvic lymph node dissection can be performed via a transperitoneal or extraperitoneal route. Both techniques can be used before a radical prostatectomy during the same operative session in those patients who have an indication for lymph node dissection. In this case, the position, number and size of the ports that are needed will be determined by what is needed to perform a laparoscopic radical prostatectomy. In cases where only a lymph node dissection is needed as a staging procedure, four ports in a diamond-shaped configuration are sufficient (Fig. 4a). Two trocars, the umbilical and one of the lateral ones, should be 10–12 mm in size. The umbilical port will be used for the camera, and the lateral port is used for specimen retrieval. The left and right lateral ports are at McBurney's point in the midclavicular line. The other two trocars are 5 mm in size. An additional fifth 5-mm trocar can be needed to create an optimal working space when there is a severe optical obstruction due to intra-abdominal obesity or a shift of the bowels towards the pelvis. This fifth trocar can be placed between the umbilical and lateral trocars. In case of extreme obesity, five trocars can also be placed in a U-shaped configuration at the start of the procedure (Fig. 4b).

Although the surgeon may have a favorite technique, there can be existing conditions or relative contraindications that favor obtaining a pneumoperitoneum with an open access instead of insertion with a

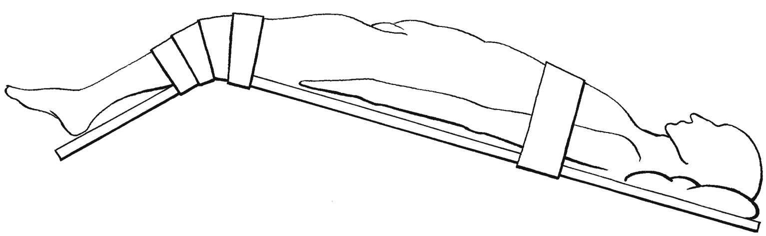


Fig. 3. Lateral view of operating table. Approximately 15°–25° Trendelenburg position and 15°–20° bending of the knees. Bandage strapping of knees and chest to avoid sliding

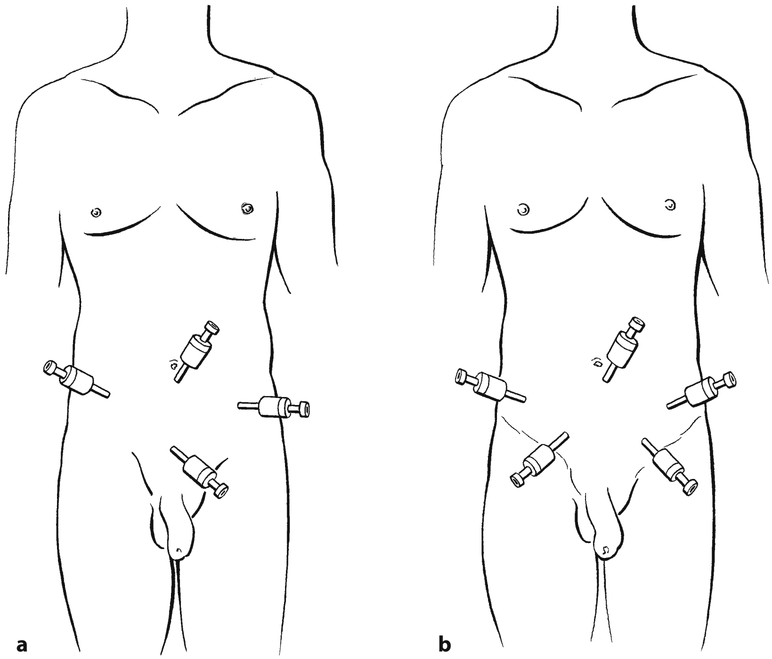


Fig. 4 a, b. Position of trocar placement. **a** Diamond-shaped configuration, and **b** U-shaped configuration in morbidly obese patients

Veress needle, and an extraperitoneal instead of an intraperitoneal approach towards the obturator lymph nodes. An open access is advocated in cases of organomegaly, ascites, and extensive prior abdominal or pelvic surgery. An extraperitoneal approach is recommended in conditions such as iliac or aortic aneurysms, extensive prior abdominal surgery, and diaphragmatic hernia (Table 3). Alternatively, in this last group of patients, the procedure can be initiated retroperitoneally and the peritoneum then entered [28].

Some laparoscopists believe that in patients with morbid obesity it can be helpful to increase the abdominal pressure above the level of 15 mmHg in order to create a better working space. McDougall et al. showed in a pig model that increasing the abdominal pressure increases the volume of CO_2 insufflated.

Table 3. Laparoscopic, open modified and mini-laparotomy technique for pelvic lymph node dissection for prostatic carcinoma. Comparative studies

	Technique	Number of patients	Average number of nodes dissected	Average operative time (min)	Average hospital stay (days)	Average convalescence (days)
Winfield et al. 1992 [34]	OPLND	26	24	124	6.5	17
	LPLND	89	9	154	1.5	7
Parra et al. 1992 [35]	OPLND	12	11	–	–	–
	LPLND	12	10.7	185	–	–
Kerbl et al. 1993 [36]	OPLND	16	–	102	5.3	42.9
	LPLND	30	–	199	1.7	4.9
Herrell et al. 1997 [41]	OPLND	38	9.2 (n27)	72	6.5	–
	LPLND	19	8.5 (n9)	168	2.7	–
	MPLND	11	8.8 (n5)	59	3.3	–

However, this additional volume did not significantly change the actual abdominal volume [29].

Once the pneumoperitoneum is established and the first trocar is placed at the umbilicus location, a 0° optical lens with camera is introduced. Subsequent trocar placement is accomplished under direct vision. Each entry site is inspected for unsuspected intra-abdominal injury.

Transperitoneal Laparoscopic Pelvic Lymph Node Dissection

Pneumoperitoneum is created by either inserting a Veress needle or the open Hasson laparoscopic approach at the inferior crease of the umbilicus. Carbon dioxide is insufflated to 15 mmHg pressure via the Veress needle or the 10- to 12-mm trocar sheath unit is inserted into the peritoneal cavity. Inspection of the intraperitoneal contents with a 10-mm, 0° laparoscope ensures absence of visceral injury. All three or four other working ports are introduced under direct vision. Once the ports are inserted, the patient is placed in a 15°–25° Trendelenburg position with approximately a 30° lateral rotation towards the surgeon, in order to raise the side of the operative target. This allows the bowel to gravitationally fall away from the planned lymphadenectomy field, centered over the iliac vessels and obturator fossa.

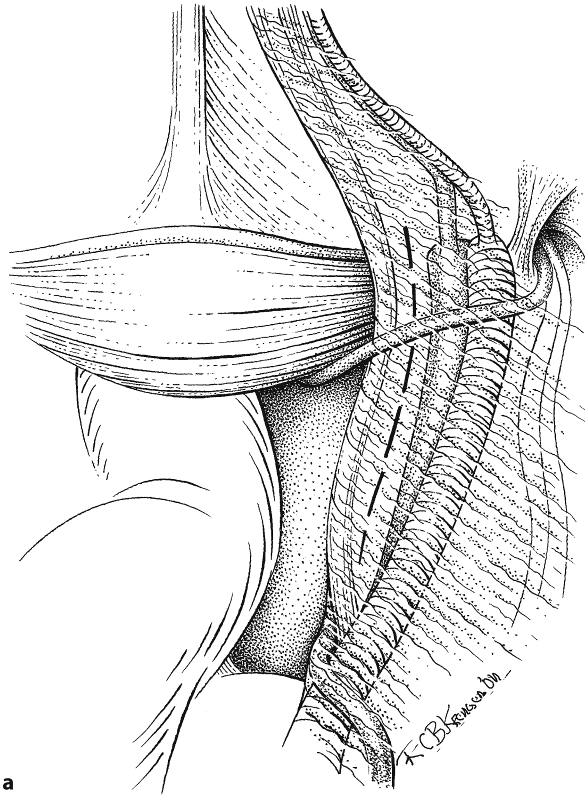
Extraperitoneal Laparoscopic Lymph Node Dissection

An infraumbilical midline or right paraumbilical incision is made and carried down to the rectus abdominis aponeurosis. The posterior rectus fascia is exposed after incising the anterior rectus fascia and blunt dissection in a vertical manner of the rectus muscle fibers. Stay sutures are placed in the rectus fascia. Along the posterior rectus sheath, the preperitoneal plane is digitally initiated towards the back of the pubic bone. A commercial or homemade balloon trocar is then inserted and inflated with approximately 1,000 ml saline or air. This is kept in place for 5 min in order to obtain hemostasis of small torn vessels. After deflating and removing the balloon, a blunt Hasson-type sheath is inserted and secured with the previously placed stay sutures. Carbon dioxide is insufflated up to 15 mmHg. All other ports will be introduced under laparoscopic vision (0°). After placing the first port cranial to the pubic bone in the midline, it can be necessary to continue the dissection in order to completely free the posterior aspect of the rectus muscle at both sides. The lateral ports should not traverse the peritoneal membrane because leakage of carbon dioxide into the peritoneal cavity will cause insufflation of the intraperitoneal space, and thus collapse of the extraperitoneal space. Small tears can be closed with a laparoscopic suture in an attempt to prevent leakage to the peritoneal cavity.

Modified Dissection and Anatomical Landmarks

It is important to identify the anatomical landmarks. In a transperitoneal approach, the pulsating external iliac artery can normally be easily identified. Sometimes they are covered with the overlying sigmoid colon at the left side, the cecum at the right side or the small intestine with associated adhesions. After mobilizing these organs, the iliac region must be visible. The external iliac vein is posterior to the external iliac artery. The vein is the lateral-anterior border of the dissection. The spermatic cord can sometimes be hard to recognize. It crosses in a medial direction from the inguinal ring toward the posterior side of the bladder. Traction at the ipsilateral testicle can help to identify the cord. Medial of the vessels is the umbilical ligament, which is in fact the obliterated umbilical artery. In order to access the lymph nodes, an incision with the scissors of the posterior peritoneal membrane must be made, beginning just lateral to the umbilical ligament and medial to the pulsating external iliac artery, at the level of the crossing vas deferens extending cranial toward the bifurcation of the common iliac artery (Fig. 5a). One must be cautious at the level of the bifurcation because at this level the ureter may cross the common iliac vessels.

When the vas deferens is lifted toward the pubic ramus, the dissection starts with gently pulling the fibroadipose tissue medially with a grasping forceps and a careful blunt dissection of the lymphatic and connective tissue off the external iliac vein. When developing this first part of the lateral plane, one can identify the muscle fibers of the pelvic floor. Small vessels and lymphatic channels close to the vein should be coagulated with a bipolar forceps or clipped and divided in order to prevent bleeding and postoperative lymphoceles. This is the lateral border of the dissection. Often in this area, near the pubic bone, a circumflex vein runs into to the external iliac vein. If



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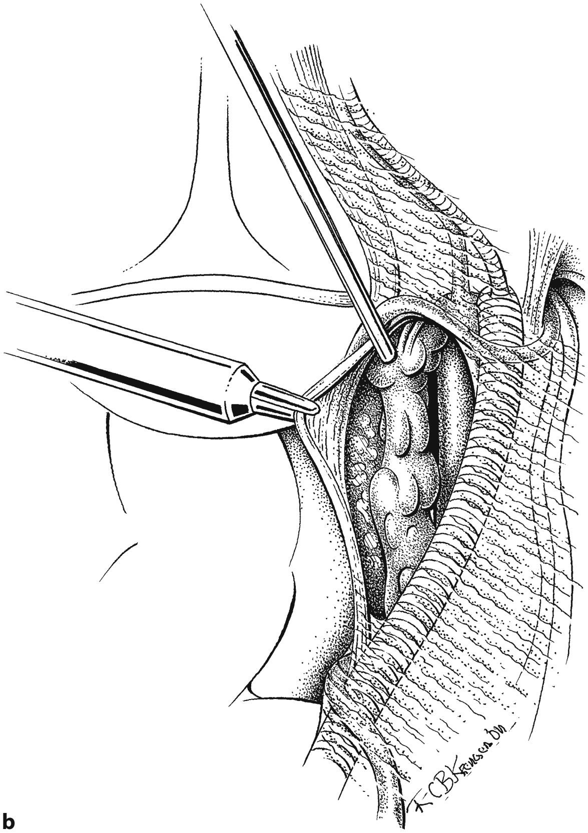

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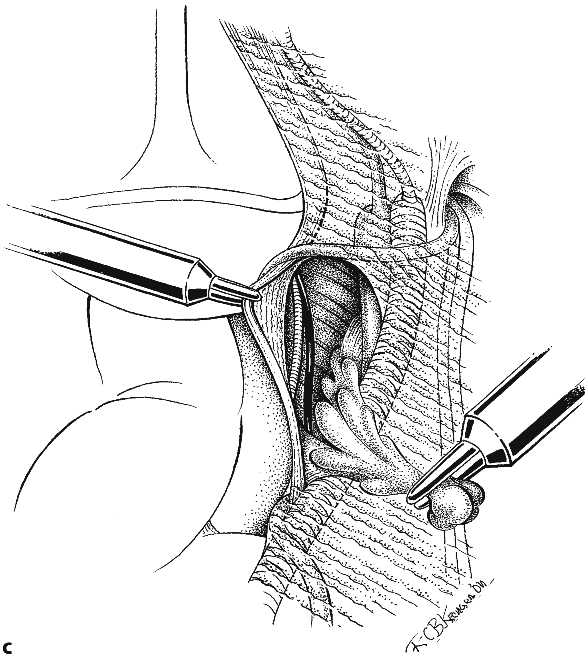

c

Fig. 5 a–c. Landmarks in laparoscopic transperitoneal pelvic lymph node dissection. **a** incision of the posterior peritoneum, **b** Start of the dissection with the node of Cloquet, and **c** developing the plane of the lymph node dissection in cephalad direction toward the iliac bifurcation necessary, it can be clipped and divided without any harm. This plane will be followed caudally to the junction with the pubic bone where the lymph node of Cloquet is situated (Fig. 5b). This node must be included in the dissection and is the inferior border of the package. With the assistant retracting the nodal tissue to the lateral side, the medial border of the lymph node package can be developed by blunt dissection between the medial umbilical ligament and the nodal tissue. The obturator nerve and associated artery and vein are often identified at this point in the dissection and must be carefully protected. The use of monopolar coagulation should be avoided until the obturator nerve has been identified. After the medial, lateral and caudal aspects of the obturator lymph node tissue have been defined, the nodal tissue can be retracted cephalad. This provides a clear view at the obturator nerve (Fig. 5c). Reaching the superior border of the package at the common iliac bifurcation, the remaining connective tissue is thinned and divided after clipping or bipolar coagulation.

The landmarks in an extraperitoneal approach are similar as for the transperitoneal approach, except that the region of interest is now not covered with the posterior peritoneal membrane and thus lymph node dissection proceeds directly onto the iliac vessels, which are often already exposed. The vas deferens is pushed cephalad with the peritoneal membrane and thus will not be identified as a structure running form the inguinal ring toward the medial side.

Closure

After the nodal tissue of the last side is removed under direct vision through the 10- to 12-mm lateral port, the intra-abdominal pressure is decreased to 5 mmHg and the left and right iliac areas are inspected carefully for adequate hemostasis. If this is the case, all ports can than be removed under direct vision in order to check for significant bleeding of the abdominal wall. After complete desufflation of the abdomen, the fascia of the 10- to 12-mm sites is closed with Vicryl sutures. The skin is intracutaneously closed at all sites with soluble sutures.

Extended Dissection

The extent of the lymphadenectomy can vary from limited dissection of only the obturator fossa to an extensive dissection, including external iliac nodes, hypogastric nodes and presacral nodes. Most urologists will perform a modified lymph node dissection, as is described earlier (external vein laterally, the obturator nerve and hypogastric artery posteriorly, the node of Cloquet distally, and the bifurcation of the iliac vein proximally). Debate continues on the extent of lymphadenectomy that is required for appropriate staging of the prostate cancer. The standard template also includes the common iliac and external iliac regions. Unfortunately, there is a price to be paid for this standard approach. The complication rate of the standard template is significantly higher. Comparing the two templates in a laparoscopic approach, Stone and associates [30] reported a 36% complication rate using the standard template vs 2% with the modified template. The standard template yields a higher number of nodes and a higher incidence of metastases, 23% vs 7%, respectively. The authors concluded that this was due to a higher risk profile rather than to the more extensive dissection. When the risk groups are similar, as in the study of Heidenreich et al. [31], they also find a higher rate of lymph node metastases. Clark and associates [32] randomized to an extended node dissection on the right vs the left side of the pelvis with the other side being a limited dissection in 129 patients undergoing a radical prostatectomy. The majority of their patients were at low risk for lymph node metastases. They concluded that at extended lymph node dissection, they not only did find more evidence of metastatic spread of prostate cancer, but this also led to unacceptably higher levels of complications attributable to the extent of the dissection. The incidence of histologically detected lymph node metastases depends not only on the number of lymph nodes removed, but also on how the specimen is examined. Extensive histopathological techniques such as step sectioning and immunohistochemical staining have a considerable influence on the lymph node status in prostate cancer, according to Wawroschek et al. [33].

Laparoscopic Versus Open Pelvic Lymph Node Dissection

Open and laparoscopic pelvic lymph node dissection can be compared on several points such as operation time, intraoperative blood loss, economic advantage, complications and morbidity, and the number of nodes dissected. So far, several comparative studies have been carried out [34–36, 41] (Table 3). The largest series is from Winfield et al. [34], describing 89 patients with the laparoscopic and 26 patients with the open technique. They found that the intraoperative blood loss, postoperative narcotic use, length of hospitalization and convalescence all favored the patients who underwent a laparoscopic procedure. On the other hand, the number of lymph nodes was higher in the open procedure; although this difference was not significant (laparoscopic 9 vs open 11 nodes). Parra et al. [35] described 24 consecutive men, who were electively scheduled for radical retropubic prostatectomy, to undergo either an open or a laparoscopic pelvic lymph node dissection. The number of lymph nodes obtained in both groups was comparable to the numbers found by Winfield et al. The number of nodes found at the left (mean, 5.9 ± 3.6) and right (mean, 5.5 ± 3.2) side were similar. There was no comparison made in hospitalization, narcotic use and intraoperative blood loss. In the nine patients who underwent radical prostatectomy after laparoscopic dissection, no additional lymph nodes could be obtained from the surgical margins of the obturator fossa.

Guazzoni et al. [24] performed an open surgical revision of their first 30 patients who underwent a laparoscopic dissection. They also did not find a difference in the number of nodes resected at the left and right side. After eight cases, and gaining confidence, they extended the area of dissection from the obturator fossa to the iliac lymph nodes. The number of nodes they found was on average 10.9 (range, 0–19) in the first 15 procedures and 18.7 (range, 11–25) in the last 15 procedures. The number of nodes left behind after the laparoscopic dissection and found at the open revision was 9.7 (range, 0–25) in the first and 1.2 (range, 0–2) in the second group. Kerbl et al. [36] retrospectively studied their initial 40 laparoscopic lymph node dissections and compared them to 16 open procedures carried out between 1990 and 1992. Ten patients underwent a radical prostatectomy in the same session and were excluded from the study. The number of nodes that were retrieved is not described. The average operation time was significantly longer in the laparoscopic group (199 vs 102 min). Blood loss, narcotic use and convalescence was significantly better in the laparoscopic group, indicating that the laparoscopic procedure seems to be minimally invasive in terms of postoperative pain awareness and quality of life.

A way of minimizing the hospital stay and convalescence period, in an open approach toward the obturator lymph nodes, is the minimally invasive extraperitoneal lymphadenectomy through small bilateral incisions using a customized retractor blade or a specially designed retractor, the pelvioscope [37, 38]. Mohler and associates showed that outpatient surgery with this technique is feasible. Guy et al. described a large series of 192 patients who underwent a unilateral or bilateral lymph node dissection. With an average operative time of 109 min for a bilateral procedure, they showed that they were able to retrieve a mean number of 5.6 lymph nodes form each side. Also a midline incision of 6 cm appears to be a safe alternative with similar outcomes as the bilateral procedures [39]. Brant et al. [40] evaluated two separate series of bilateral inguinal minilaparotomy and laparoscopic pelvic lymphadenectomy. They found that there was an equivalent staging effectiveness.

There is one study, by Herrell and associates [41], that compared three surgical techniques: laparoscopic intraperitoneal (19 patients), minilaparotomy (11 patients) and standard open modified pelvic lymph node dissection (38 patients). There was no statistically significant difference in terms of the number of nodes harvested with each technique. The laparoscopic procedure revealed a significantly prolonged operative time compared to the open techniques. The total hospital stay was significantly longer for the modified open dissection (6.5 ± 0.9 days) compared to the laparoscopic (2.7 ± 1.1 days) and minilaparotomy (3.3 ± 0.2 days) groups.

Several investigators have attempted to make cost comparisons between laparoscopic and open pelvic lymph node dissections for staging in prostatic cancer [35, 36, 40, 42–44]. Objectively comparing costs is inherently difficult for a number of reasons such as marked differences in health care systems and delivery between medical systems in different countries. Troxel et al. [42] showed that the preoperative costs may not differ that much. Intraoperative expenses were 52% greater for laparoscopic procedures compared to an open dissection. This was due to the longer operative times and the use of disposable instrumentation. The overall postoperative costs following open pelvic lymphadenectomy were 280% more expensive than for the laparoscopic procedure because of the longer hospitalization period and analgesic requirements.

We have to keep in perspective that the surgical experience of pelvic lymphadenectomy, operative techniques and surgical equipment has improved over the years. Even so, the costs have changed. The aforementioned comparative studies were all conducted in the earlier days of urologic laparoscopic surgery. Therefore, they are not completely representative for today, after many improvements have been made in favor of both techniques.

Results

The result of laparoscopic pelvic lymphadenectomy depends on the way patients are selected. The best predictors are Gleason sum, serum PSA level and clinical stage. If there is more than one of these the likelihood for positive lymph nodes increases. When more patients at risk are operated on, the probability for positive lymph nodes increases. Table 4 summarizes the influence of Gleason sum, PSA, and clinical stage on lymph node involvement of prostate cancer in men who underwent a laparoscopic pelvic lymph node dissection. The study of Stone and associates [18] also shows the influence of seminal vesicle involvement at the outcome.

Complications

It is common knowledge that open pelvic lymphadenectomy is not devoid of complications. In a review of literature, McDowell et al. [46] found a 29% incidence of peri- and postoperative complications such as hematoma, ileus, urinary retention, deep vein thrombosis, pulmonary embolism, and wound infection. The most common complications specifically related to the laparoscopic pelvic procedure are vascular injury, bowel injury, ureter injury, lymphedema and lymphoceles.

A 16.6% overall complication rate was found in 96 cases of laparoscopic pelvic lymphadenectomy in a study by Parra et al. [47]. We have to take into account that these procedures took place in the early days of laparoscopic pelvic lymphadenectomy and that the templates will not always be similar. Two later studies, one single center [48] and one multicenter [49], in 177 and 130 patients who underwent a laparoscopic pelvic lymph node dissection, showed an over-

Table 4. Results of laparoscopic pelvic lymph node dissection (modified template). Gleason sum, PSA (ng/ml), clinical stage, and seminal vesical biopsies in relation with the lymph nodal involvement status

		Number of patients	Number of patients with lymph node + (%)	Number of patients with lymph node –
Hoenig et al. 1997 [19]	PSA ≤20	75	10 (13%)	65
	PSA >20	45	24 (53%)	21
	Gleason <7	59	4 (7%)	55
	Gleason ≥7	61	25 (41%)	36
Rutskalis et al. 1994 [45]	PSA ≤20	40	0 (0%)	40
	PSA >20	54	19 (35%)	35
	Gleason <7	48	6 (12%)	42
	Gleason ≥7	46	13 (28%)	33
	PSA >20 and Gleason ≥7	27	13 (48%)	14
Stone et al. 1998 [18]	PSA ≤10	53	3 (6%)	0
	PSA >10; ≤20	35	1 (3%)	34
	PSA >20	42	10 (24%)	32
	Gleason <7	89	1 (1%)	88
	Gleason ≥7	41	13 (32%)	28
	T1 b+c	16	0 (0%)	16
	T 2a	28	0 (0%)	28
	T 2b	69	10 (15%)	59
	T2c	17	4 (24%)	13
	Seminal vesical biopsy positive	23	11 (48%)	12
	Seminal vesical biopsy negative	107	3 (3%)	104

all complication rate of 5.5% and 12%, respectively. The complications after laparoscopic pelvic lymphadenectomy are markedly decreased with experience. Lang and associates [50] compared their first 50 and second 50 laparoscopic pelvic lymphadenectomy procedures. There was a 14% complication rate in the first group, compared with only 4% in the second group. Complications reported after LPLND vary from 0% to 33% (Table 5), taking into account that different templates were used and studies were performed at different stages in the laparoscopic learning curve. Also, morbid obesity will contribute to increasing the risk of complications to 30% in laparoscopic procedures [25].

The most frequently reported complication after lymph node dissection is lymphoceles. The reported incidence of clinically detected lymphoceles after open pelvic lymph node dissection ranges from 8.4% to 14.8% [58, 59]. Solberg and associates [60] reported in their study that the frequencies of pelvic lymphocele formation after laparoscopic and open pelvic lymphadenectomy in patients with prostate cancer were 61% and 37%, respectively. These lymphoceles were detected with CT scan 1 month after the procedure. Prophylactic anticoagulation was not consistently used in the laparoscopic group and may have contributed to the difference in the total number of lymphoceles in both groups. In a randomized prospective study of low-dose heparin as a thromboembolic prophylaxis in patients undergoing open PLND for staging in prostate carcinoma, Tomic et al. [61] found significantly less lymph leakage and fewer lymphoceles postoperatively in the patients who did not receive heparin. Nevertheless, at the study of Solberg et al., all clinically significant lymphoceles were in the open group with an overall incidence of 2.3%. Several studies showed that the incidence of lymphoceles depends substantially on the extent of the dissection [30, 50]. Tumor seeding in laparoscopic staging lymphadenectomy for prostate cancer is not likely. Rassweiler and associates [62] reported no local recurrences and port site metastasis in 478 cases where they performed piecemeal or intact specimen retrieval using a reduction sheath, extraction bag or laparoscopic sac. To our knowledge, only one port site recurrence has been reported (Bangma et al.) [63].

The series summarized in Table 6 suggest a low complication rate in the case when an extraperitoneal technique is used. This risk for complications in the extraperitoneal approach can be different from those in the transperitoneal technique. Persson and Haggman [69] compared transperitoneal ($n=11$) and extraperitoneal ($n=11$) LPLND in a randomized study. They found that, although the operative time was shorter in the extraperitoneal group, there was no difference with regard to the length of hospitalization. They also reported that the complication rate was higher in the extraperitoneal group, including two conversions to open surgery because of subcutaneous emphysema that interfered with the procedure and the development to lymphoceles. Raboy and associates [68] report a 6.4% conversion rate to either laparo-

Table 5. Complications in transperitoneal laparoscopic pelvic lymph node dissection

	Number of patients	Average number of lymph nodes dissected	Operative time (min)	No complications (%)	No conversions (%)
Winfield et al. 1992 [34]	66	9.6	150	17 (26%	11 (16%)
Scheussler et al. 1993 [51]	86	45.3	150	28 (33%)	–
Kerbl et al. 1993 [35]	30	–	200	6 (20%)	0 (0%)
Kavoussi et al. 1993 [52]	372	–	–	55 (15%)	13 (3.5%)
Parra et al. 1994 [36]	96	–	–	16 (16.6%)	–
Rutskalis et al. 1994 [45]	103	8.9	153	14 (14%)	10 (10%)
Guazzoni et al. 1994 [24]	30	14.8	–	7 (23%)	0 (0%)
Doublet et al. 1994 [53]	29	8.4	90	6 (21%)	3 (10%)
Lang et al. 1994 [50]	100	9.3	138	9 (9%)	0 (0%)
Klän et al. 1995 [54]	70	13.6	136	11 (16%)	2 (3%)
Brant [40] 1996	60	10	120	2 (3%)	2 (3%)
St Lezin et al. 1997 [55]	22	–	175	7 (32%)	1 (5%)
Kava et al. 1998 [56]	24	10.8	174	3 (13%)	0 (0%)
Stone and Stock 1999 [57]	189	9	75	17 (9%)	0 (0%)

Table 6. Complications in extraperitoneal pelvic lymph node dissection

	Number of patients	Average number of lymph nodes dissected	Operative time (min)	No complications (%)	No conversions (%)
Shafik 1992 [64]	9	19.6	106	0	0
Villers et al. 1993 [65]	18	–	84	1	0
Etwaru et al. 1994 [66]	12	7	130	2	0
Das 1996 [67]	36	12.2	50–100	2	3
Raboy et al. 1997 [68]	125	10.2	104	3.2	6.4

scopic (4%) or open lymphadenectomy (2.4%). In addition, the risk of postoperative lymphoceles may be higher in the extraperitoneal approach because a peritoneal window is not created, as is the case by the intraperitoneal approach.

Some have suggested that carbon dioxide absorption during the extraperitoneal approach may be higher than that with intraperitoneal surgery [70]. In such circumstances the risk for hypercarbia is increased.

Controversies

Taking into consideration that the PLND is only used as a staging procedure for prostate cancer, one might question whether the burden of cure is somewhat high. Although we define certain groups at risk and limit the dissection to only those at intermediate and high risk, we still find no more than 10% lymph node metastases. On the other hand, in cases of minimal lymph nodal metastatic disease, some patients may benefit from the dissection. Han et al. [71] showed that occasionally these patients have no PSA recurrence during a follow-up of 10 years. This is confirmed by Bader et al. [72], who found 25% positive lymph nodes in patients with clinically confined prostate cancer when performing a meticulous extended lymph node dissection. This all implies that some patients with minimal lymph node involvement might benefit from lymph node dissection in combination with a curative treatment for the prostate. A long-term prospective trial is needed to prove a survival benefit for men undergoing an extended lymphadenectomy approach. There is also some data now that suggest that adjuvant hormonal therapy in these patients may be beneficial.

Messing et al. [73] reported a survival advantage for immediate vs delayed hormonal treatment in a prospective study in men with node-positive prostate cancer after radical prostatectomy. Before definitive surgical curative treatment for patients with an intermediate risk for lymph node metastases, a lymph node dissection with frozen section examination in the same session is advocated. The incidence of false-negative results at frozen section is 6%–18% [74, 75]. Microscopic node disease will particularly be missed. Together with the fact that positive lymph nodes also exist outside the extent of a modified lymph node dissection, one can question whether there is any need for frozen section in men with intermediate risk for nodal metastatic involvement. The indications for lymph node dissection in intermediate-risk patients before performing radical surgical treatment in the same session remains controversial. Selection of men at low, intermediate and high risk needs improvement and needs to be more accurate. For example, clinical staging is based on the Gleason sum obtained through prostate biopsies. Under- and overestimation of the pathological outcome does frequently occur. Also, the dissection field that is approached needs to be better defined. This should be based on an improved anatomical understanding of the lymphatic drainage of the prostate and a better method for detecting lymph nodes that obtain micro- and macroscopic metastatic disease.

An investment in time and training is required in order to overcome the learning curve of laparoscopy. Furthermore, the use of disposable materials makes the procedure costly. Troxel and Winfield [42] found that the overall costs in laparoscopic lymphadenectomy were approximately $ 1,250 higher compared to open pelvic lymph node dissection. They stated that the wages that are earned in the period during the difference in return to normal activity between open and laparoscopic surgery would justify the cost. Now that laparoscopy has gained much more popularity, the relative cost will go down. Moreover, with experience the operation time will decrease. To put this subject in the right perspective of time, a new prospective comparative study on the overall cost with a special attention given to materials, operation time and the return to normal activities and work during follow-up is needed.

Ultimately, for each patient the balance between costs and quality of life on the one hand, and survival on the other hand must be found.

Current Limitations of Laparoscopic Management

The accuracy and safety of the laparoscopic procedure is comparable to that of the open technique. There are also no technical limitations according to the extension of the dissection. Laparoscopic pelvic lymph node dissection has now become a standard procedure. A prospective comparison between transperitoneal and extraperitoneal approaches has been performed by Persson and Haggman [69]. In this study, 11 men were included in both arms. A new and larger study may show whether the differences they found with respect to complications and operative time still exist in this decade. Moreover, it will be interesting to know if there are any obvious advantages to one of the techniques.

Future Horizons

The future will be determined if staging of prostate cancer with the aid of pelvic lymph node resection is accurate enough and furthermore, if the outcome is in balance with the burden of cure, while taking into account that nodal metastases outside the obturator region occur. Bader and associates [76] found that, in 365 patients with a median serum PSA of 11.9 ng/ml, 88 patients (24%) had positive lymph nodes at extended pelvic lymph node dissection for staging in prostate cancer. More than 50% had positive nodes outside the obturator region. In 17 patients (19%), the only positive nodes were found in the internal iliac region. In order to limit our resection, and thus decrease the risk of complications such as lymphoceles, a sensitive and detailed mapping of pathological lymph nodes is needed. Therefore, detection of the lymph node metastases with a sentinel node technique [77, 78] or with contrast-enhanced MRI [12] can make a targeted selective laparoscopic lymph node dissection possible. In the future, the pelvic lymph node dissections that will be performed before surgical radical prostate treatment in the same session will depend on how the technique that is used for the entire procedure and thus will be dependent on the future developments in that area [79].

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6.2 Extraperitoneal Laparoscopic Radical Prostatectomy: The Brussels Technique

Renaud Bollens, Sarb Sandhu, Thierry Roumeguere, Claude Schulman

Contents

Introduction

Laparoscopic radical prostatectomy is now an accepted minimally invasive treatment for localised prostate cancer [1–4]. Access to the prostate gland can be obtained by two distinct techniques. Initially our French colleagues, led by the Montsouris group, advocated a transperitoneal approach. This technique is based on the primary incision of the peritoneum above the rectovesical cul-de-sac followed by dissection of the seminal vesicles [6–10]. However, this approach does not adhere to the basic laparoscopic tenet of replicating the open operation. Therefore, we developed an alternative, purely extraperitoneal approach. This technique is being adopted by an increasing number of centres [11–13]. We have now performed in excess of 250 extraperitoneal radical prostatectomies (Table 1) and in this chapter we will describe our technique in a step-by-step manner, including any modifications that we have made since our initial series was published [4].

Patient Positioning

It is important to ensure that the operating table is positioned correctly for this procedure. The foot of the table should be at the level of the patient's pelvis. This allows the upper body to descend for a Trendelenburg position. The patient is placed supine with the legs abducted, allowing the laparoscopy column to be placed between the legs of the patient and thus be nearer to the surgeons.

All pressure points are protected and the patient is secured. The patient is prepped and draped and catheterised.

Trocar Placement

The initial incision is made infraumbilically to the right of the midline. The rectus abdominalis muscle's anterior aponeurosis is incised on the right of the linea alba. The muscular fibres are cleared to the right and the posterior aponeurosis is identified. To minimise perioperative CO_2 leakage, a purse string suture is placed on the anterior aponeurosis and the lens, with a 10-mm trocar, is advanced along the posterior

Table 1. Demographics ($n=250$ patients) and oncologic results

Mean age (years)	62 (48–70)
Mean PSA	7.6 (2.2–12.4)
Mean Gleason score	6 (4–8)
pT2a	12%
pT2b	45%
pT3	43%
N0	30
N1	3
NX	167
Positive margins in pT2	9.6%

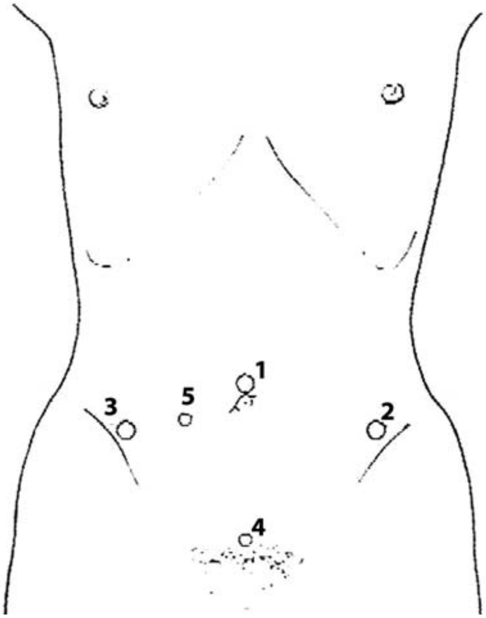

Fig. 1. Placement of trocar. *1* First 10-mm trocar with laparoscopic rod lens. *2* 10-mm port as working instrument. *3* 10-mm port as suction. *4* 5-mm port as palpator. *5* 5-mm port as working instrument

aponeurosis towards the semicircular arch of Douglas (no. 1, Fig. 1). The CO_2 pressure is set at 12 mmHg on high flow. The tip of the lens is used to develop the space of Retzius. Care is taken to avoid damaging the epigastric vessels (Figs. 1, 2).

A second 5-mm port (no. 4, Fig. 1) is inserted 2 cm above the pubic bone to the left of the midline; this minimises the degree of conflict between the infraumbilical lens and any instrument placed in the suprapubic port. The bipolar forceps are placed in the suprapubic port and along with the lens are used to develop the space lateral to the right epigastric vessel between the peritoneum, the transversalis fascia and the inguinal ligament – the space of Bogros. This dissection is carried out under direct vision with the instruments advancing in the direction of the right anterior superior iliac crest. The bipolar forceps are used to elevate the epigastric vessels while the lens is used to mobilise the loosely adherent peritoneal reflection off the deep inguinal ring. If the peritoneum is perforated it can act as a flap valve trapping the CO_2, which increases intraperitoneal CO_2 pressure and thus reduces the extraperitoneal space. If this occurs, the peritoneal perforation should be extended and this will allow equilibration in the pressure of CO_2, and thus improve the volume of the working space.

Having developed the right Bogros space, the bipolar forceps are used to lift the epigastric vessels with their tips pushing on the abdominal wall, identifying the site of the insertion of lateral 10-mm trocar, i.e. two centimetres medial to the anterior superior iliac spine. The skin is incised from the tip of the bipolar forceps laterally. The trocar is placed in the incision and by pushing down on the muscle and not the skin, the port is introduced (no. 3, Fig. 1). The direction of the trocar is inferior but parallel to the bipolar forceps; this further protects the epigastric vessels.

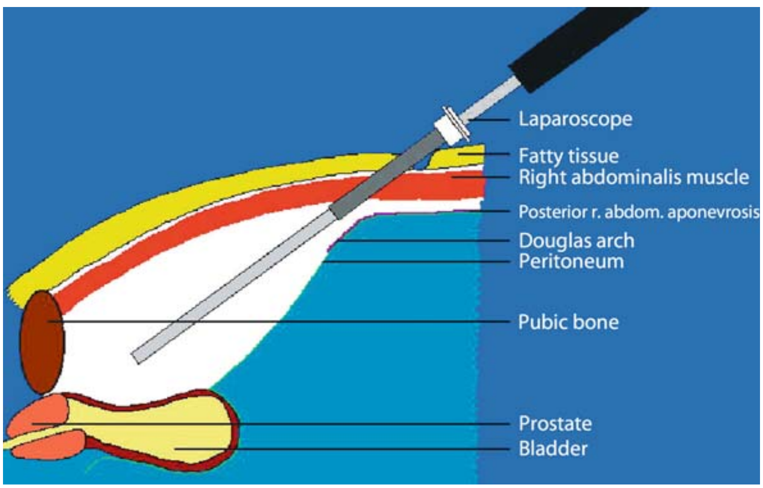

Fig. 2. Creation of the extraperitoneal space. The first trocar with the laparoscope is inserted 1 cm from the mid-line on the right side at the umbilical level and the space is developed under continuous optical control to avoid injury to the peritoneum or blood vessels

To develop the left Bogros space, the monopolar diathermy scissors are placed in the right lateral port to aid the bipolar forceps. The technique for developing the left Bogros space and placing the left lateral 10-mm trocar is as for the right side (no. 2, Fig. 1).

The last 5-mm port is inserted into the right rectus muscle (no. 5, Fig. 1). Particular care must be taken to identify and protect the right epigastric vessels. The lens being on the right of the linea alba allows this to be carried out under direct visual control.

Surgeons' Position

The surgeon stands on the left of the patient facing the caudal monitor and uses the left lateral port and the right 5-mm port. The assistant stands on the right of the patient also facing the monitor and uses the infraumbilical port to control the lens and the right lateral port for suction. In order to minimise the potential for conflict between the surgeon's right arm and the assistant's left arm, the surgeon stands on a platform. This allows the surgeon and the assistant to work in different horizontal planes. A second assistant can retract the bladder with the suprapubic port if required and is responsible for the urethral bougie, which can aid in the dissection of the prostate.

Retzius Space Development

Prior to dissecting the prostate, any residual peritoneal attachments are mobilised; this further improves the working space. The periprostatic fat is removed from the anterior aspect of the prostate and the superficial dorsal vein is diathermied with the bipolar forceps. The limit of the periprostatic fat helps identify the bladder neck.

Bladder Neck Dissection

In the past we started our dissection at the apex of the prostate but if bleeding occurs at this stage and is not adequately controlled, the blood can pool in the dependent areas and thus compromise the later dissection of the seminal vesicles. Therefore, we now start our dissection at the bladder neck. Fibres from the puboprostatic ligament run towards the bladder. The bladder neck is identified as the point where these fibres decussate. If further confirmation is required intermittent traction can be applied to the catheter balloon.

To facilitate the urethrovesical anastomosis, preservation of the bladder neck is attempted. Applying traction to the bladder cranially with counter-caudal traction to the prostate and monopolar diathermy allows the plane between the prostate and the bladder neck to develop. Bipolar diathermy is used to cauterise any bleeding. If the bladder neck cannot be preserved, i.e. previous TURP, the presence of a median lobe, or difficult planes, then the bladder neck is reconstructed.

The urethra is identified and its anterior plate is divided. The catheter is then removed and replaced with a metal bougie. By elevating the bougie, the posterior urethral plate and bladder neck is identified. The posterior dissection is started laterally and progresses medially. This minimises the opportunity for the development of false planes. In our experience, this method allows rapid dissection combined with preservation of the bladder neck.

Once the bladder neck is dissected, the vertical fibres of the fascia covering the vas deferens and seminal vesicles are visualised. Mobilising the bladder off the vas and the seminal vesicles further develops this plane. If necessary a probe can be inserted via the suprapubic port to aid in retraction of the bladder.

Seminal Vesicles and Vas Deferens Dissection

The fascia covering the vas and seminal vesicles is incised 1 cm from the prostate. This fascia merges with the peritoneum, and one can inadvertently incise the peritoneum if one drifts too far cranially. Once the vas deferens is identified, it is mobilised off the prostate and divided. It is important not to dissect the vas from its lateral seminal vesicles. A good length of vas allows one to apply traction, which in turn aids in the liberation of the seminal vesicles.

There are three vascular pedicles, the first is identified anteriorly between the vas and the seminal vesicle, the second and most significant is at the apex of the seminal vesicle, and the third is on the posterior aspect of the vesicles. All three have to be identified and cauterised with bipolar diathermy. By applying continuous traction to the vas deferens, the attached seminal vesicle is elevated. The apical pedicle defines the limit of the seminal vesicle. Once this has been divided, the vesicle is completely free anteriorly, the posterior dissection is relatively straightforward and uses the same technique of traction and counter-traction coupled with judicious diathermy.

Ligation of Santorini's Complex and Preservation of the Accessory Sphincteric Nerve

The endopelvic fascia between the prostate and the pelvic sidewall is now incised bilaterally. The adherent muscle fibres of the levatori ani are cleared off the surface of the prostate. Between the prostate and the levator ani muscle, a small accessory nerve to the urethral sphincter is often identified; this should be preserved (Fig. 3). The risk of injury to this nerve is increased when the neurovascular bundles are being sacrificed. To improve the mobilisation of the apex, the puboprostatic ligament is incised with cold scissors. The dorsal vein complex is now readily visible, and is ligated with 0 Vicryl.

Neurovascular Bundles Dissection

The neurovascular bundles are adherent to the posterior aspect of Denonvilliers fascia, therefore we develop the anatomical plane between the prostate and the fascia by separating the prostate from Denonvilliers fascia and preserve the bundles with no traction. The seminal vesicles and the vas are elevated, and this defines the plane to be dissected. The plane is developed laterally between the prostate and the neurovascular bundle and during this process, the main vascular pedicle is identified. Blunt dissection is used to go around the pedicle, and a 0 Vicryl tie is used to control the pedicle. The same technique is performed bilaterally (Figs. 4, 5).

The pedicles are divided using cold scissors and the bundles are freed from the prostate. To avoid thermal injury to the neurovascular bundles, monopolar cautery is never used during this stage of the operation, and only bipolar forceps are used to limit the venous back bleeding from the prostate.

Apical Dissection

The remaining attachments of the prostate are the apical urethra and Santorini's complex. The deep dorsal veins along with the periurethral tissue are now divided. This allows the urethra to be clearly identified, the anterior aspect of this is now divided. The posterolateral neurovascular bundles are now identified and mobilised off the urethra. Once this has been achieved, the posterior urethral plate is divided (Fig. 6).

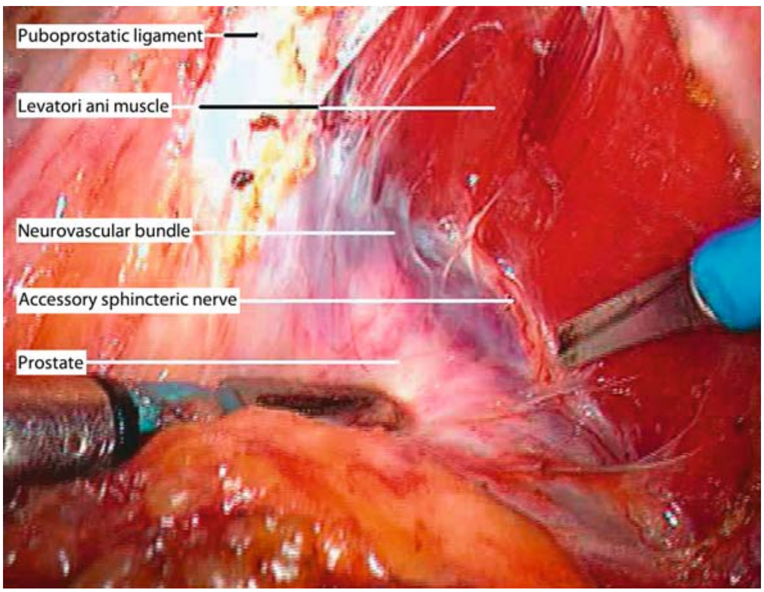

Fig. 3. Bladder neck dissection. The bladder neck is usually preserved to avoid reconstruction time

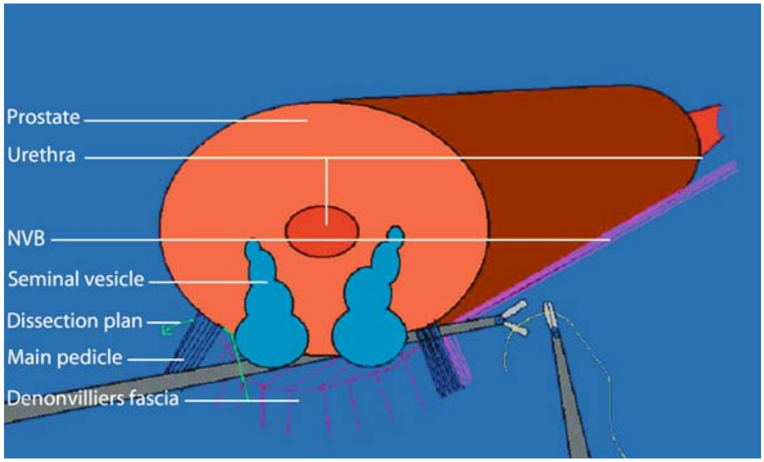

Fig. 4. Accessory sphincteric nerve preservation. After incising the endopelvic fascia bilaterally, careful dissection is carried out to preserve the small accessory nerve to the urethral sphincter

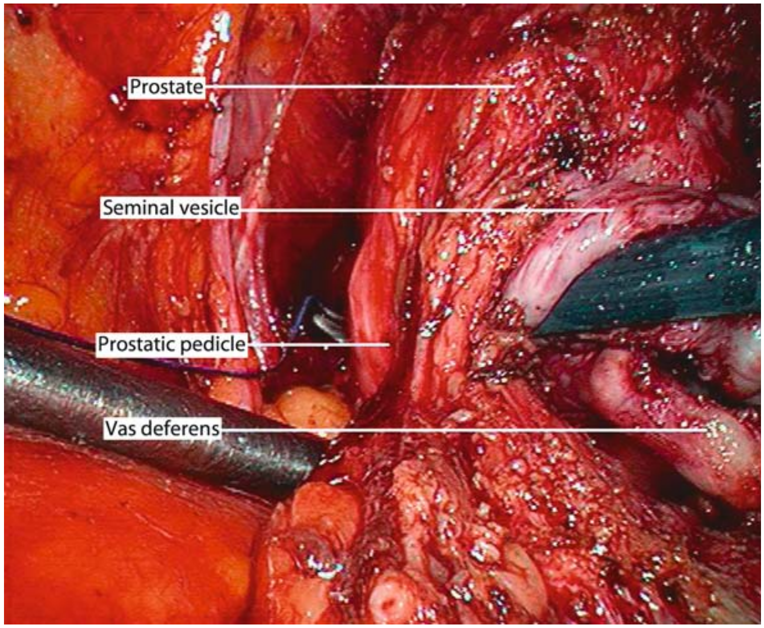

Fig. 5. Neurovascular bundle dissection. To minimise injury of the neurovascular bundle, we do not use bipolar coagulation or clips. A simple ligature is used on the main prostatic pedicle

This technique maximises the available urethral length as well as minimising the risk of apical positive margins.

Anastomosis

The prostate is now placed in a laparoscopic bag (Endocatch) and the string of the bag is pulled through the right lateral port. A probe is introduced in the port and the port is removed over it. The string is placed outside the port, and the port is replaced over the probe. The bag is then pulled and partially exteriorised; this fixes the prostate out of the working environment and makes all the ports available (Figs. 7, 8).

The first suture of the anastomosis is in the midline at 6 o'clock. It is a U-shaped suture (Vicryl 00, SH needle), locked and tied inside the bladder. The metal bougie is then inserted into the bladder and two lateral sutures are made on each side. The final suture

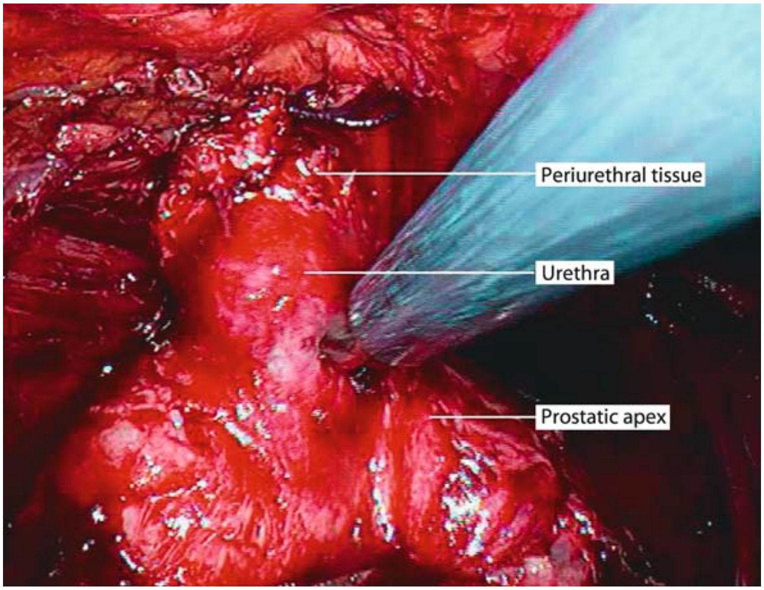

Fig. 6. Apical dissection. The periurethral tissues are incised first without the urethra. Defining the apex of the prostate before transacting the urethra can increase the urethral length

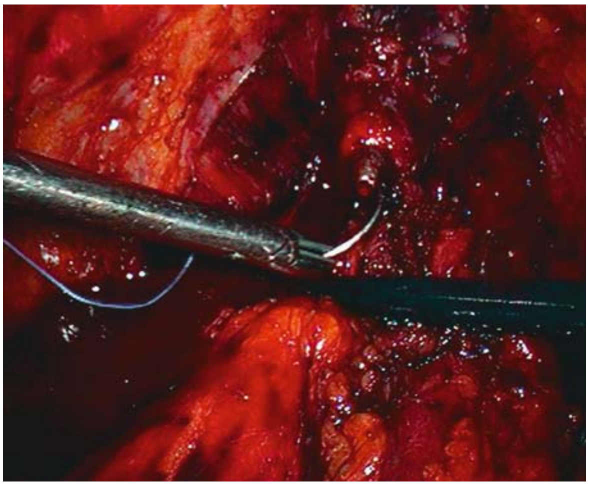

Fig. 7. Urethrovesical anastomosis. A metallic probe is used to help needle introduction into the urethra. Anastomosis is done with two U-shaped sutures and four separate stitches

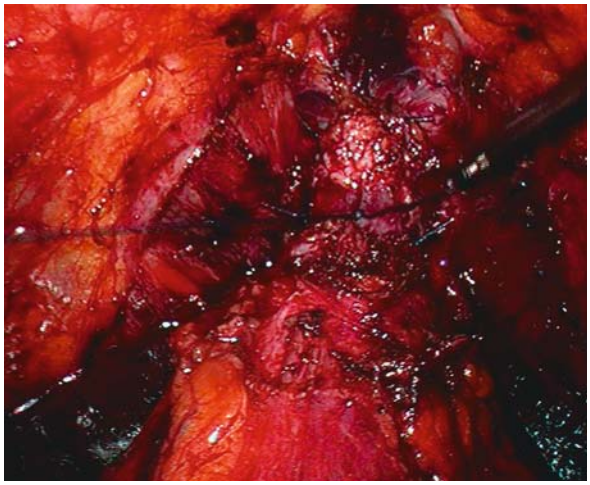

Fig. 8. End of the procedure

is at 12 o'clock and is once again a U-shaped suture. The anastomosis is now complete.

If the ureteric orifices are close to the bladder neck, the bladder neck is reconstructed at 6 o'clock. If the bladder neck is too large but the ureteric orifices are a safe distance from the bladder neck, the anastomosis is carried out as before and the redundant bladder neck is closed anteriorly using the 12 o'clock suture to carry out a running closure.

Once the anastomosis is complete, the patient is catheterised with an introducer. The integrity of the anastomosis is tested with 200 ml of saline. A suction drain is placed in the pelvis, the prostate is removed through an enlarged lateral port site. The aponeurosis of all 10-mm ports are closed with 0 Vicryl and a subcuticular suture is used to approximate the skin.

Postoperative Management

The patient is given appropriate analgesia as per protocol. The suprapubic drain is usually removed after 48–72 h. If the urine is clear at day 5 the bladder catheter is removed; if there is residual haematuria a cystogram is performed as a precaution.

Discussion

Over the last 5 years, several teams have developed different modalities of laparoscopic radical prostatectomy. The two main differences are the approaches used to gain access to the prostate, i.e. trans- or extraperitoneal. On reviewing the recent literature, the extraperitoneal approach appears to be gaining favour.

Since our initial publication describing the Brussels technique [4] several revisions have been made, which have led to an improvement in our functional results.

In order to safely develop the extraperitoneal space one needs good knowledge of the pelvic anatomy to minimise the risk of peritoneal perforation or vascular injury. The entire dissection should be performed under continuous vision. If the peritoneum is perforated, the perforation may need to be extended, and a probe inserted via the suprapubic port can be used to retract the bladder and peritoneum cranially. We believe that the risk of peritoneal or vascular injury is increased with blind or balloon dissection of the Retzius space and we do not advocate this.

The technique for bladder neck dissection has also evolved. Originally, we developed the urethra at the bladder neck and then divided it, leaving a considerable urethral stump [5]. We have abandoned this in favour of the technique described above; our present technique is safe and efficient and preserves the bladder neck. The preservation of the bladder neck decreases the risk of ureteric injury, avoids unnecessary reconstruction and reduces the operating time. If, however, there is a median lobe or if the planes of dissection are not well defined the bladder neck is sacrificed and reconstructed.

The division of the bladder neck allows one to gain optimal access to the vas deferens and the seminal vesicles. In our series, we have been able to dissect and remove the vas and seminal vesicles in all of our patients; additionally the use of clips or bipolar diathermy at this stage does not adversely affect the functional outcome.

The magnification and vision provided by the laparoscope has allowed us to identify a small accessory nerve between the prostate and the levator ani muscle. Although previously described [14], adequate importance has not been given to this nerve. The course of this nerve is not fixed, but it can run along the levator ani muscle before innervating the urethral sphincter [15]. Its precise functional impact on the continence mechanism is not fully elucidated, but we always try and preserve it.

We do not use any electrical or thermal energy to control the main prostatic pedicle, and we have been rewarded by a rapid return of potency in the majority of our patients. On reviewing our last 50 cases, who had bilateral nerve sparing and who were previously sexually active, 89% were having sexual intercourse (78% spontaneously and 11% with sildenafil) at 6 months.

Modifications in our method of apical dissection have led to an improvement in the immediate continence of patients combined with a reduction in the positive margin rate. We cut the periurethral tissue before dividing the urethra itself. This improves the length of the urethra, avoids traction on the posterior aspect of the prostatic apex and reduces the risk of leaving residual prostatic tissue close to the sphincter. Using this apical dissection technique, the recovery of continence in our last 20 patients was significantly improved: perfect continence (strict definition: no pad, no leak) in 70% at 3 months and 90% at 6 months (Table 2).

The posterior and anterior U-shaped suture reduce the risk of urinary leakage and helped to proximate the anastomosis. The bladder catheter remains in situ until at least day 5. We have attempted to remove it earlier in the past but 20% of our patients went into retention and needed recatheterisation. This is probably due to residual oedema at urethrovesical anasto-

Table 2. Continence rate (no pad, no leak) in the last 90 patients and sexual intercourse rate for the last 50 patients previously potent and bilateral nerve sparing

	Continence	Spontaneous sexual intercourse	With sildenafil	Total
1 month	51%	48%	+8%	56%
3 months	84%	56%	+12%	68%
6 months	91%	78%	+11%	89%

mosis. With respect to our oncological results, the most important criteria for surgical evaluation is the positive margin rate for pT2 tumours, and this is 10%.

Conclusions

Laparoscopic radical prostatectomy is an acceptable alternative to open surgery and has become the procedure of choice in an increasing number of centres around the world. The Brussels technique is a pure extraperitoneal approach most comparable to the reference procedure described by Walsh.

The main goal of a new surgical procedure for radical prostatectomy is to improve recovery of continence and sexual function without compromising the oncological results. With increasing experience, this technique has evolved, allowing us to optimise our functional results whilst maintaining the oncological imperative.

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6.3 Laparoscopic Radical Prostatectomy: The Transperitoneal Antegrade Approach

Karim Touijer, Edouard Trabulsi, Waleed Hassen, Bertrand Guillonneau

Contents

Introduction

Laparoscopic radical prostatectomy (LRP) has gained increasing importance in the laparoscopic urologic oncology field and became an established treatment for organ-confined prostate cancer. The initial report of LRP by Schuessler was of nine cases treated through an intraperitoneal approach [1]. Shortly thereafter, a single case of a laparoscopic radical prostatectomy through an extraperitoneal approach was reported [2]. However, in the largest initial series from France, the transperitoneal approach was used [3–6]. With the accumulated experience and worldwide use, variations in the approach and the instrumentation used were introduced. Herein we will discuss the technique of an antegrade transperitoneal LRP as currently performed at the Memorial Sloan-Kettering Cancer Center (MSKCC).

Preoperative Care and Surgical Technique

Indications

LRP has the same indications and contraindications as its open counterpart. There are no specific contraindications to the laparoscopic approach. However, certain conditions such as extensive prior pelvic surgery, prior prostate surgery or pelvic radiation therapy can raise the difficulty level of the procedure.

Preoperative Patient Preparation

Patients receive an enema before surgery. Thromboprophylaxis is ensured with sequential compressive devices on both lower extremities and low-molecular-weight heparin administered prior to surgery, then daily afterwards until discharge from the hospital. Thromboprophylaxis is essential given the presence of three risk factors: cancer surgery, pelvic surgery and laparoscopy. Patients also receive antibiotic prophylaxis with a single preoperative dose of intravenous second-generation cephalosporin.

Patient Positioning

The operation is performed under general anesthesia. The patient is positioned in a low lithotomy position with both arms set along the body to avoid brachial plexus injuries. The shoulders are adequately padded, and the patient is secured to the operating table with surgical tape. A voice-controlled camera holder is used. With both hands free, the assistant can concentrate and actively participate with total involvement in all the steps of the operation. A right-handed surgeon stands on the patient's left with the assistant and the camera holder on the opposite side; the monitor is placed between the patient's legs, at the surgeon's eye level and as close as necessary.

Port Placement

The pneumoperitoneum is obtained through a Veress needle. A 10-mm trocar is inserted through the umbilicus for passage of the 0° laparoscope. Upon entry in the peritoneal cavity, the abdomen and pelvis are explored and the pelvic anatomical landmarks are noted (Fig. 1). Four 5-mm working ports are inserted: in the left iliac fossa, the right iliac fossa, at McBurney's point, and on the midline halfway between the umbilicus and the pubic symphysis. During the prostatectomy part of the operation, the surgeon uses the laparoscopic scissors and the bipolar cautery forceps; the assistant uses the laparoscopic suction device and the graspers.

The surgical technique of LRP includes, if indicated, a transperitoneal pelvic lymph node dissection as previously described [7] and the following standardized steps [4].

Surgical Technique

Approach to the Vesicular Complex

The surgeon incises the posterior vesical peritoneum transversally approximately 1–2 cm above the level of the Douglas cul-de-sac. This exposes the Denonvilliers fascia and the outlines of the seminal vesicles and vasa deferentia. The vasa deferentia are dissected and coagulated with bipolar forceps, then transected. One must be aware and carefully coagulate the deferential artery running along the opposite side. Division of the vasa deferentia allows access to the seminal vesicles. The latter should be dissected along their surface to individualize its vascular pedicle. These arteries are meticulously coagulated with the bipolar forceps facing the seminal vesicles to avoid any thermal injury to the neural plexus in close proximity. The seminal vesicles are then completely mobilized with the prostate as their sole attachment.

The assistant pulls the vasa deferentia upward; the Denonvilliers fascia is then incised medially and horizontally, bringing into view the prerectal fat (Fig. 2). Further dissection toward the prostatic apex or laterally is ill-advised at this time.

Approach to the Retzius Space and Control of the Dorsal Venous Complex

The bladder is filled with approximately 120 cc of saline, to help identify the contours and pull it posteriorly. The anterior parietal peritoneum is incised from

Fig. 1. Transperitoneal view of the pelvic anatomy

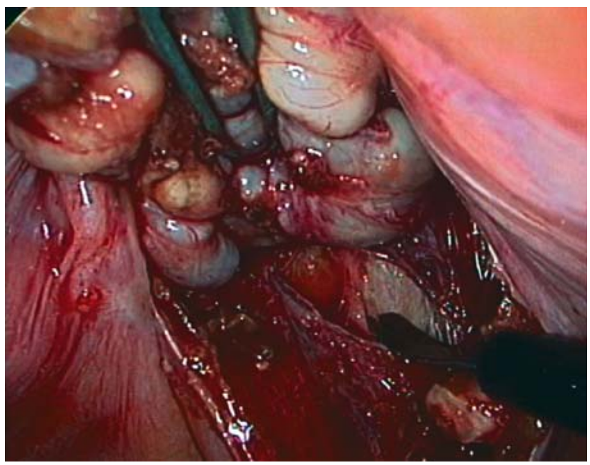

Fig. 2. Transperitoneal opening of Denonvilliers fascia

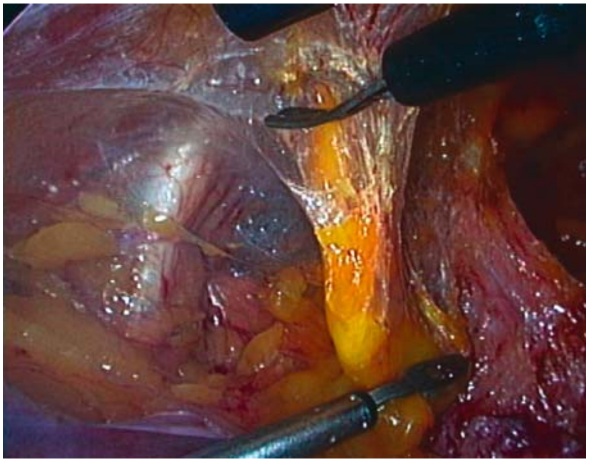

Fig. 3. Transperitoneal development of the Retzius space

one umbilical ligament to the other. It is essential to free the bladder well from its anterior and lateral attachments in order to create a large working space and to allow a tension-free vesicourethral anastomosis at the end of the operation (Fig. 3). The endopelvic fascia is incised, uncovering the levator ani muscle fibers. Incision of the puboprostatic ligaments is done under visual control away from Santorini's venous plexus. The incision can be prolonged toward the fascia that covers the dorsal venous complex laterally. Although delicate, this step will delineate the anatomy and facilitate further dissection and exposure of the dorsal venous complex and the urethra later during the operation.

The dorsal venous complex is ligated but not transected at this time.

Bladder Neck Dissection

The bladder neck is incised transversally and the tip of the catheter is pulled up by a grasper via the suprapubic port, to expose the posterior aspect of the bladder neck, allowing the surgeon to grasp the posterior bladder neck and separate the bladder from the prostate and reach the longitudinal muscular extension of the detrusor between the prostate base and the bladder neck. This layer should be incised in order to gain access to the previously dissected retrovesical space. The vasa deferentia and the seminal vesicles are then simply brought into the operating field by the assistant. This maneuver exposes the lateral prostatic pedicles on both sides.

Lateral Dissection of the Prostate

The lateral prostatic pedicle is controlled high on the base of the prostate, theoretically at a safe distance from the neurovascular elements of the bundle. However, because of the traction on the seminal vesicles, they appear to rise vertically, which facilitates their exposure but distorts their normal anatomical orientation. It is therefore important for the surgeon to reorient himself or herself constantly during the dissection of the pedicles and be cognizant of the exact location of the neurovascular bundle.

Once the pedicle is controlled, the two fascial incisions (superior, periprostatic, and inferior, Denonvilliers fascia) can be joined to develop a plane of dissection of the neurovascular bundle. It is preferable to continue the apical dissection of the bundle after transecting the dorsal venous plexus, which gives mobility to the gland and facilitates the exposure of the apical and the distal third of the prostate.

If nerve sparing is not considered, the prostatic pedicles are transected far from the prostate and the posterolateral attachments of the prostate are not dissected but simply controlled (using bipolar coagulation or clips) and divided. It is important to remember that although this step looks easier, the risk of rectal injury is higher because the dissection is performed close to it, in the perirectal fat.

Apical Dissection of the Prostate

The incision is tangential to the prostate to avoid iatrogenic incision into the prostatic tissue at the apex. Gradually, an avascular plane of dissection situated between the dorsal venous complex and the urethra is developed. The remainder of Denonvilliers fascia connected to the rectourethralis muscle fibers are divided. At the apex, the neurovascular bundles are divergent from the prostate, but must be followed to their entrance into the pelvic floor, below and lateral to the urethra; the key element in this dissection is to follow the anatomic contours of the prostate. At the end of this step, the neurovascular bundles and the rectum are separated away from the prostate, and the only attachment left is the urethra, which is incised sharply.

Urethrovesical Anastomosis

It is not necessary to evert the bladder mucosa or to resize the bladder neck. However, in some cases with a large bladder neck, an anterior or posterior tennis racket reconstruction is required. We perform the anastomosis with interrupted sutures, using a 3-0 resorbable on an RB1 needle. All the sutures are tied intracorporeally. The first three sutures are posterior, placed at the 5, 6 and 7 o'clock positions, going inside-out on the urethra and outside-in on the bladder neck. These sutures are therefore tied intraluminally. Four other sutures are symmetrically placed at the 4 and 8, then the 2 and 10 o'clock positions, and tied outside the lumen. Three final anterior stitches are placed at the 11, 12 and 1 o'clock positions, and placed symmetrical to the posterior stitches. Once the sutures are tied, the Foley catheter is inserted. The bladder is filled with 180 cc of saline to ascertain a watertight anastomosis and confirm the correct position of the catheter.

Morbidity

Blood Loss

The average estimated blood loss in the series from Montsouris was 380 ml and an allogeneic transfusion rate of 4.9% with no autologous blood transfusion for all 550 patients. In the last 350 patients, the mean blood loss and transfusion rate declined to 290 ml and 2.6% [8]. In a contemporary series of transperitoneal LRP at the MSKCC, the average blood loss is 300 ml and the allogeneic transfusion rate is 5%, similar to that reported from other centers worldwide [9–11]. For instance, Eden et al. reported a mean blood loss of 313 ml and an allogeneic transfusion rate of 3% in a series of 100 transperitoneal LRPs [12]. This contrasts with the experience from Heidelberg, which reported an average blood loss of 1,100 ml and a transfusion rate of 30% for their initial 219 patients and 800 ml with 9.6% transfusion rate for the last 219 patients. The authors attributed the relatively higher blood loss and transfusion rate in their series to difficulties encountered with the ascending technique [13]. All these data should be confronted to those reported during radical retropubic prostatectomy (RRP), where the blood loss remains relatively significant, ranging from 818 ml to 1,500 ml with an allogeneic transfusion rate of 9%–19% [14–16].

Thromboembolic Complications

Deep venous thrombosis (DVT) is a rare event after LRP (0.3%) [17] but more frequent in the open experience where fatal pulmonary embolism accounts for most causes of death following RRP. For instance, Catalona et al. reported a 2% rate of thromboembolic accidents [16]. Leandri et al. reported 2.3% rate of deep venous thrombosis (DVT) and 0.8% rate of PE [19]. In older series, the rates of PE and DVT range from 6.9% to 12% and 2% to 2.7%, respectively; in more recent series the thromboembolic events range from 0.8% to 2.7%. In comparison, Rassweiler et al. reported pulmonary embolism (PE) in 0.45% [13]. In the series by Salomon et al., the rate of DVT and PE was 0.6% for both [18], comparable to our experience with a DVT rate of 0.25% at the MSKCC. This relatively low incidence results from early ambulation, the use of sequential compressive devices and prophylactic anticoagulation.

Rectal Injury

Two types of rectal injuries can occur. The first is a rectal tear, which most commonly occurs during the dissection of the posterior surface of the prostatic apex and mainly during non-nerve-sparing prostatectomy, often recognized intraoperatively. The second is diagnosed postoperatively after the patient develops a rectourethral fistula. The latter is secondary to either a microperforation, or thermal or ischemic injury to the anterior rectal wall during a vigorous dissection.

The reported incidence of rectal injury in patients undergoing LRP ranges from 1% to 2.7% [12, 20]. In the initial Montsouris experience of 1,000 LRPs, rectal injury was noted in 13 patients and repaired primarily in 11; in the remaining the diagnosis was made postoperatively and required reoperation and temporary colostomy [21]. In the Créteil experience of 300 LRPs, six rectal injuries were reported, one patient developed a rectourethral fistula was treated by a diverting colostomy [22]. Rassweiler et al. reported three rectal injuries and seven rectal fistulas in a series of 438 LRPs. All of the rectal injuries occurred in the first 219 patients [13]. The incidence of rectal injury in contemporary RRP series ranges from less than 1% to 3.6% [19, 23–25]. This is now a rare event whose occurrence decreases with experience and the rate at the MSKCC is now 0.25%.

Ileus

Postoperative ileus is not commonly reported in postoperative morbidity. Its incidence following the transperitoneal approach was reported at 1% in one study [17]. Some of the arguments in favor of the extraperitoneal approach are the absence of peritoneotomy and therefore a lower risk of bowel injury and peritoneal irritation. In the most recent series of 250 transperitoneal LRPs performed at the MSKCC, per os intake is started the night of surgery in all patients, the hospital stay is 1.9 night with 92.5% of the patients discharged within 48 h after the surgery. Postoperative ileus occurred in two patients with postoperative hemorrhage and pelvic hematoma treated with conservative measures.

Urinary Extravasation and Anastomotic Stricture

Anastomotic urine leakage may be another cause of postoperative ileus but the true incidence of anastomotic leaks after radical prostatectomy is uncertain, as most small leaks remain undiagnosed and resolve spontaneously with bladder drainage. After transperitoneal LRP, a large leak is usually manifested by back pain, uroperitoneum and ileus, with laboratory signs of intraperitoneal urine reabsorption. The reported incidence after LRP ranges from 1% to 10% [10, 17].

The anastomotic stricture after LRP is uncommon, 0% to 3.3% [9, 17, 20], compared to the incidence of urethrovesical anastomotic strictures in modern RRP series, varying from 4.0% to 20.5% [16, 26]. This lower incidence can most likely be attributed to a tension-free anastomosis achieved at best by the bladder mobilization during the transperitoneal approach.

Oncological Results

Positive Surgical Margin Rate

The prognostic significance of a positive surgical margin (PSM) is a higher risk of biochemical, local and systemic progression [28, 29]. The positive surgical margin rate following radical prostatectomy varies widely among series, probably depending on the population selected, the experience of the surgeon, and the pathologist. The PSM rate following RRP in the last 5 years ranges from 11% to 36% [30, 31], and the target recommended by experienced surgeons is to reduce the PSM to 10% or less. In the LRP experience, the PSM rates range from 11.4% to 26.4% [32, 33], with an overall PSM rate of 22.6%. These results represent the authors' initial experience since the inception of LRP. In the large series of 1,000 consecutive LRP from Montsouris, the PSM rate was 19.2% overall, 15.4% in pT2 and 31% in pT3 [34]. In a recent series of LRP at the MSKCC, the positive surgical margin rate by pathological stage was 3.8% for pT2 and 26% for pT3 tumors.

Biochemical-Free Progression

The reported 5- and 10-year PSA nonprogression rates after RRP have been 77%–80% at 5 years and 54–75% at 10 years [35–39]. Because LRP has been performed only within the past 6 years, long-term data on PSA nonprogression after LRP are unavailable. The short-term oncologic data, however, are encouraging. Guillonneau et al. published the short-term follow-up of the first 1,000 LRP performed at the Montsouris institute between 1998 and 2002. With a median follow-up period of 12 months, the 3-year actuarial progression-free probability was 90.5%, progression being defined as a PSA greater than 0.1 ng/ml. According to the pathological stage, the biochemical progression-free survival at 3 years was 91.8% for pT2a N0/Nx, and 88% for pT2b N0/Nx, 77% for pT3a N0/Nx and 44% for pT3b N0/Nx and 50% for pT1–3 N1 ($p < 0.001$).

Functional Results

Interpretation of the functional results following radical prostatectomy needs to take into account the lack of uniformity in the methodology of definition and assessment, as this may lead to biases in comparing results between different series.

Continence

In an evaluation of short-term functional results at the MSKCC, at 3 months after transperitoneal LRP, 49% of the patients had regained urinary continence and did not require the use of any pads, while 22% had mild stress urinary incontinence (SUI) (leakage only with heavy physical activity) and wore one pad a day as a precaution. Later on, at 12 months following LRP, a prospective evaluation of the recovery of continence using the validated self-questionnaire of the International Continence Society found that 82.3% were totally continent [8]. Others [12, 20] defining continence as freedom from any pads, reported a 91% and 90% continence rate at 12 months, respectively.

Potency

Patient age, preoperative potency status and extent of neurovascular bundle preservation are significant predictors of potency recovery following radical prostatectomy and need to be taken into consideration when interpreting the potency results [27]. Most series of LRP include potency data only on a small subset of patients, usually treated after the LRP technique and neurovascular bundle preservation was mastered.

The length of follow-up is another important facet in analysis of sexual function after prostate surgery, since potency can return months or years after surgery. Of their initial 550 patients at Montsouris, Guillonneau et al. reported a subset of 47 consecutive patients less than 70 years of age. Of those patients who were preoperatively potent and underwent bilateral nerve sparing, 31 patients (66%) were able to have intercourse with or without sildenafil [8]. In a contemporary cohort of 110 patients treated at the MSKCC, 58% of the preoperatively fully potent patients were able to have intercourse at 3 months after LRP (with or without sildenafil) when bilateral neurovascular bundle preservation was performed vs 25% after unilateral preservation (p=0.013; odds ratio, 4.1; 95% CI, 1.3–12.6). Among patients with bilateral nerve sparing the outcome was different depending on the quality of preservation. Seventy-one percent of patients with complete bilateral preservation were able to have intercourse vs 57% of the patients who had one nerve completely preserved and possible damage on the other (p=0.003; odds ratio, 12.2; 95% CI, 2.3–65.3) and 16% in patients who had bilateral possible damage (p=0.03; odds ratio, 6.8; 95% CI, 1.2–40.3). On multivariate analysis, the quality of neurovascular bundle preservation was predictive of potency at 3 months after LRP.

Future Horizons

As the LRP technique has become standardized and widespread, it has enabled surgeons to successfully expand the application of pelvic laparoscopy to procedures such as radical cystectomy, salvage LRP and recently building on the laparoscopic experience of sural nerve grafts, as reported by Scardino et al. during open RP [40, 41]: Turk et al. demonstrated the technical feasibility of performing nerve grafting during LRP [42].

Conclusions

A successful laparoscopic prostatectomy program requires advanced laparoscopic skills, but more importantly substantial knowledge of the prostatic anatomy and expertise in surgical oncology. This combined expertise is indispensable to achieve the best surgical, oncologic and functional results.

Short of a randomized trial comparing the transperitoneal and extraperitoneal approaches, and even the retropubic approach, the debate over which approach is best remains futile. Only the surgeon's training and experience and the results offered to the patient should dictate that choice.

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6.4 The Laparoscopic Radical Prostatovesiculectomy – Transperitoneal Access

Thomas Frede, Michael Schulze, Reinaldo Marrero, Ahmed Hammady, Dogu Teber, Jens Rassweiler

Contents

Introduction

Radical prostatectomy is a major potentially curative procedure for the treatment of organ-confined prostate cancer. Most urologists use the retropubic approach because of familiarity with the surgical anatomy, as well as the nerve-sparing technique first described by Walsh et al. [1]. The first attempt to perform laparoscopic prostatectomy in two cases was published by Schuessler et al. in 1992 (abstract presented to the American Urology Association Congress). In 1997, the same team published nine cases of laparoscopic radical prostatectomy and reached the conclusion that this technique did not provide any advantages over open surgery, due to procedural difficulties in the control of the dorsal vein plexus; adequate anatomic dissection of the apex and creation of the urethrovesical anastomosis, resulting in very long operating times with increased morbidity; and the duration and difficulty of the operation [2]. Based on our own promising initial results, we standardized the technique and have operated so far on more than 1,000 patients who presented with localized cancer of the prostate [3, 4]. The vast majority of these patients were operated on using a transperitoneal approach. This chapter describes our technique and the functional and oncological outcome of our patients. Furthermore, we present the learning curve date of the initial three generations of surgeons.

Material and Methods

Indications and Contraindications

The indications for laparoscopic transperitoneal radical prostatectomy are identical to those for open retropubic radical prostatectomy and include every type of localized cancer of the prostate. After completing the learning process, the laparoscopic approach is no longer limited to the size of the prostate, nerve-sparing techniques or prior abdominal surgery. Even after laparoscopic hernia repair, a laparoscopic transperitoneal exposure of the prostate is possible.

The clinical stage influences the outcomes of the radical prostatectomy, together with the Gleason score and the preoperative PSA. The Gleason grade is an important prognostic factor, but it cannot be used with certainty to determine prognosis or to justify management; PSA also cannot definitively distinguish the stage of the cancer in an individual patient and should not be used alone as a contraindication to definitive treatment. The last decision must be made with the consent of the patient after the explanation of the likelihood of success and complications of each procedure.

There is no specific contraindication for a laparoscopic surgical approach for localized prostate cancer apart from open surgery. There are four absolute contraindications not only for laparoscopic radical prosta-

Fig. 1. Positioning of the patient for laparoscopic prostatectomy

tectomy but also for the other laparoscopic surgical approaches: abdominal wall infection, generalized peritonitis, bowel obstruction and an uncorrected coagulopathy.

Technical Aspects

Perioperative Care

The patients receive oral bowel preparation (hydroxyanthracene glycoside) the day prior to surgery, heparinization (3×5,000 IU sc/d) and perioperative antibiotic prophylaxis (trimethoprim/sulfamethoxazole). Mobilization starts the day after surgery. A cystourethrogram is performed routinely on day 7.

Operative Access and Technique

The patient is positioned in the deflected supine position with arms parallel to the body and the legs adducted (Fig. 1). The rectal balloon catheter is placed and inflated with 70 cc air (Fig. 2).

The abdomen is shaved from the costal margins to the pubic bone. The abdomen, penis, scrotum, upper thighs and perianal region are prepared with iodine-based disinfectant. The table is placed in the 300 Trendelenburg decline supported with an inflatable balloon pillow under the patient's buttocks. Before port placement, a 16F Foley catheter is inserted under sterile conditions and blocked with 15 cc saline.

Fig. 2. Rectal balloon

Transperitoneal Approach

The trocars are placed in a W-shaped arrangement (Fig. 3). The first trocar (12-mm) is inserted following a periumbilical mini-laparotomy. This port is used for the laparoscope and later for retrieving the specimen. The other four ports (two 10-mm and two 5-mm) are placed under endoscopic control after establishing the pneumoperitoneum (maximum pressure, 15 mmHg; maximum gas flow, 30 ml). First, we incise the peritoneum to the internal inguinal rings laterally, traversing the light prepubic areolar tissue of the space of Retzius using sharp and blunt dissection exposing the pubic bone caudally as the first landmark and the external iliac vessels laterally, freeing the bladder from its anterior attachments. Then a 6th port (5-mm) is

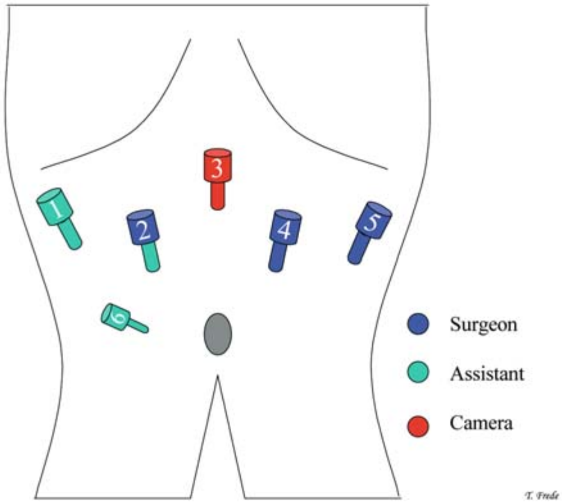

Fig. 3. Placement of the trocars: W-shaped arrangement

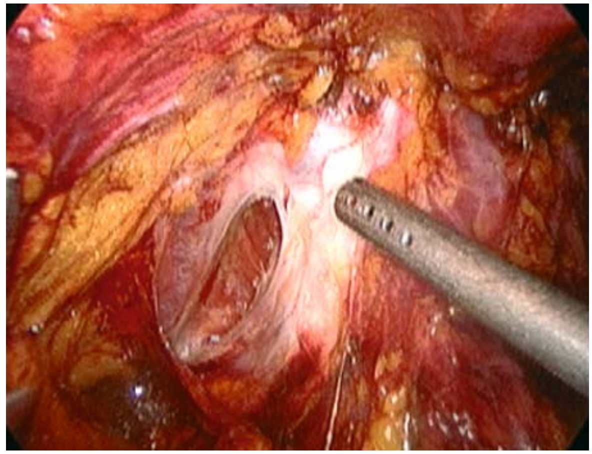

Fig. 4. Opening of endopelvic fascia

placed in the right lower abdomen through which a grasping endodissector is used to grasp the urachus, pulling it with dome of the bladder cranially. Next a pelvic lymphadenectomy is carried out depending on the PSA and Gleason score.

Extraperitoneal Approach

The extraperitoneal access is achieved by transverse incision 1 cm below the umbilicus and sharp incision of the rectus fascia, a blunt digital dissection between the rectus muscle and the posterior sheath of its fascia is carried out, with special care taken to avoid peritoneal perforation. Then 10-mm trocars are placed lateral to the infraumbilical incision under palpatory control into the preperitoneal space. After establishing the pneumoextraperitoneum, the peritoneum is further dissected cranially to allow the safe insertion of the two lateral 5-mm trocars under visual control. This extended lateral preparation also allows placement of the specimen after removal of the prostate.

Santorini Plexus Control and Transection

The fibroadipose tissue covering the prostate is carefully dissected away to expose the pelvic fascia, puboprostatic ligaments, and superficial branch of the dorsal vein. The point of incision is where the fascia is transparent, revealing the underlying levator ani musculature, lateral to the arcus tendineus fascia pelvis because the lateral branches of the dorsal venous complex are directly beneath it [5]. The incision in the endopelvic fascia is then carefully extended in an anteromedial direction toward the puboprostatic ligaments (Fig. 4). With the puboprostatic ligaments transected, the superficial branch of the dorsal vein is readily apparent in the midline over the bladder neck. The adherent levator ani muscle is gently detached from the prostate, followed by transection of the puboprostatic ligaments (pubovesical ligament) [5]. Finally, the prostatic apex is optimally exposed using a 10-mm 120° endodissector over the prostatovesical junction, with the tips up to avoid injuries to the bladder. The prostate is invested with the prostatic fascia and levator ani fascia. Anteriorly and anterolaterally, the prostatic fascia is in direct continuity with the true capsule of the prostate. The major tributaries of the dorsal vein of the penis and Santorini's plexus travel within the anterior prostatic fascia. Laterally, the prostatic fascia fuses with the levator ani fascia, which covers the pelvic musculature, to form the lateral pelvic fascia [6]. As the major tributaries of the dorsal vein of the penis and Santorini's plexus travel within the anterior prostatic fascia, so the Santorini plexus (deep dorsal vein complex) is adequately controlled by two stitches distally. The needle is positioned parallel to the curve of the symphysis pubis; the angle between the needle and the needle holder should be 100° (Fig. 5), passing it from the right to the left side encircling the dorsal venous plexus (17 mm Vicryl MH 2/0). Another stitch is placed proximally at the base of the prostate as a backflow stitch. The dorsal vein complex is first coagulated with bipolar forceps then transected cranial to

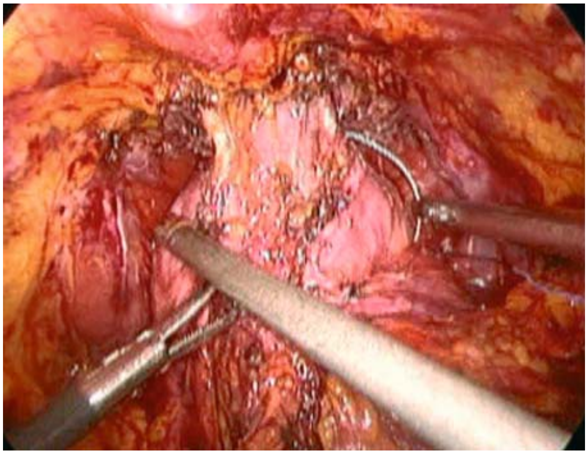

Fig. 5. Control of the dorsal vein complex

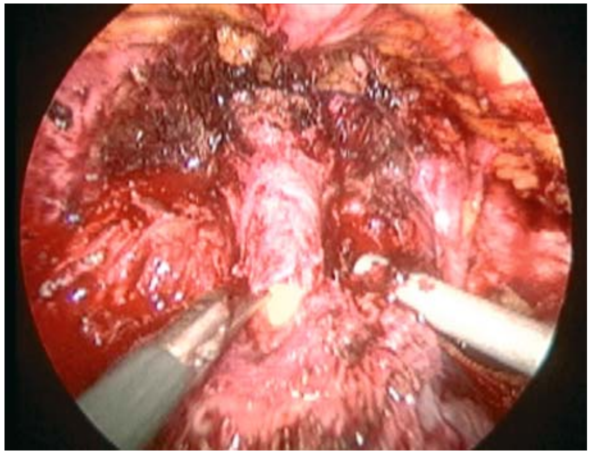

Fig. 6. Urethral transection

the two distal stitches, due to the coagulation-induced shrinkage of the tissue; with slight cranial traction on the prostate the coagulated veins and the surrounding fibromuscular fatty tissue retract on both sides [7].

Apical Dissection

The approach to the apex of the prostate is determined by the decision of proceeding with the nerve-sparing or non-nerve-sparing technique.

The Non-Nerve-Sparing Technique

After transection of the dorsal vein complex, the anterior striated sphincteric urethral complex is demonstrated. The fibers of this complex at the apex are horseshoe-shaped and form a tubular, striated sphincter surrounding the membranous urethra [6]. The urethral sphincter is incised using bipolar forceps and endoscissors, exposing the smooth muscle of the urethra. Under the gentle cranial traction of the prostate, anterior rotation of the apex of the prostate occurs and the prostatourethral junction is illustrated where the anterior wall of urethra is incised sharply (no electrocoagulation). As the verumontanum is considered the beginning of the distal continence zone (Table 1), the urethral transection should be performed at or just distal to the verumontanum (Fig. 6). Sometimes the apical prostate overlaps the urethra beyond the verumontanum with urethral transection at or beyond the apex. The patient can expect a period of incontinence that exceeds what could be achieved if the transection had been made just distal to the verumontanum [5]. For this reason, the urethra should be dissected as near as possible to the apex of the prostate before transection is carried out. The Foley catheter is ligated at the urethral meatus cut and pulled inside the abdomen to achieve retraction of the gland cranially, using a grasper (6th port). The 20F bougie is placed to assist in the division of the posterior ure-

Table 1. Patient data for laparoscopic radical prostatectomy

Criteria	All (957) patients	First 300 patients	Last 300 patients
Recruitment time	03/99–04/04	03/99–09/01	04/03–04/04
Patient age (range)	64 years (43–82)	64 years (43–77)	64 years (47–80)
No. pathological stage			
pT1 (%)	9 (0.9)	4 (1,4)	3 (1)
pT2a (%)	155 (16.2)	58 (19.3)	46 (15.3)
pT2b (%)	391 (40.9)	110 (36.7)	109 (36.3)
pT3a (%)	232 (24.2)	61 (20.3)	84 (28)
pT3b (%)	123 (12.9)	48 (16)	38 (12.7)
pT4 (%)	38 (1.5)	14 (4.7)	18 (6)
pN+ (%)	13 (4)	6 (2.8)	6 (3.2)
Median Gleason score	6 (3–10)	6 (3–9)	6 (2–9)
PSA (ng/ml)	11.2 (0.2–194)	12.7 (0.6–148)	10.3 (0.5–120)
Prostate volume (cc)	33.9 (3–102)	30.8 (3–102)	36.4 (5–101)
Specimen weight (g)	43.4 (10–125)	41.2 (10–125)	44.3 (10–114)
Tumor volume (cc)	2.86 (0.1–40)	3.1 (0.3–40)	3.1 (0.1–20)

thral wall. This maneuver is facilitated by the use of the 120° endodissector to retract the prostate. The apex of the prostate and rectal ampulla are in close proximity; explaining why rectal injuries during radical laparoscopic prostatectomy commonly occur at this location. The apex of the prostate is dissected gently from the rectum using right-angle forceps and a suction device. The neurovascular bundle (NVB) areas are clipped using 10-mm Hem-o-Lok clips and incised, releasing the posterolateral attachment of the prostate, while the midline is dissected bluntly.

The Nerve-Sparing Technique

The nerves are microscopic in size. Their anatomic location can be estimated by using the capsular vessels as a landmark. The NVBs are located in the posterolateral side of the prostate, inside a triangle formed by the lateral pelvic fascia (lateral wall), prostatic fascia (medial wall) and the anterior layer of the Denonvilliers fascia (base) [8]. Near the apex, the NVBs travel at 5 and 7 o'clock positions. The lateral pelvic fascia is incised prior to the incision of the urethra. Displacing the prostate on its side exposes the lateral surface of the prostate. A right-angle clamp is inserted under the lateral pelvic fascia beginning at the bladder neck and extending distal towards the apex of the prostate, detaching the area of NVBs from the posterolateral border of the prostate and dissected gently from the apical part of the prostate. All the prostatic branches from the NVBs are controlled step by step using 5-mm titanium clips. We avoid the use of bipolar or monopolar coagulation in the bundle area. The urethra is incised as in non-sparing technique, but when the striated sphincter is divided closer to the apex of the prostate, there is risk that the neurovascular bundle may be damaged. As the neurovascular bundle approaches the apex of the prostate, it is often fixed medially beneath the striated sphincter by an apical vessel. For this reason, the lateral edges of the sphincter should be divided only down to the lateral edge of the smooth muscle of the urethra and not any farther posteriorly (not close to the apex of the prostate) [6].

Bladder Neck Incision

After the detaching the prostate from rectum, the apex is gently pulled ventrally by applying traction on the intra-abdominal Foley catheter. The catheter balloon helps to identify the vesicoprostatic junction. The anterior wall of the bladder neck is incised using bipolar forceps and endoscissors, exposing the balloon. Now, division of the catheter proximal to the suture deflates the balloon; then it is used as a loop-like retractor. After identification of the ureteric orifices, the posterior bladder neck wall is dissected using right-angle dissector and transected, exposing the retrovesical space where both vasa deferentia and seminal vesicles can be identified.

Division of Lateral Pedicles and Dissection of Seminal Vesicles

Both lateral pedicles are divided step-wise starting by dividing the superficial portions of pedicle and then the deeper portions using two or three lockable 10-mm Hem-o-Lok clips to secure it. When using the nerve-sparing technique, we place the clips to avoid injury to the NVB and the pelvic plexus. Following transection of both vas deferentia, the seminal vesicles are dissected and transected after clipping the vascular supply using 10-mm metal clips. In the nerve-sparing technique, the small arterial branches that travel to the seminal vesicles are clipped close to the seminal vesicles. The specimen is then entrapped in the self-opening extraction bag.

Urethrovesical Anastomosis

For the urethrovesical anastomosis, the right medial port (for the needle holder) and the left lateral port (for the endodissector or the second needle holder) are used to achieve an optimal angle (30°–50°) between the instruments. The anastomosis is performed using 15–17 cm of Vicryl 3/0 with an RB needle. Dur-

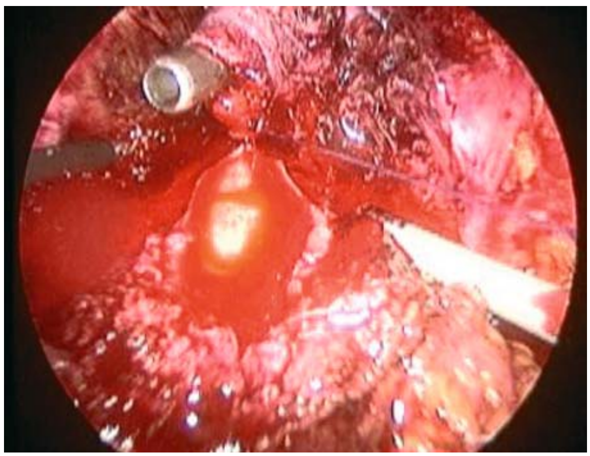

Fig. 7. Vesicourethral anastomosis

ing this part, we insert the bougie for optimal exposure of the urethra (Fig. 7). If necessary, the bladder is retracted cranially by a grasper via the left medial port. We start with a 17-cm suture at 6 o'clock, taking the posterior urethra together with the rectourethralis muscle. The telescope is inserted deep in the pelvis with the 30° angle looking upwards. Subsequently, two further stitches are made at 5 and 3 o'clock followed by two stitches at 7 and 9 o'clock, starting with the bladder side then the urethral side. All stitches are made using the intracorporeal knotting technique and tension-free stitches.

Reconstruction of the Bladder Neck

After insertion of a 20F Foley catheter with a Tiemann tip, the anterior reconstruction of the bladder neck is performed with two or three interrupted sutures (15 cm Vicryl 3/0, SH needle). Subsequently, the anterior part of the anastomosis is closed over the indwelling catheter.

Posterior bladder neck reconstruction is necessary when the orifices are very close (less than 5 mm) to the resection line (i.e., in case of large middle lobe). In cases of difficult anastomosis, the 20F bougie with a working channel allows the insertion of a guidewire (0.035-in.) into the bladder and an open tipped 20F Foley catheter can be placed safely over the guidewire.

Specimen Retrieval

After placing the drainage tube via the right medial 10-mm port under vision and fixed to the skin, the prostate is extracted within the organ bag via the periumbilical incision (site of telescope Port). For this purpose, the rectus fascia is incised longitudinally according to the size of the gland. The entire specimen then is sent to the pathologist for staging the disease.

Results

From March 1999 to May 2004 we performed an ascending laparoscopic radical prostatectomy (a-LRP) in more than 1,000 patients (53 extraperitoneal and 957 transperitoneal), mean age 64 years (43–82), with clinically organ-confined prostate cancer (Table 1).

Perioperative Data

The mean operating time was 280 min (130–600) for the early laparoscopic group and 208 min (102–369) for the late laparoscopic group. Conversion to open surgery was necessary in 2.7% of the early group and 0.3% of late group. There were ten conversions, four because of rectal injury, three because of severe periprostatic adhesions, and three because of major bleeding at the dorsal vein complex. Reintervention was required in 3.7% of our early and 1% of our late laparoscopic patients (Table 2).

Table 2. Laparoscopic perioperative data

Criteria	All patients (*n* = 957)	First 300 patients	Last 300 patients
Mean operating time (min)	235 (97–600)	280 (130–600)	208 (102–369)
Median blood loss (ml)	1,091 (100–7,000)	1,505 (200–7,000)	1,092 (200–3,500)
Nerve-sparing radical prostatectomy (%)	229 (23.9%)	40 (13.3)	83 (27.6)
Unilateral	121	34	37
Bilateral	108	6	46
Conversion rate	10 (1)	8 (2.7)	1 (0.3)
Early reintervention rate (DJ, UC, PCN)	33 (3.4)	11 (3.7)	3 (1)

DJ double-J catheter, *UC* ureteral catheter, *PCN* percutaneous nephrostomy

Complications

The major intraoperative complications associated with LRP are rectal injury and hemorrhage. Rectal injury usually occurs during apical dissection following transection of the urethra. In our series, we had 16 (1.6%) rectal injuries, all of them were repaired laparoscopically with longer maintenance of the bladder catheter except four (0.4%) cases requiring conversion to open surgery (Table 3).

As regards hemorrhage, the most common site of significant bleeding was the dorsal vein complex. During LRP, precise visual control is essential for completion of the procedure. In order to get sufficient security of the dorsal complex, a number of important geometric factors have to be considered regarding endoscopic suturing, which can be done only if the angle between the two instruments (i.e., needle holders) is 30°; therefore, the right-hand needle holder is introduced via the medial right port and the other instrument in the lateral left port. Furthermore, the angle

Table 3. Complications of laparoscopic radical prostatectomy

	Rectal injury (%)	Extravasation (%)	Bleeding (%)	Epigastric injury (%)	Rectourethral fistula (%)	Ileus (%)	Overall (%)
Tuerk et al. [10]	2.4	13.6	1.6	–	0.8	3.2	14.4
Hoznek et al. [11]	1.5	3.0	1.2	–	0.7	2.4	8.9
Gill et al. [31]	2.5	NA	5	NA	–	NA	10
Guillonneau [32]	1.4	8	5	0.5	–	1.0	18.5
Rassweiler [33]	1.6	5.1	1.7	0.2	0.9	1.8	11.7

between the shaft of the needle holder and the needle has to be about 100° to guarantee easy passage through the dorsal complex. Other less common sites of bleeding during LRP are the seminal vesicular artery, the periprostatic venous plexus, and the epigastric vessels (trocar site injury). In our series, there were three cases (0.03%) with major bleeding at the dorsal vein complex managed by laparotomy and 13 cases (0.13%), with postoperative bleeding managed conservatively, except four cases (0.04%) that required reintervention (three laparotomy, one laparoscopic). Other postoperative complications included prolonged ileus, pelvic hematoma, urinoma, rectovesical fistula, thromboembolic complications, and anastomotic stricture.

Postoperative Analgesia

The postoperative amount of analgesics (morphinoids) was 33.8 mg in the early interventions and 30.1 mg in the late ones. On day 2 after surgery, only 9% of the patients required analgesics.

Catheter Time and Convalescence

The median catheter time was 7 days (5–30). After laparoscopic radical prostatectomy, the median hospital stay was 8 days (6–27) and the patients returned back to normal activity after a maximum of 4 weeks after surgery.

Oncological Data

The first 500 patients with a minimal observation period of 21 months have been followed prospectively regarding positive margins, PSA failure, clinical progression, and survival. The mean preoperative PSA value was 11.7 ng/ml, and the median Gleason score was 7 (3–10). The mean prostate volume was 32.3 ml (3–102). All specimens were stained with two different colors for each lobe and examined with gross sections according to the Stanford protocol [9]. Tumor stage was defined according to the TNM-classification (1997). Prostate-specific antigen (PSA) was determined on the 10th postoperative day, after 3 weeks, and then every 3 months. If not performed in our laboratory, the data were obtained by telephone contact or transmitted via fax from the referring urologist. As cut-off for PSA progression, two values above 0.2 ng/ml were defined according to other open and laparoscopic series. In case of PSA progression, further clinical investigation included transrectal ultrasound, bone scan as well as computer tomography in selective cases. The mean specimen weight was 42.9 g (10–125) and tumor volume averaged 2.7 ml (0.2–40). In 109 (21.8%) patients, preservation of the neurovascular bundle was performed: in 68 cases unilaterally and in 41 cases bilaterally. Conversion to open surgery was necessary in nine (1.8%) patients, whereas three (0.6%) patients required open surgical reintervention

Table 4. Oncological outcome of laparoscopic radical prostatectomy: general data on the first 500 patients

Criteria	
Recruitment time	03/99–08/02
Median follow-up (months)	38 (21–63)
Mean age (years)	64 (43–81)
Median Gleason score	7 (3–10)
PSA (ng/ml)	11.7 (0.2–148)
Prostate volume (ml)	32.3 (3–102)
Specimen weight (g)	42.9 (10–125)
Tumor volume (ml)	2.7 (0.2–40)
No. neoadjuvant therapy (%)	112 (22.4)
No. lymph node dissection (%)	417 (83.4)
No. conversion to open surgery (%)	9 (1.8)
No. early open re-intervention (%)	3 (0.6)
No. nerve-sparing (%)	109 (21.8)
Unilateral	68
Bilateral	41

due to postoperative bleeding. The median observation time was 38 months (21–63) (Table 4).

Pathological Stage. One hundred twelve (22.4%) patients underwent neoadjuvant antiandrogen therapy; 417 (83.4%) patients underwent pelvic lymph node dissection, revealing positive nodes in six (1.4%) cases. In nine (1.8%) patients, no tumor was found in the specimen, four times following transurethral resection (pT1) and five times after antiandrogen therapy (pT0). Ninety-five (19.0%) tumors were stage pT2a, 201 (40.2%) were stage pT2b, 107 (21.4%) were stage pT3a, 69 (12.8%) were pT3b, and 19 (3.8%) pT4 (Table 5).

Table 5. Oncological outcome of laparoscopic radical prostatectomy: pathological stage and positive margins ($n = 500$)

Pathological stage	*N* (%)	Positive margins (%)
pT0/1	9 (1.8)	0
pT2a	95 (19.0)	2 (2.1)
pT2b	201 (40.2)	20 (9.9)
pT3a	107 (21.4)	27 (25.2)
pT3b	69 (13.8)	29 (42.0)
pT4	19 (3.8)	17 (89.4)
pN+	6 (1.2)	4 (66.6)
No. positive margins		95 (19.0)
Apex		46 (48.4)
Bladder neck		16 (16.8)
Lateral		8 (8.4)
Posterior lateral		5 (5.3)
Seminal vesicles		8 (8.4)
Multilocular		12 (12.6)

Table 6. Oncological outcome of laparoscopic radical prostatectomy: PSA recurrence ($n = 500$)

Pathological stage	*N* (%)	PSA recurrence (%)
pT0/1	9 (1.8)	1 (11.1)
pT2a	95 (19.0)	3 (3.2)
pT2b	201 (40.2)	13 (6.5)
pT3a	107 (21.4)	17 (15.9)
pT3b/4	88 (17.6)	21 (23.9)
pN+	6 (1.2)	2 (33.3)
No. PSA recurrence (%)		55 (11.0)
Mean interval to recurrence (months)		20.8(6–36)
PSA-free survival at 3 years (%)		225/271 (83.0)
pT2		237/249 (95.2)
pT3a		43/58 (74.1)
pT3b/4		40/58(69.0)
PSA-free survival at 5 years (%)		30/41 (73.1)
pT2		17/19 (89.5)
pT3a		9/11 (81.2)
pT3b/4	6/11 (54.5)	

Positive Margins. In 95 (19.0%) specimen, positive margins (SM+) were found ranging from in two of 95 (2.1%) pT2a-stages, 20 of 201 (9.9%) pT2b-tumors, 27 of 107 (25.2%) pT3a-tumors, 29 of 69 (42.0%) pT3b-tumors, to 17 of 19 (89.4%) pT4-stages. The majority of positive margins were located at the apex (48.4%) and bladder neck (16.8%), whereas in 12.6% multifocal SM+ were diagnosed (Table 5).

PSA Relapse. According to the pathological result (i.e., pT3b, N+, SM+), 115 (22.3%) patients received adjuvant antiandrogen therapy. PSA relapse (0.23–577 ng/ml) was observed in 55 patients (11.0%) after a mean interval of 20.8 months (6–36). The incidence of PSA recurrence varied from 3.2% in pT2a, 6.5% in pT2b, 15.9% in pT3a to 23.9% in pT3b/4 stages. Cumulative PSA progression-free rates were 83.0% at 3 years (225 of 271 patients) ranging from 95.2% for pT2 tumors to 69.0% for pT3b/4 stages, and 73.1% (30 of 41 patients) at 5 years with a range from 89.5% for pT2 to 54.5% for pT3b/4 stages (Table 6).

Survival. Local recurrence was evidenced by biopsy (TRUS-guided, TUR) or imaging studies (PET scan, MRI) in 12 (2.4%) cases, whereas distal metastases (five bone, one liver) were documented by bone scan, ultrasound and X-ray in six (1.2%) patients. Secondary treatment in case of PSA progression and/or clinical symptoms consisted of antiandrogen therapy (following no or intermittent treatment) in 12 cases, local radiotherapy in six cases, radiotherapy of bone metastases in two cases, chemotherapy (i.e., docetaxel, estramustine) in four cases and bisphosphonates in six cases. Of all 1,029 men, two patients (pT3b, pT4) died due to progression of the disease (21 and 36 months postoperatively), yielding an overall 3-year cause-specific survival of 99.6%. Five patients died because of other causes (carcinoma of the liver ($n = 2$) and rectum, plasmocytoma, cerebral aneurysm) resulting in an overall 3-year all-cause survival of 98.6%. No port site metastases were observed (Table 7).

Table 7. Oncological outcome of laparoscopic radical prostatectomy: clinical progression and survival ($n=500$)

Criteria	*N* (%)
No. adjuvant antiandrogen therapy (%)	115 (23.0)
Clinical evidenced progression (%)	18 (3.6)
Local recurrence	12 (2.4)
Distant metastases (bone, liver)	6 (1.2)
at 3 years	11/271 (4.1)
at 5 years	4/41 (9.8)
No. secondary treatment	18
Antiandrogen therapy	12
Radiation	6 [a]
Chemotherapy	4+
Overall all cause survival (%)	98.6
Disease-specific survival (%)	99.6

[a] Two patients received radiotherapy and antiandrogen therapy for distant metastases; all four patient underwent simultaneous antiandrogen deprivation

Aspects of the Learning Curve

At our institution the laparoscopic radical prostatectomy is performed by three generations of surgeons:

First generation	The pioneer of the technique
Second generation	Primary training in open radical prostatectomy, secondary training in laparoscopy by the pioneer
Third generation	Primary training in laparoscopic radical prostatectomy, trained by the first two generations

To analyze the influence of standardization and to prove the reproducibility of the procedure, we compared the first 450 laparoscopic radical prostatectomies of the first-generation surgeon (in groups of 50), the first 100 of the second generation (in groups of 50) and the first 50 of the third generation.

Perioperative Data

With regard to the operation time, the data of the first-generation surgeon showed a significant reduction from initial 324 min to an average of 184 min for the last 50 cases analyzed (179 min without pelvic lymph node dissection). The initial data of the second- and third-generation surgeons revealed a time reduction of about 60 min compared to the time required by the first-generation surgeon (Fig. 8). Whereas the transfusion rate of the first-generation surgeon decreased step by step from initially 48% to less than 10%, the rate of the second generation surgeon showed a decline of 60% already for the operations 51–100. The initial percentage of transfusion of the third-generation surgeon was more than 30% lower compared to the first two generations. The initial conversion rate was 8% for the first-generation surgeon; the following generations had to convert in a maximum of 4%. The number of complications did not differ within the three groups (Fig. 9).

Functional Data

During the first 50 cases of the first-generation surgeon, 66% of the urethral catheters were removed within 14 days; this increased to 92% for patients 51–

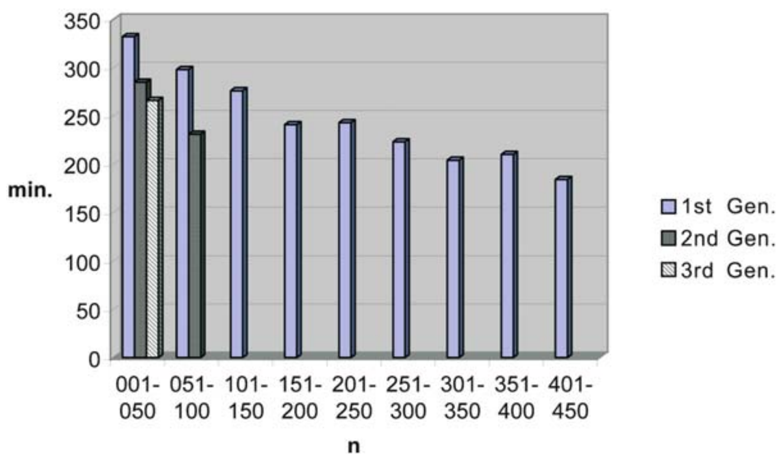

Fig. 8. Operation time in the three generations of surgeons

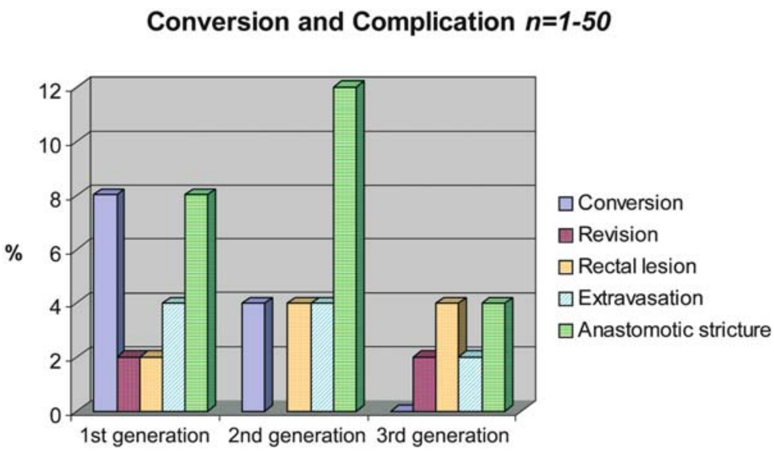

Fig. 9. Initial conversion and complication rate

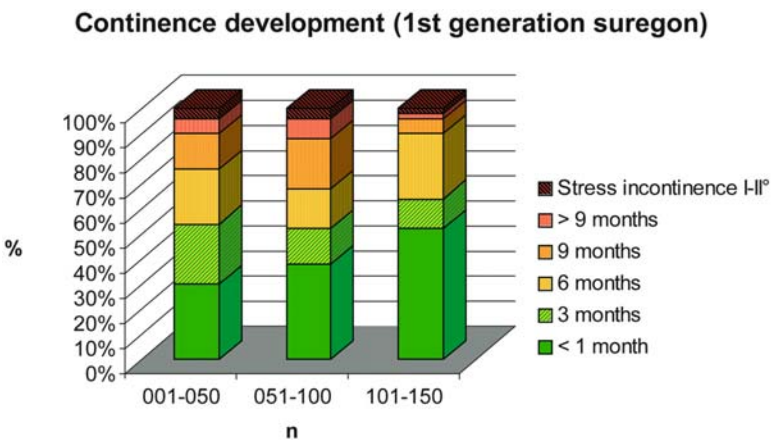

Fig. 10. Continence rates

100. The initial data of the following generations were comparable. Furthermore, a continual increase in early continence was observed within the learning curve, leading to a continence rate of 96% for the cases 101–150 of the first-generation surgeon's patients (Fig. 10).

Oncological Data

There was no difference in positive surgical margins comparing the initial data of all generations (maximum of 21%).

Discussion

Since its introduction in 1999, there has been an ongoing discussion about the benefits and hazards of laparoscopic radical prostatectomy [10–14]. On the one hand, laparoscopic radical prostatectomy transfers the well-known advantages of laparoscopy such as minimal morbidity and short recovery; on the other hand, the laparoscopic technique is demanding and includes a learning curve which is, even for laparoscopic centers of expertise, longer than for laparoscopic nephrectomy or other indications (not surprisingly comparing open nephrectomy and open prostatectomy). Furthermore, the experts of open retropubic prostatectomy define the (high) level concerning oncological and functional outcome of the patients that has to be reached by laparoscopy.

To evaluate the influence of experience and standardization, we compared the early and late data of our series of laparoscopic radical prostatectomy. Furthermore there was a reduction of early and late complications. In particular, the rates of conversion and reintervention decreased to 0.3% and 1% (Table 2). We should mention that these reductions in morbidity were seen within our first 300 patients, which underlines the prolonged learning curve of the laparoscopic approach to the prostate.

Another argument against laparoscopy is that laparoscopic radical prostatectomy is mainly performed by the pioneers and experts of this technique and, therefore, the technique is not transferable to the majority of urologists [15]. At our institution, three generations of laparoscopic surgeons are performing this procedure. The initial data of all three groups are comparable concerning the complication rate (Fig. 9) as well as oncological and functional data. Furthermore, the initial data on operation time, transfusion rate and conversions are lower in the groups of learners compared to the early data of the teacher, documenting the benefit from a standardized technique and the experience of the senior surgeon.

Certainly, comparable to open surgery, there is still a potential for further improvements in technique and performance. The basis of ablative and, especially, reconstructive laparoscopic surgery is adequate training and understanding of the geometry of laparoscopic suturing. As already shown, practice in suturing techniques will reduce the time required for reconstruction and, thereby, the overall surgery time [16].

Improving the laparoscopy training program will be the goal for a wider acceptance of the technique. Besides training in the pelvitrainer and hospitalization at a center of expertise, the use of telementoring techniques could bridge the gap between training under guidance and performing the first cases without the expert.

Telepresence surgery may become the solution in the future and the systems available (ZEUS Computer Motion, Sunnyvale, CA, USA; DA VINCI Intuitive Surgical, Sunnyvale, CA, USA) proved already to be effective in laparoscopic surgery, but the major drawback of these systems are still the high operation costs [17–20].

The evaluation of the oncological outcome of recent technical modifications of open radical prostatectomy (i.e., nerve-sparing techniques, bladder neck sparing) is also based on the same limited follow-up. Since the overall results on the different series mainly depend on the case selection (i.e., with or without adjuvant radiation or antiandrogen therapy), a comparison with the current literature should be based on a stratification according to the pathological stage (pT2 vs pT3).

Surgical margin status is one of the well-defined pathological predictors of outcome following radical prostatectomy. Positive margins can occur either because of inadequate surgery for cancer extended outside the prostate (i.e., nerve-sparing) or surgical incision into subcapsular cancer. For an objective evaluation of the positive margins, the specimen should be stained with two different colors for each lobe and examined with gross sections according to the Stanford protocol [9]. We could not detect a significant difference when comparing the rate of positive margins after open or laparoscopic radical prostatectomy, neither for pT2 stages (2.1%–16.4% vs 7.9%–21.9%, respectively) nor pT3 tumors (26.4%–67.7% vs 31.1%–45.7%, respectively). However, there is a remarkable range in the different series (Table 8). A recent paper found a higher positive margin rate after laparoscopic radical prostatectomy among junior surgeons compared to experienced surgeons (34% vs 19%) [21]. In our recently published comparative study, the overall rate of positive margins (SM+) did not differ significantly in the open vs the early and late laparoscopic group (28.7% vs 21.0% vs 23.7%, respectively) [22]. On the other hand, Katz et al. were able to reduce the rate of positive margins continuously after technical changes of laparoscopic radical prostatectomy: including wide resection of the bladder neck and cutting the puboprostatic ligaments [23]. In accordance with our own observation, nerve preservation did not increase the incidence of positive margins.

In our series, the PSA value was determined on the 10th postoperative day, after 3 weeks, and then every 3 months. If not performed in our laboratory, the data were obtained by telephone contact or transmitted via fax from the referring urologist. In the series of open retropubic prostatectomy, patients were usually followed every 3 months in the 1st year, and every 6 months until year 5 [24–28]. PSA relapse, defined as increase of serum levels above 0.2 ng/ml, was observed in 4.8%–11.0% of pT2 stages and 28.4%–43.2% of pT3 tumors 3 years after laparoscopic radical prostatectomy (Table 8). Oncological studies after open prostatectomy usually present a longer follow-up, ranging from 5–15 years [24–28]. We have analyzed the Kaplan-Meier curves of the respective articles to calculate 3-year results. This revealed similar results for open radical prostatectomy (3.7%–15% for pT2 and 14.7%–42.0% for pT3 stages) compared to the laparoscopic series. Even our preliminary 5-year data did not differ from the respective open series (Table 8).

Table 8. Laparoscopic vs open radical prostatectomy: oncological results in the literature

Authors	*N*	Positive margin (%)		PSA recurrence (>0.2)				Clinical progress	
		pT2	pT3	At 3 years		At 5 years		At 3 years	At 5 years
				pT2	pT3	pT2	pT3		
Laparoscopic radical prostatectomy									
Salomon [34]	137	21.9	40.8	9.6	43.2	NA	NA	NA	NA
Roumeguere [35]	85	7.8	45.7	8.6 [a]	11.4 [a]	NA	NA	NA	NA
Guillonneau [29]	1,000	15.5	31.1	11.0	33.0	NA	NA	NA	NA
Present series	500	7.4	31.8	4.8	28.4	10.5	31.8	4.1	9.8
Open radical prostatectomy									
Catalona [28]	1,778	20.9		7.5	21.3	10.0	31.3	NA	4.5
Huland [24]	789	14.9	36.5	6.8	27.7	7.7	NA	NA	NA
Han [26]	2,494	NA	26.4	15.0	25.0	25.0	NA	NA	4.0
Hull [27]	1,000	12.8		4.4	14.7	5.1	24.7	NA	10.1
Salomon [34]	264	16.4	44.3	6.8	42.0	NA	NA	NA	NA
Roumeguere [35]	77	7.3	67.7	6.9 [a]	14.7 [a]	NA	NA	NA	NA
Harris [25]	508	2.1	47.8	3.7 [b]	33.1 [b]	NA	NA	6.9	NA

NA not available
[a] Results at 1 year;
[b] Results at 4 years

Consistent with other contemporary open series [24–28] and the Montsouris experience following laparoscopic radical prostatectomy [29], our data demonstrate that advancing Gleason score indicates adverse outcome. Conclusively, the prognostic factors (i.e., pathological stage, Gleason score, surgical margins) of the few existing laparoscopic series are the same as those previously described for the open retropubic approach.

The data on clinical progression are difficult to compare because of the different follow-up, presentation and treatment schedules in case of PSA failure and clinical progression (i.e., antiandrogen therapy, radiotherapy, chemotherapy). Nevertheless, current data indicate that the oncological outcome after laparoscopic radical prostatectomy will not differ from open surgery. For example, the 5-year metastasis survival rates in our series (90.2%) are almost identical to the data of Hull et al. [27] following open retropubic prostatectomy (89.9%). More importantly, recent studies could not detect any specific oncological risk factors related to the laparoscopic technique, such as port site metastases [30].

Conclusion

After more than 1,000 cases at our institution and more than 5,000 worldwide, laparoscopic radical prostatectomy is a standardized therapeutic option for treatment of localized cancer of the prostate combining functional and oncological results comparable to open surgery with the well-known advantages of minimally invasive surgery such as low morbidity and fast recovery. Optimized training programs are required to transfer the technique and achieve a wider acceptance.

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6.5 Robotic Radical Prostatectomy: Surgical Technique

Mani Menon, Michael J. Fumo, Ashok K. Hemal

Contents

Introduction

Medical science is very adept at adapting technological advances to its own needs in promoting patient care. Recent advances in robotics have been translated to medicine with the use of robotic assistance in surgery [1]. The degree of robotic assistance has grown by leaps and bounds over the last decade from the use of simple robotic tools, to camera holders, to remotely controlled robotic instruments. Robotic advances make even the possibility of remote telesurgery a reality [2, 3]. Furthermore, robotic instruments offer a degree of preciseness and dexterous maneuverability unmatched even by the human hand [4].

As robotics has advanced, the new field of minimally invasive surgery via laparoscopic access has matured as well. Laparoscopy has allowed successful advancements in diagnostic, ablative and reconstructive procedures while keeping with a goal of minimal invasiveness. The true potential of both robotics and laparoscopy can now be met with the joining of these two technological advances to perform technically demanding reconstructive procedures in a minimally invasive manner. Various urologic procedures have been retailored to a laparoscopic approach, the most difficult of which is laparoscopic radical prostatectomy, which at one time was considered impossible [5]. It has since been shown to be feasible and successful [6, 7]. The addition of robotics has allowed greater access to laparoscopic radical prostatectomy while improving upon it with the benefits innate to robotics. Minimally invasive surgery has now evolved from simple laparoscopic surgery to robot-assisted laparoscopic surgery.

Robot-assisted laparoscopic radical prostatectomy is now standardized following the basic tenets of anatomic prostatectomy [8] and laparoscopic surgery [9]. Using the daVinci system (Intuitive Surgical, Mountain View, CA, USA) Menon et al. have now performed over 100 cases of robotic radical prostatectomy (popularly known as Vattikuti Institute Prostatectomy – VIP), the largest series in the world [4, 10–12]. This chapter will discuss the technique of robotic radical prostatectomy using the daVinci robot along with its advantages and disadvantages as performed at the Vattikuti Urology Institute.

The Robot

The daVinci system is a truly complex piece of machinery, yet the machine's design offers great benefits in its ease of use by translating the surgeon's movements into laparoscopic robotic movements. The system is comprised of a number of parts, starting with the control center or the surgeon's console. The console uses the InSite Vision System to display 3D images in the orientation of open surgery while combinations of hand and foot controls organize the machine's movements. The surgeon's fingertip movements are transposed to the tiny robotic instruments, while the foot pedals in combination with the hand controls command the camera and electrocautery. The movements have motion scaling and tremor elimination to maximize surgical precision. The surgical arm cart is designed for easy set-up and access to the patient. The two instrument arms are designed for real-time responsiveness and agility without the use of the patient's body wall for leverage, thus minimizing tissue damage. The single endoscope arm is designed to be steady and strong. Each arm has multiple positioning joints to easily access any patient anatomy. The instruments are termed EndoWrist, which describes their dynamic articulations that provide the dexterity of the human wrist at the instrument tip. The movements are all controlled via high-strength cables that function like the tendons in the hand. Most importantly, there are multiple tip designs for a wide range of procedures, and the instruments are designed for quick release to speed instrument changes intraoperatively. Finally, the all-important InSite image-processing equipment is the key to the 3D image. It comprises of two high-intensity illuminators to ensure a bright image of the operative field, two camera control units to enhance color and contrast of image, and two image synchronizers to maximize clarity and resolution of image.

Indications and Contraindications

Robotic radical prostatectomy follows the tenets of open radical prostatectomy in the treatment of patients with localized carcinoma of prostate (T1, T2) based on their PSA, Gleason score and digital rectal examination. Patients should be medically fit to undergo surgery, preferably have a body mass index less than 30, and have had minimal previous abdominal surgeries. Obesity is not a contraindication to this approach; however, in the few cases when this criterion has been relaxed, with patients weighing as much as 320 lb (145 kg), the difficulty level has increased significantly. Previous abdominal surgery alone is also not an exclusion criterion. Multiple surgeries with the possibility of numerous adhesions or a hostile abdomen should give the surgeon pause to consider the best approach. Approximately one-third of our patients have had previous abdominal surgery; however, the basic tenets of laparoscopic access guide us, and the need for a limited lysis of adhesions is commonplace, yet not restrictive to the robotic portion if done correctly. In 5%–10% patients, surprisingly adhesions are seen even in the absence of previous abdominal surgery. The characteristic of the prostate must also be taken into account. The size of the prostate can greatly affect difficulty in that a small prostate, less than 20 g, often will not have the classic landmarks one uses visually during dissection. Even though we have performed VIP on patients with prostates as large as 190 g, we have found that large prostates greater than 100 g can make dissection difficult as angles of vision and approach of instruments can become too acute for access. A narrow pelvis can lead to the same difficulties with average-sized prostates. Other important considerations are a history of recurrent prostatitis, neoadjuvant hormonal therapy, or repeated prostatic biopsies, especially close to the time of surgery, as these factors can leave periprostatic tissue fibrosed and sticky, thus making dissection in that area much more difficult. Overall a previous history of surgery or complicating prostatic factors are not contraindications to robotic radical prostatectomy; however, they do need to be taken into account in the operative planning. Operative position should be taken into account for patient screening, as the steep Trendelenburg position with a thoracic wrap and relative dehydration intraoperatively may exclude patients with cardiac and pulmonary comorbidities from this approach.

Robotic Radical Prostatectomy: Technique

Preparation

Preoperatively the patient is prepared with a standard antibiotic prophylaxis consisting of a third-generation cephalosporin. Prophylactic antithrombotic therapy is necessary as well, considering the risk factors of this procedure for DVT, including cancer, pelvic surgery, prolonged immobilization, laparoscopy and steep Trendelenburg positioning. Sequential compression devices are routinely placed during surgery, and a single subcutaneous injection of 5,000 IU of heparin should be given before surgery. Bowel preparation is not necessary, but it is preferable to give a laxative the night before so the patient moves his bowels prior to surgery helping to decompress the lower intestines. Lastly, a skin preparation per surgeon preference is optional.

Patient Positioning

General endotracheal anesthesia is mandated given the laparoscopic nature of the surgery as well as the patient's positioning. An orogastric tube is also placed for the duration of the case and removed at the time of extubation. The patient is placed in a supine, modified lithotomy position with his arms at the sides of his body to avoid the risk of brachial plexus injury. This will then be transferred to a steep Trendelenburg position (Fig. 1). The patient should be supported via a thoracic wrap, which more comfortably supports the patient without placing undue pressure on the shoulders and causing postoperative pain. The legs are separated in flexion and abduction because the length of the robotic arms necessitates bringing the robotic stand in between the legs. Care is taken to adequately pad the pressure points and lower extremities. The abdomen, genitalia, and upper thighs are prepped with an iodine-based preparation and draped. An 18F Foley catheter is inserted in the sterile field, and the bladder is drained.

Laparoscopic Port Placement

Proper port placement is imperative for adequate robotic access to the pelvis. Three ports are required for the robotic arms and two to three ports for the assistants. Throughout our series we have performed surgeries employing a left and right assistant as part of our residency training process, thus necessitating three assistant ports; however, the procedure can just as easily be completed with only a right-side assistant, thus decreasing the number of assistant ports to two. First, initial access to the peritoneum is gained via a Veress needle, and then, after raising initial pressures to 20 mmHg for the placement of ports, the Veress needle is replaced with 12-mm trocar and a 30° laparoscope is inserted to transilluminate the abdominal wall. The rest of the ports are then placed under direct vision starting with the two 8-mm metal trocars for robotic arms, which are placed 3–5 cm below the level of the umbilicus, lateral to the rectus muscle on either side. Next, a 12-mm trocar for passing needles, removing biopsy tissue material, and introducing the Hem-o-Lok (Weck, Triangle Park, NC, USA) clips, etc., is placed in the mid-axillary line, 2.5 cm above the right iliac crest for the right-side assistant. A 5-mm trocar is placed between the camera port and the right-side robotic port while a second 5-mm trocar is then placed in left iliac fossa 5 cm above and lateral to the anterior superior iliac spine, each of which is for use by that side's respective assistant. It is important to remember that the position of each trocar's insertion may vary from patient to patient, as the

Fig. 1. General positioning in steep Trendelenburg with legs in flexion and abduction to provide space for daVinci placement. Note thoracic wrap support

anatomy of port placement varies based on height, weight, and previous operations. Great care is taken to place the ports under direct vision and any adhesions should be taken down to facilitate this. It is noteworthy that there are often physiologic adhesions in the left lower quadrant as well as around the cecum, and these adhesions should be released first, to allow proper port placement, and second, to permit easy passage of instruments into the pelvis and thus avoid unnecessary trauma to the bowels. The release of these pelvic adhesions will later aid in lymphadenectomy as well.

Bladder Mobilization

After all laparoscopic ports have been placed with dissection and removal of any adhesions, attention is then focused on entering the preperitoneal space. With the camera aimed 30° up, an inverted U-incision is made using the cautery hook so that the horizontal part of the incision is high enough on the anterior wall of the abdomen to preclude injury to the bladder and each vertical limb is located lateral to the medial umbilical ligament (Fig. 2). This dissection is performed in the avascular plane involving the dissection of adipose and loose areolar tissue. The first landmark visualized is the pubic bone, and dissection is completed laterally on either side, anteriorly and completely exposing the endopelvic fascia bilaterally.

Apical Dissection

The endopelvic fascia is incised at the point where it reflects over the pelvic side wall, thus exposing the levator ani muscle, which can then be gently dissected laterally to expose the lateral surfaces of the prostate (Fig. 3). The incision is then extended towards the apex of the prostate to expose the dorsal vein, the urethra, and the striated urethral sphincter. The puboperinealis muscle covers the urethra and is the most anteromedial component of the levator ani; it has a special role in the urinary continence mechanism [13]. It is dissected bluntly from the apex of the prostate, thus exposing the urethra. The urethra should be dissected as little as possible and freed at the apex of the prostate from its underlying neurovascular bundles bilaterally using only blunt dissection. Many small arterial and venous branches of the pudendal vessels are often encountered during this dissection and should be controlled with robotic bipolar forceps cautery.

Puboprostatic Ligament Division and Dorsal Venous Complex Control

Now that the anterior-lateral surfaces of the prostate and bladder are exposed, the camera is changed to a 0° lens. The fat over the prostate is then swept cephalad and laterally. In an effort to maximize continence, we routinely do not divide the puboprostatic liga-

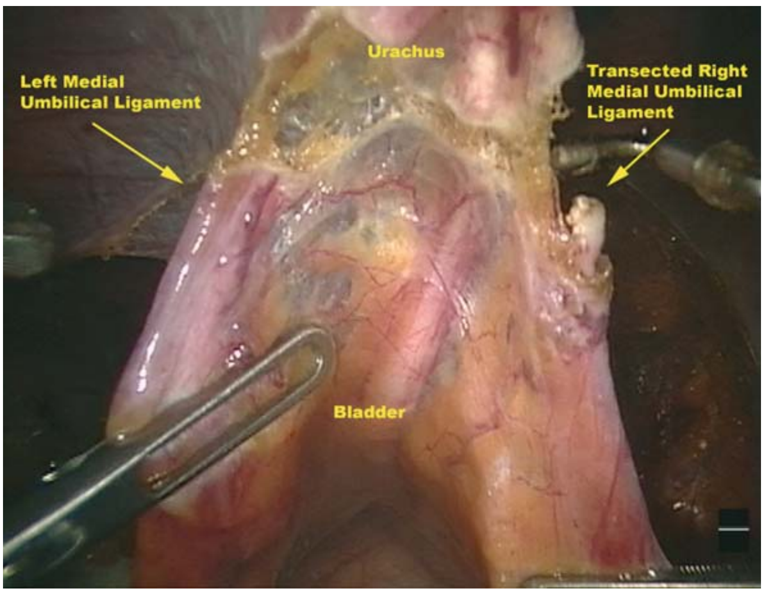

Fig. 2. Mobilization of bladder with lateral aspects dissected free, revealing pubic symphysis while transverse incision of median umbilical ligaments and urachus is in progress

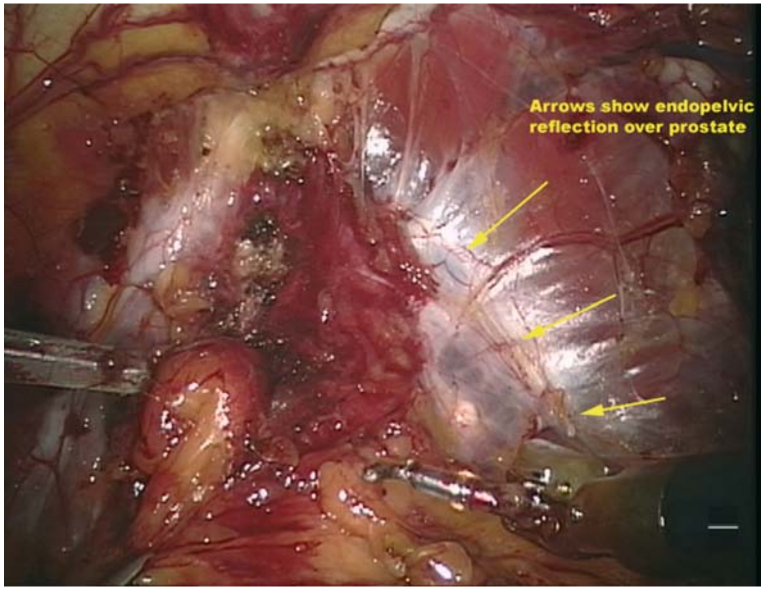

Fig. 3. Endopelvic fascia view prior to incision and mobilization of levator ani muscle

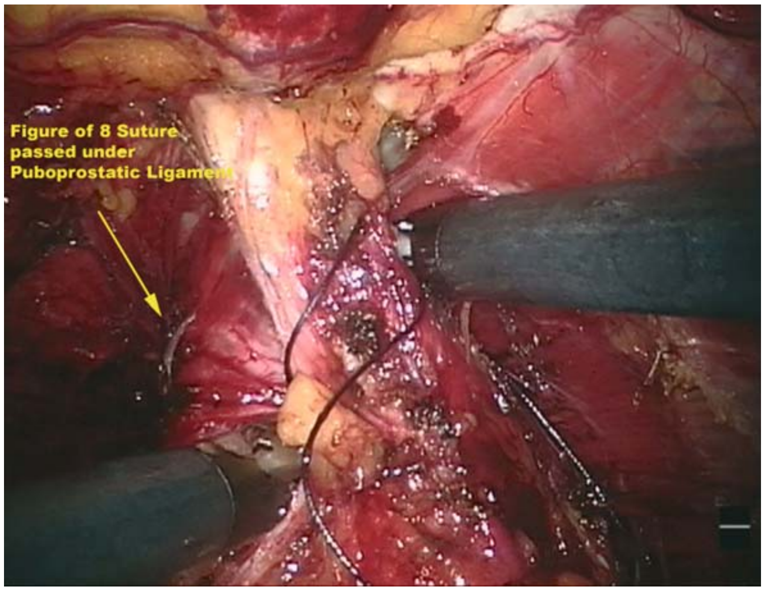

Fig. 4. Ligation of dorsal venous complex with figure-eight suture passed behind the preserved puboprostatic ligament

ments, given that our exposure is excellent even with the ligaments intact [14]. A 0 Vicryl suture on CT-1 needle is used to ligate the deep dorsal vein located behind the puboprostatic ligaments while attempting to exclude the puboprostatic ligaments (Fig. 4). Technically this is performed by passing the needle under the dorsal vein from one side to the other, and then it is grasped from the contralateral side, passed above the dorsal vein complex and under the puboprostatic ligaments. This way the ligaments are not included in the suture and a tighter knot may be created. One suture usually suffices; however, occasionally a second suture is needed for hemostasis. Next, a deep biting suture is placed horizontally across the anterior surface of the prostate through the anterior commissure near the base to prevent back bleeding and to serve as a retraction point as the ends of stitches are cut long.

Bladder Neck Dissection and Division

Moving forward with our dissection, we change over to a 30° angled lens directed downward for the bladder neck dissection. The identification of the bladder neck can be very difficult given that only vision can be depended on to find the junction. We employ multiple visual clues to find the proper plane of dissection. The long ends of the previously placed anterior deep dorsal vein sutures are grasped with a laparoscopic needle holder by an assistant and then retracted tautly contralateral to the side of dissection so as to identify junction between the floppy bladder and the solid prostate. The movements of an inflated balloon inside the bladder may also aid in this maneuver. There is a shiny smooth pad of fat that also helps to demarcate the prostatovesical junction. Starting laterally with a hook, gentle blunt dissection is employed to find the area where the shiny prevesical fat ends and to then make an incision there, which is then duplicated on the contralateral side. The stay suture is then held up anteriorly and taut so as to make the bladder neck prominent, and both lateral incisions are then joined horizontally, thus dividing the anterior bladder neck in the mid-line. As the dissection is carried down, the catheter should be encountered, and after deflating the balloon, the tip of the Foley catheter can be delivered through this opening (Fig. 5). The tip of the Foley catheter can then be grasped by an assistant and retracted upwards so as to help visualize the rest of the dissection as the posterior wall of the bladder neck is divided. Great care must be taken at this point to localize and avoid the ureteral openings so as to avoid damage and to maintain a clear, wide detrusor margin for subsequent vesicourethral anastomosis. Larger prostates or prostates that have a large median lobe often distort the anatomy, which not only makes both the posterior and apical dissection difficult, but also may leave a large defect in the bladder that requires reconstruction prior to the vesicourethral anastomosis.

Posterior Dissection

The camera continues to be a 30° lens directed downward. The previously made incision in the posterior bladder neck will lead to Denonvilliers fascia and is therefore followed down. An assistant grasps the tip of the Foley catheter and retracts upwards, thus exposing the space posterior to the prostate. Dissection is carried down until the ampulla of the vas deferens and seminal vesicles are encountered (Fig. 6). The vas deferens should be divided before commencing with the dissection of the seminal vesicles. The seminal vesicles are dissected using both blunt and sharp skills with the aid of retraction from the assistants. One

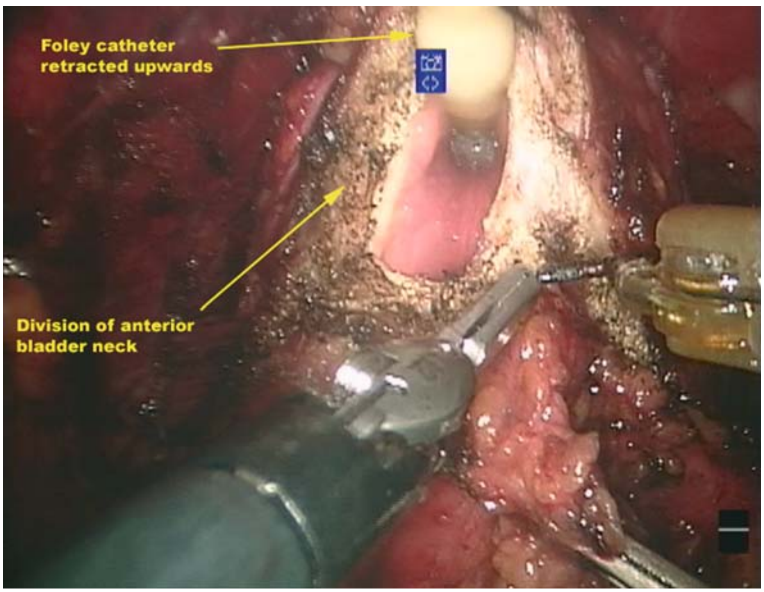

Fig. 5. Divided anterior bladder neck dissection with catheter retracted upwards to expose division of posterior bladder neck

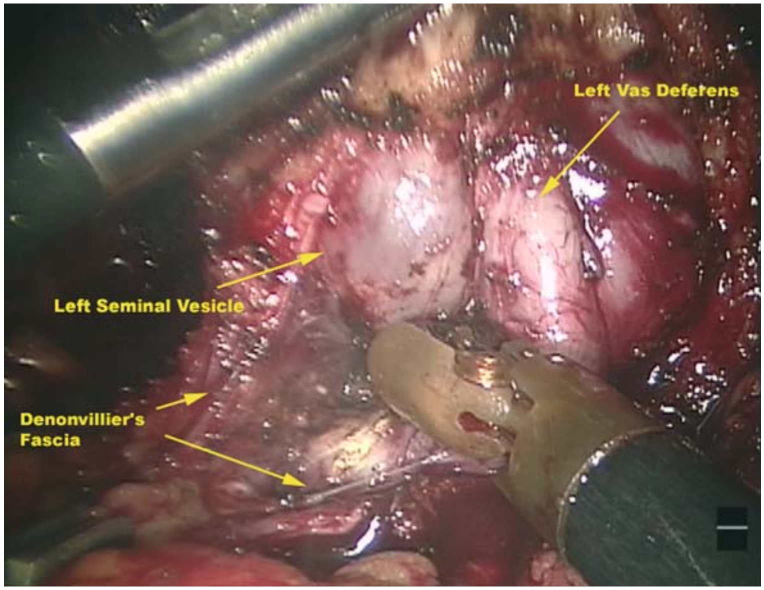

Fig. 6. Exposure after division of posterior bladder neck and Denonvilliers fascia showing seminal vesicle and vas deferens

must be mindful of the artery to the vas, which passes between the vas and the seminal vesicle and requires control before the seminal vesicle can be fully dissected free to its base. Attempts should be made to use minimal electrocautery so as to avoid heat or electrical injury to the neurovascular bundles. Both seminal vesicles are freed circumferentially. The seminal vesicles and vas are now used as a leverage point to retract the entire prostate upwards, thus exposing the prostatic pedicles. The pedicles are well vascularized and can be controlled prior to their division with two Hem-o-Lok clips or with bipolar forceps and round-tipped robotic scissors. Lastly, the seminal vesicles are lifted up anteriorly to demonstrate the longitudinal fibers of Denonvilliers fascia near the apex of the prostate so that a transverse incision can be made deep enough to appreciate the prerectal fat posteriorly, thus completing the posterior dissection.

Nerve Sparing

The camera continues to be 30° directed downward while the robotic arms are left as articulated scissors and bipolar forceps. The packet of tissue containing the neurovascular bundles is freed, starting by incising the lateral pelvic fascia anterior-medially and parallel to the neurovascular bundles between the prostatic venous plexus and the prostatic capsule. The posterolateral surface of the prostate is sharply cleared by dropping a layer of fascia, fat, nerves, and blood vessels from the base and working towards the apex. Most of the dissection occurs in a relatively avascular plane, such that the neurovascular bundles can be freed from the prostate laterally and easily without the use of cautery. If needed, bipolar cautery alone can be used to control dissected, isolated vessels. The neurovascular bundles should now be completely freed of the prostate since each step in the dissection has been optimized in view of nerve preservation (Fig. 7).

As the development of our approach has evolved, we have made some important technical modifications. One of the most important is an attempt to spare the accessory penile and cavernosal nerves, which may course along the side of the prostate. Animal and human studies suggest that there may be accessory cavernosal nerves that run underneath the lateral pelvic fascia on the anterolateral surface of the prostate [15]. These nerves may be physiologically relevant in erectile function. Given the improved vision and robotic manipulation, it is feasible to dissect this lateral fascia free of the prostate. In young patients without significant risk for extraprostatic extension, the lateral periprostatic fascia is preserved, creating a veil of tissue, the Veil of Aphrodite.

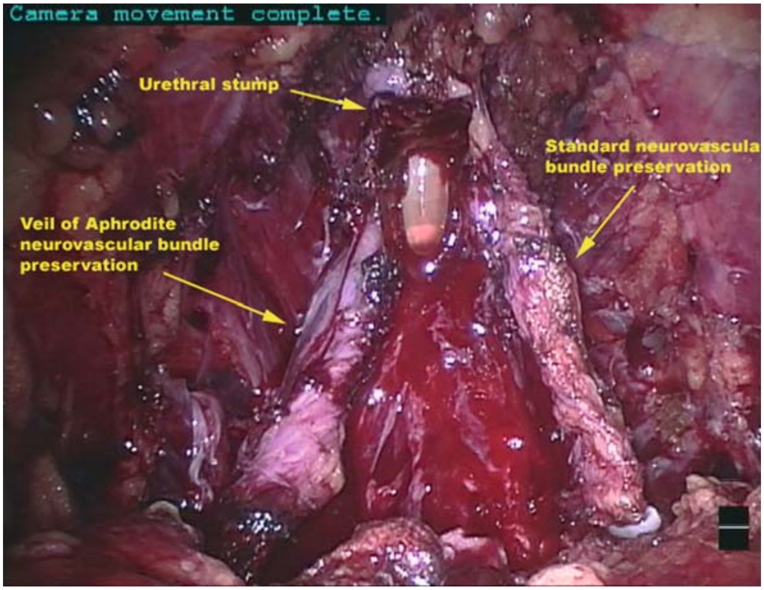

Fig. 7. Apical dissection and urethral transection with preserved neurovascular bundle/veil of Aphrodite

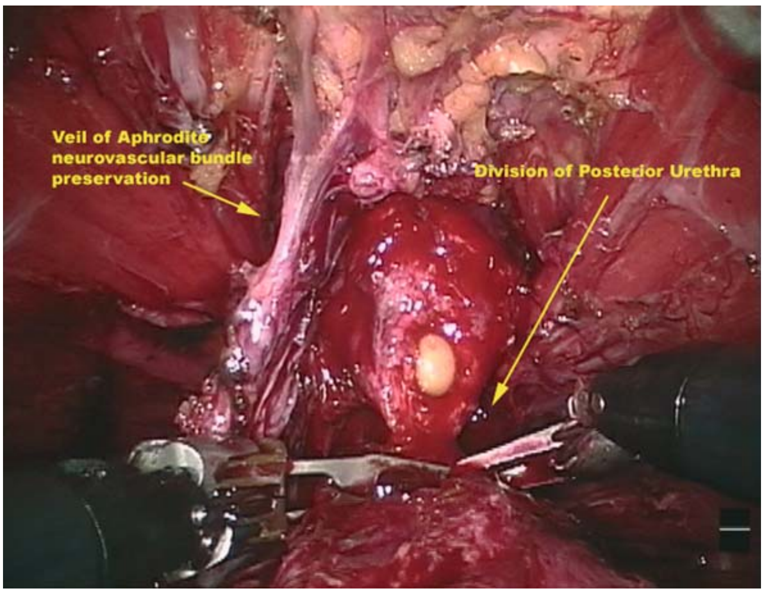

Fig. 8. View after right standard nerve sparing and left veil of Aphrodite nerve sparing

Urethra Division

The urethra should now be the last connection remaining to the prostate. At this point the camera is changed to a 0° lens. Once again the long ends of the previously placed anterior deep dorsal vein sutures are grasped and retracted cephalad so as to stretch the urethra and dorsal vein complex, thus making them prominent and taut. The previously ligated dorsal venous complex is now divided with scissors proximal to the puboprostatic ligaments, and the incision is continued to divide the urethra at the apex of the prostate. Great care is taken to preserve as much urethral stump as possible to facilitate anastomosis. With the anterior urethral wall divided, the catheter is retracted out and care is taken to ensure that the neurovascular bundles have been freed laterally such that the last remaining tissue, posterior urethral wall and the rectourethralis muscle can be sharply incised (Fig. 8).

Parietal Biopsies

Given the constraints of the anatomic dissection, we believe in biopsies at the margins. Parietal biopsies from the anterior, posterior and lateral margins of the urethra as well as from the bladder neck are sharply excised and sent for frozen section. Depending upon the results of the biopsies, the margins are further resected as appropriate.

Lymphadenectomy

Bilateral pelvic lymphadenectomy is performed in the standard fashion. This step is performed with a 0° and occasionally a 30° lens directed downward for proximal dissection, especially at the bifurcation of common iliac vessel. The internal inguinal ring can easily be seen, and laterally the external iliac vessels are hidden in a lateral fold of the peritoneum. The peritoneal incision is extended posteriorly as far as needed, now lateral to the medial umbilical ligament and medial and inferior to the internal inguinal ring. The nodal package will be lifted off the anterior surface of the external iliac vessels medially. Starting at the medial border of the external iliac vein, the nodal packet is cleaned medially, and careful dissection continues along its inferior border until the obturator nerve is identified. The obturator nerve serves as the inferior margin of dissection. This nodal package contains the external iliac and the obturator nodes. In most patients, a third packet of nodes, the internal iliac group, posterior to the obturator vessels and anterior to branches of the internal iliac vessels, is also recovered. The anterior aspect of the nodal packet is dissected starting near the pubic ramus, and electrocautery is used as needed to control bleeding. Dissection continues to release the nodal packet posteriorly, with gentle traction medially to give the best exposure (Fig. 9). The accessory obturator veins should be avoided, as they are frequently present and need to be clipped or cauterized if encountered. Last, the packet of fibrous fatty and nodal tissue, which is normally contained as one piece, is dissected down towards the intersection of the external iliac vein, the obturator nerve, and the umbilical ligament. Each nodal package and the prostate are now placed into a 10-mm Endocatch specimen bag (US Surgical, Norwalk, CT), and the bag is then placed in the left upper quadrant of the abdomen until the end of the procedure.

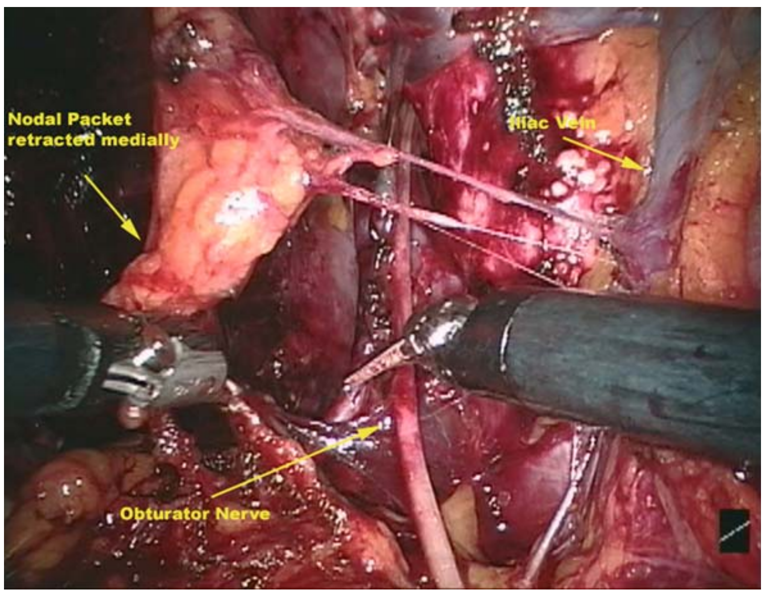

Fig. 9. Lymphadenectomy landmarks as nodal packet posterior dissection is completed

Vesicourethral Anastomosis

The vesicourethral anastomosis has evolved over the course of our experience. Initially it was performed with eight interrupted sutures; however, we have currently advanced to a continuous anastomosis [16]. The tails of two 3/0 poliglecaprone 25 (monofilament) sutures (one dyed and one undyed for ease of identification during anastomosis) on an RB-1 needle (Ethicon, New Brunswick, NJ, USA) are tied together extracorporeally. The total length of the suture varies according to the diameter of the bladder neck, and it may be anywhere from 15–20 cm as required. Thus, the final suture for anastomosis has a knot in the center and needles at either end of a dyed and an undyed suture. A 0° laparoscopic lens is employed with a left handed EndoWrist long-tip forceps and a right-handed EndoWrist large-needle driver. The anastomosis is begun by passing the needle outside-in at the 4 or 5 o'clock position on the bladder neck and inside-out on the urethra. After two or three throws on the urethra and three to four throws on the bladder to create an adequate posterior base, the suture is doubly locked and bladder is cinched down against the knot of the sutures lying on the posterior surface of the bladder (Fig. 10). At this point, the long-tip forceps is replaced with the large needle driver and the anastomosis is continued clockwise to the 9 o'clock position on the bladder. The suture is then turned into the bladder in such a way that it runs inside-out on the bladder and outside-in on the urethra to continue further up to the 11 or 12 o'clock position. Then the suture (dyed) is pulled cephalad towards the left lateral side of the pelvis and maintained under traction by an assistant. Subsequently, the anastomosis is started on the right side of the urethra with the undyed end, passing it outside-in on the urethra and then inside-out on the bladder, from the point where the anastomosis was started and continuing counter-clockwise to the point where the other suture is met. After the initial two throws with the undyed suture, it too is also doubly locked as previously performed with the dyed suture. The needle of the dyed end is cut off, and the free dyed end and undyed ends are tied together with several knots. The urethral catheter is used throughout the anastomosis as a guide in showing the urethral mucosa and finally is advanced into the bladder just before tying the sutures. The patency of the urethrovesical anastomosis is tested via instillation of 150–200 ml of water. If no leakage is seen the balloon of the Foley catheter is inflated. Sometimes bladder neck reconstruction is not deemed necessary prior to the anastomosis, but if after completing the urethrovesical anastomosis there remains an large opening, the bladder neck can then be refashioned with interrupted full thickness sutures of 3/0 absorbable sutures (Fig. 11).

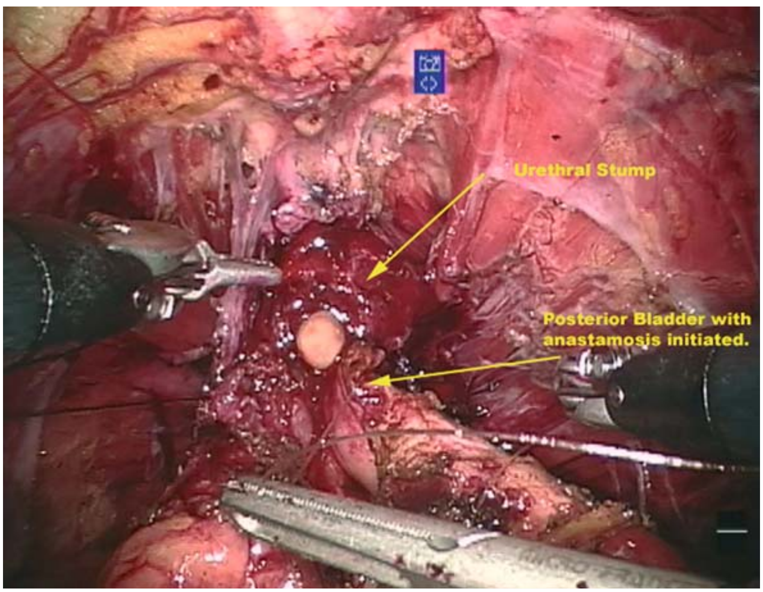

Fig. 10. Initiation of urethrovesical anastomosis posteriorly

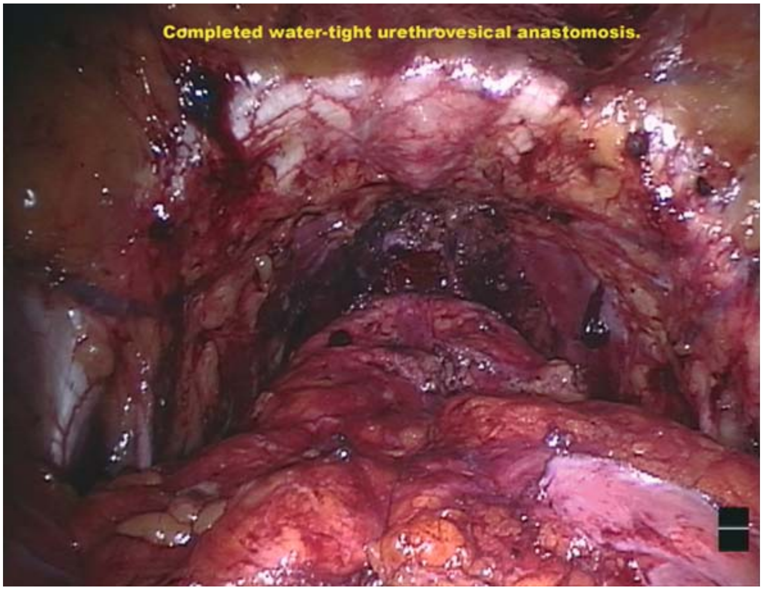

Fig. 11. Completed water-tight urethrovesical anastomosis

Specimen Retrieval and Port Closure

The specimen is extracted via the umbilical port with extension of the semicircular incision as needed. Fascial closure is performed only at this incision given its size. Since small noncutting trocars are used for all ports except the umbilical site, these other ports are closed with subcuticular skin sutures only. A Jackson-Pratt drain is left extending into the pelvis from one of the 5-mm ports.

Complications

Robotic radical prostatectomy has offered excellent results with minimal morbidity. There have not been any intraoperative complications or conversions to an open approach, and no patient has required intraoperative transfusion. Minimal venous thrombosis has been observed during our series, probably as a result of excellent perioperative prophylaxis and the fact that the transperitoneal approach makes lymphocele unlikely and thus secondary venous thrombosis unlikely as well. The fact that the peritoneum is in continuum with the urethrovesical anastomosis also places the bowels at risk for irritation and ileus secondary to anastomotic leak. Foley catheter drainage is usually sufficient treatment; however, there has been a need for postoperative drain placement to remove urine from the peritoneum in patients who present with abdominal distention until healing of the anastomosis is complete. There have been few port site hematomas, and when they do occur, they can all be managed conservatively. The risk of port site herniation is also a possibility; however, despite routinely closing only the fascia of the umbilical port, we have only had two port site hernias that required surgical repair.

Results

Review of outcomes after robotic radical prostatectomy has been quite promising. The vast majority of patients are discharged from the hospital within 24 h of surgery. Patients are discharged with a urethral catheter in place, which is usually removed within 7 days of surgery.

During our initial experience, we compared the results of open radical prostatectomy, laparoscopic radical prostatectomy with the VIP (robotic radical prostatectomy) technique at our center, and Table 1 compares the operative variables during radical, laparoscopic radical prostatectomy and VIP [3].

As we gained further experience, a study was designed as a single-institution, prospective, nonrandomized comparison of pathology, and functional outcomes, at baseline and during and after surgery, in 100 patients undergoing open radical prostatectomy

Table 1. Comparison of open radical prostatectomy, laparoscopic radical prostatectomy and robotic radical prostatectomy (VIP)

Variable	RRP (100)	VIP (200)	*P*
Mean (SD)			
Age, years	63.1 (42.8–72)	59.9 (40–72)	NS
Serum PSA, ng/ml	7.3 (1.9–3.5)	6.4 (0.6–41)	NS
Prostate volume, ml	48.4 (24.2–70)	58.8 (18–140)	NS
Clinical stage, %			
T1 a	0	0.5	NS
T1 c	59	49	
T2 a	10	10	
T2 b	35	39	
T3 a	4	1.5	
Gleason score			
Mean	6.6	6.5	NS
Mean BMI	27.6 (17–41)	27.7 (19–38)	NS
Previous abdominal and hernia surgery, %	19	20	NS
Charlson score	2.5	2.3	NS
Operative time, min	163 (86–395)	160 (71–315)	NS
Mean (range)			
Estimated blood loss, ml	910 (200–5,000)	153 (25–750)	< 0.001
Mean (range)			
Postoperative pain score	7 (4–10)	3 (1–7)	< 0.05
Discharge Hb, g/l	101 (69–146)	130 (73–151)	< 0.05
Hospital stay, days	3.5 (3–6)	1.2 (< 1.5)	< 0.05
Discharged < 24 h, %	0	93	< 0.001

Table 2. Patient profile and operative, perioperative parameters

Pathological stage, %	RRP (100)	VIP (200)	*P*
T2 a	18	15	NS
T2 b	75	72	
T3 a	4	7	
T3 b	3	6	
Positive node	2	1	NS
Margin positivity in organ-confined cancers (pT2 a–T3 a), %			
Extensive (> 1 mm)	15	1	< 0.05
Focal (≤1 mm)	8	5	
Complications, number			
Aborted	1	2	
Conversion	–	0	NS
Rectal injuries	1	0	NS
Postoperative ileus	3	3	NS
Wound dehiscence/hernia	1	2	NS
Postoperative fever/pneumonia	4	0	< 0.05
Lymphocele	2	0	NS
Obturator neuropathy	2	0	NS
DVT	1	1	NS
Postoperative MI	1	0	
Postoperative bleeding/re-exploration	4	1	NS
Total	20	5	< 0.05

Table 3. Outcome after surgery in 300 contemporary patients undergoing prostatectomy

Parameters	Open radical prostatectomy	Laparoscopic radical Prostatectomy	Robotic radical prostatectomy (VIP)
Number of patients	100	50	100
Operative time in min	164	248	140
Blood loss, ml	900	280	< 100
Positive margins, %	24	24	5
Complications, %	15	10	5
Catheter duration	15	8	7
Hospital stay	3.5	1.3	1.2

with 200 undergoing VIP. These results are summarized in Tables 2 and 3 [17].

In this study cohort of 100 consecutive RRP and 200 VIP patients, their demographics as mentioned in the table, were comparable in age, BMI, PSA, prostate volume, clinical stage, Gleason score, comorbidity and previous abdominal surgery. The mean operation time was comparable RRP (163 min) and VIP (160 min). The estimated blood loss differed significantly and need for blood transfusion was greater in the open radical prostatectomy group. The mean hospital stay was longer for the RRP group. The percentage cancer, Gleason score, and pathological stages were comparable between the groups; 9% of the VIP and 23% ($p<0.05$) of the RRP patients had tumor at the inked margin. There was also a significant difference in the proportion of patients with an undetectable PSA at a mean follow-up of 18 months and 8 months, respectively. Sexual function was also evaluated; patients who underwent VIP had a more rapid return of erections (50% at 6 months). The return of intercourse was also quicker after VIP, with half the patients achieving intercourse at a mean follow-up of 12 months. Amongst the VIP patients, 42% are known to be using sildenafil. It is our policy to encourage patients to try sildenafil early, in an attempt to prevent possible corporal fibrosis.

As of now we have experience of 1,100 cases and our results are continuing to improve. Intraoperative blood loss averages around 100 ml, and operative time averages around 140 min. The positive margin rate for localized cancer prostate has come down to 4%. In our set up, 50% of patients are continent at the time of catheter removal.

Long-term complications of urinary incontinence and impotence are minimized as well. Our patients have vastly better urinary control, which returns more rapidly, and improved potency as compared with open radical retropubic prostatectomy performed at our institution [17].

Conclusions

Robotics has irreversibly changed the face of surgery. The advantage of robotic aid is in the more facile performance of complex reconstructive maneuvers. This has allowed for improved patient outcomes with a minimum of morbidity and improved patient satisfaction. Robotics offers the next natural advancement of laparoscopic surgery, as made evident by the great success of robotic radical prostatectomy, and now awaits further application to other disease processes [18–20].

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6.6 Extraperitoneal Versus Transperitoneal Laparoscopic Radical Prostatectomy

François Rozet, Carlos Arroyo, Xavier Cathelineau,
Eric Barret, Guy Vallancien

Contents

Introduction

Radical prostatectomy is the gold standard treatment for localized prostate cancer, since the laparoscopic approach is an excellent option because by maintaining oncological control it offers the combined benefits of the minimally invasive approach and good functional results.

Currently our experience adds up to over 2,000 laparoscopic radical prostatectomies, distributed as follows: 1,400 transperitoneal and 600 extraperitoneal, among which 100 have been robot-assisted (70 transperitoneal and 30 extraperitoneal procedures). In this chapter we will briefly discuss our different techniques, benefits, difficulties, complications and the differences between the transperitoneal and the extraperitoneal laparoscopic approaches.

Indications and Contraindications

The indications for laparoscopic radical prostatectomy are exactly the same as in open surgery, no matter which approach is used, or if it is robot-assisted. Minimally invasive surgery has not modified the selection criteria for the patient to be eligible for this technique. However, as in open surgery, there are certain characteristics that will impact on the difficulty of the procedure and the results obtained.

Either laparoscopic approach can be performed in selected T3N0M0 stages, without neurovascular bundle preservation, with the implied risk of residual disease that may require complementary treatment. Finally, salvage laparoscopic radical prostatectomy after radiotherapy or brachytherapy can be performed by either laparoscopic approach, because neither will modify the higher risk of rectal injury [1].

The only absolute anesthetic contraindications for any laparoscopic procedure is high intracranial pressure of any etiology (primary or secondary to the intracranial process). There are relative anesthetic contraindications for abdominal laparoscopic surgery, because they cause an increased partial pressure of carbon dioxide (pCO_2), which requires increased minute ventilation in order to maintain a pCO_2 between 30 and 35 mmHg. These include severe emphysema, cardiac insufficiency, atrioventricular defects, chronic respiratory disease and glaucoma.

There are no anatomical contraindications for either approach, nor the robot assistance. However, there are some cases that can make the procedure potentially challenging, which include a large prostate volume (over 100 g), neoadjuvant hormone therapy, previous prostatic surgery, history of prostatitis, radiotherapy, brachytherapy and thermal ablation of the prostate (Ablatherm) [2, 3].

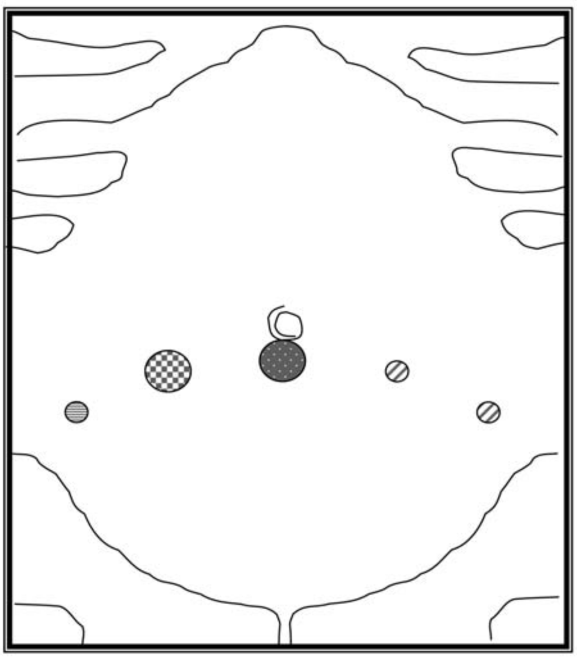
Finally for an extraperitoneal approach, the history of previous bilateral mesh hernia repair can make this approach difficult because of the adhesion formation that can make the Retzius space dissection difficult [4].

An important consideration for surgeons at the beginning of their learning curve is to carefully select their cases, because it has been shown that the surgeon's experience is inversely related to in-hospital complications and length of stay in open radical prostatectomy [5].

Techniques

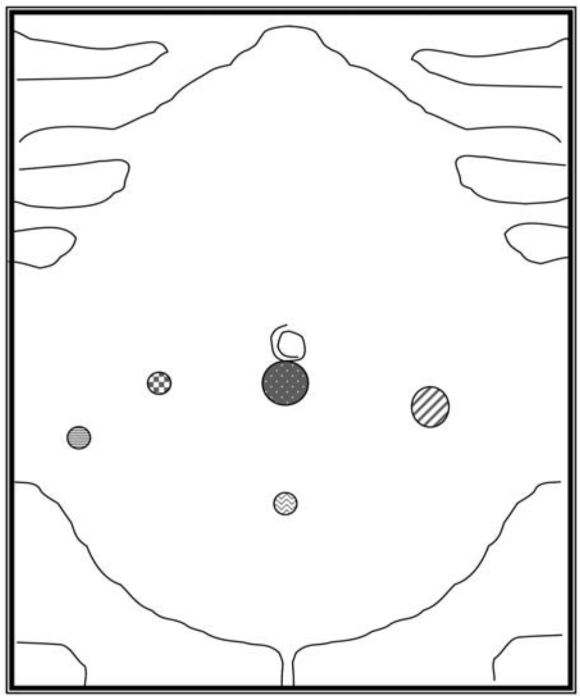
In placing trocars, we routinely use five trocars, the same with either approach, except for a slight displacement in the extraperitoneal approach in which the trocars tend to be slightly lower than for the transperitoneal approach. They depend on the surgeon's preferences.

These include linear distribution, in which a 10-mm trocar is inserted in the umbilicus for the camera. The surgeon will work with two 5-mm trocars that are inserted, one above and medial to the iliac spine and another one lower and lateral to the umbilical port. The assistant will work with a 5-mm trocar that is placed above and medial to the right iliac spine, and a second 10-mm trocar between the umbilical and lateral ports on the right (Fig. 1).



- Optic 10-mm port
- Assistant 10-mm port / surgeon during sutures
- Assistant 5-mm port
- Surgeon 5-mm ports

Fig. 1. Linear trocar position at the same height as the umbilicus, the left-side ports are used by the surgeon and the right by the assistant



- Optic 10-mm port
- Assistant´s 5-mm port / surgeon´s during anastomosis
- Assistant´s 5-mm port
- Surgeon´s 10-mm port
- Surgeon/assistant 5-mm port

Fig. 2. The triangular trocar variation involves placement of the surgeon's ports on the left side between the umbilical port and the left iliac spine and the other two-thirds of the distance between the umbilical port and the suprapubic rim along the midline

The triangular trocar variation involves placement of the surgeon's ports on the left side between the umbilical port and the left iliac spine and the other one two-thirds of the distance between the umbilical port and the suprapubic rim along the midline (Fig. 2).

In case a robot-assisted procedure is used, whether it is extra- or transperitoneal, the trocar distribution is as follows: a 12-mm trocar is inserted in the umbilicus for the camera, two 8-mm trocars for the robot arms are placed on both sides five fingerbreadths lateral to the opti and slightly lower. Finally for the assistant, a 5-mm trocar is inserted above and medial to the left iliac spine and a 10-mm trocar for the suture is placed slightly higher, between the opti and right robot trocar (Fig. 3).

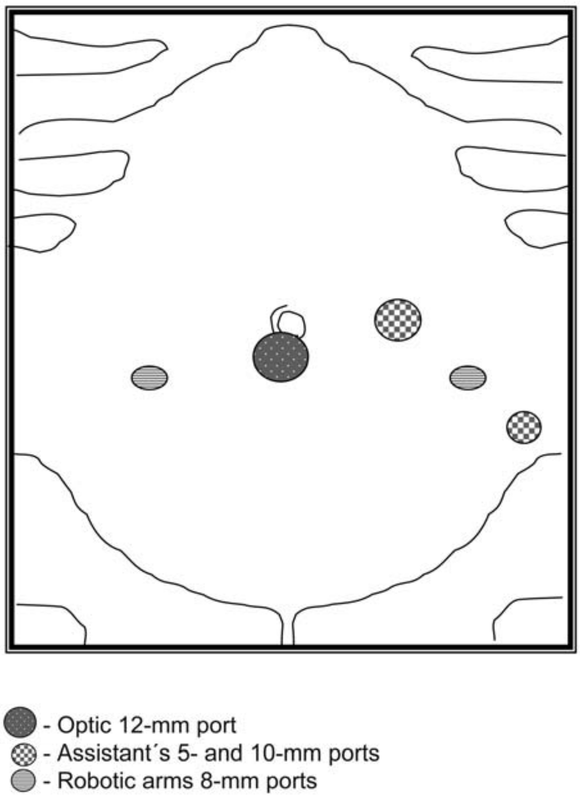


Fig. 3. The robot-assisted linear trocar placement involves the robot ports on both sides and the assistants on either side to one of the robotic arms

Transperitoneal Approach

Since 1998, we have used the Montsouris I technique [6, 7] and have divided it into seven critical steps:

1. Incision of the posterior vesical peritoneum with dissection of the vas deferens and seminal vesicles, finishing by opening the Denonvilliers fascia.
2. Dissection of the Retzius space, with incision of the intrapelvic fascia with selective suture ligation of the Santorini's plexus.
3. Identification of the bladder neck, with dissection of the seminal vesicles.
4. Dissection of the lateral surfaces of the prostate in the intrafascial plane in order to preserve the neurovascular bundles (when indicated).
5. Selective dissection of the urethra with the aid of a metal Béniqué dilator.
6. Extraction of the prostate using a laparoscopic bag for frozen section analysis.
7. The vesicourethral anastomosis is performed with interrupted or running Vicryl sutures.

Finally a Foley catheter is placed and a suction drain is left in the surgical space.

Extraperitoneal Approach

This approach has been previously described in the literature [8–10], and our Montsouris II technique [11] can also be divided into critical steps, shared with the transperitoneal approach except for:

1. The surgery starts with the dissection of the Retzius space, which is done by blunt dissection with the laparoscope or by the use of a balloon.
2. The next step is to open the intrapelvic fascia floor as in the transperitoneal approach.
3. The bladder neck is dissected and reveals the initial plane of dissection of the seminal vesicles that are dissected after this step, compared to the transperitoneal approach in which they are dissected at the beginning.

The rest of the procedure follows the same steps as the transperitoneal approach.

In case a robot-assisted procedure is used, it can be done following the same critical steps in the transperitoneal or extraperitoneal approach; the only variation involves the trocar placement as previously described [12].

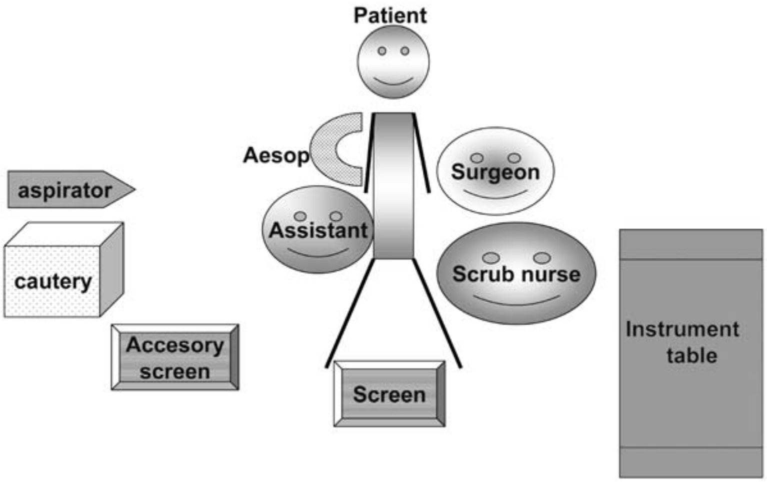


Fig. 4. This drawing shows the patient position with respect the surgeon and assistant, as well as the operating room arrangement

Preoperative Preparation

The patient is admitted to the hospital the night before the surgery to start prophylactic anticoagulation with an injection of low-molecular-weight heparin, which is continued for at least 7 days postoperatively. Another measure to prevent thromboembolic complications is the systematic use of varicose vein stockings. We do not do any gastrointestinal or skin preparation (shaving), nor do we prescribe any antibiotic prophylaxis.

Positioning of the Patient

Laparoscopic radical prostatectomies by the transperitoneal or extraperitoneal approach are performed under general anesthesia, with the patient placed in a dorsal supine position. During the transperitoneal technique, an exaggerated Trendelenburg position is preferred to a moderate position in the extraperitoneal approach. The lower limbs are in abduction for intraoperative access to the rectum. The upper limbs are positioned alongside the body to avoid the risk of stretch injuries to the brachial plexus. Two security belts are placed across the thorax in an X pattern, to

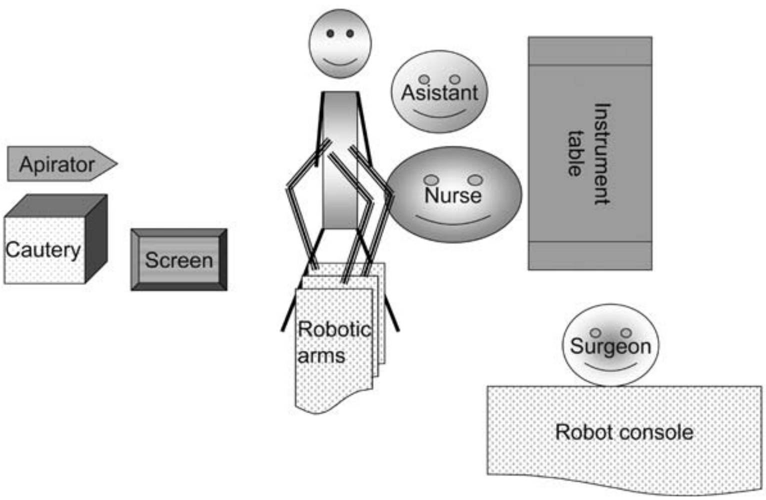


Fig. 5. Operating room arrangement in a robot-assisted laparoscopic radical prostatectomy

ensure that there is no patient movement during surgery, while ensuring there is no risk of pressure injury in using shoulder rests.

The surgeon stands on the left side of the patient with the operating room nurse and instrument table, and the assistant stands on the right side of the operating table. The video column with the insufflator and light source are placed between the legs of the patient and the electrocautery and aspirator behind the assistant (Fig. 4).

When a robot assisted technique is used, before the patient is brought into the operative room, the robot is set up (Fig. 5). The system is started and goes through a self-testing procedure during which it recognizes its own spatial position and various components. The cameras are black-and-white balanced and calibrated. The patient positioning is the same except for a slight flexion of the lower limbs to allow the robot to come as close as possible to the surgical table. The surgeon remains in the console during the entire procedure and a scrub nurse and assistant remain on the left side of the patient.

Table 1. Preoperative patient characteristics

Approach	Transperitoneal	Extraperitoneal
No. of patients	1,400	600
Mean age	61	62
PSA	9.2	7.4
Gleason score	6.5	7

Table 2. Perioperative and pathological stage

Approach	Transperitoneal	Extraperitoneal
Mean surgical time	157	173
Mean blood loss	350	380
% Transfusion rate	3.3	1.3
Conversion to open	9 patients converted to open	1 patient converted to open 5 to transperitoneal
Pathological stage	TNM 1997	TNM 2002
pT2a	20%	13%
pT2b	58%	8%
pT2c		52%
pT3a	14%	20%
pT3b	8%	9%
Mean hospital stay	4.2 days	6.3 days
Mean Foley catheter	4.5 days	7.6 days
Visual pain scale	Score	Score
Day 1	<3.6	2.8
Day 2	<2	2.4

Postoperative Management

The bladder catheter is left for 3–7 days depending on the quality of the suture evaluated by the surgeon. A postoperative cystogram is not routinely performed. Our analgesia scheme is limited to IV paracetamol during the first 24 h, followed on day 1 by oral paracetamol/dextropropoxyphene if necessary. Major analgesics are administered if necessary. The intravenous perfusion is stopped on day 1, and oral fluids are started the morning after surgery and a normal diet can generally be resumed on day 2.

Results

We have been performing laparoscopic radical prostatectomy since 1998, and our current experience adds up to over 2,000 cases, which include 1,400 transperitoneal cases and 600 extraperitoneal cases. Among them we have performed 100 robot-assisted laparoscopic radical prostatectomies, 70 transperitoneal and 30 by the extraperitoneal approach.

The patient characteristics are summarized in Table 1, and our surgical results are in Table 2. We have converted to open surgery in only ten cases: the first nine were at the beginning of our experience, and the last one was in the extraperitoneal group and was due to a malfunction of the laparoscopic camera. Concerning the approach, we have had to convert from extraperitoneal to transperitoneal at the beginning of the procedure in five cases because they had previous mesh hernia repair (two unilateral and three bilateral), which made it impossible to open the extraperitoneal space to perform the operation.

Morbidity

Our complications are summarized in Table 3. To date, we have had no deaths or cardiac complications. Our major complications include four cases of pulmonary embolism. Intermediate complications were similar in both groups and were the most frequent: lymphocele and rectal injury. It is interesting to note that although the rate of rectal injury is lower in the extraperitoneal

Table 3. Number of complications

Approach	Transperitoneal	Extraperitoneal
Deaths	0	0
Major complications		
Thrombotic events	0.1%	0.3%
Intermediate complications		
Rectal injury	0.8%	0.6%
Intestinal injury	0.1%	0%
Vesicocutaneous fistula	0.2%	0.1%
Anastomotic stenosis	0.3%	0.1%
Ureter injury	0.2%	0%
Lymphocele	0.2%	0.8%
Anastomotic leak	10%	5%
Abdominal wall abscess	0%	0.3%
Urinary retention	0.2%	3.5%

Table 4. Continence results evaluated by questionnaire after the surgery

Approach	Transperitoneal	Extraperitoneal
Continence		
No. of pads used	86%	84%
1 preventive pad		8%
1 pad routinely	14%	8%

Table 5. Average positive margins by pathological stage

Approach	Transperitoneal	Extraperitoneal
Positive margins	13%	17.7%
pT2a	5%	7%
pT2b	13%	15%
pT2c		17%
pT3a	30%	27%
pT3b	33%	23%

approach, the risk remains the same during the final part of the dissection of the prostatic apex.

Among the possible benefits offered by the extraperitoneal approach is the easier management of an abdominal wall hematoma or urinary leaks, because the peritoneum is intact, and these complications are limited and do not involve the abdominal cavity [13].

Continence

To evaluate continence results, the patient is sent a self-administered questionnaire by regular mail. The median follow-up is at 12 months, when patients report continence in terms of using no protection pads, being continent but preferring to use a precautionary pad or using one pad on a daily basis because of minor urine leaks. Our results are encouraging with a continence rate higher than 84% (Table 4).

Potency

Our results from both series are difficult to compare, as in the initial transperitoneal approach erectile function was evaluated clinically, with results depending on the procedure (bilateral or unilateral nerve-sparing procedure). The mean rate of spontaneous erection was between 62% and 77%. Currently in the extraperitoneal series, we are evaluating the erectile function with a self-administered questionnaire that is mailed to our patients postoperatively. With a median follow-up of 6 months, in the preoperatively potent patients (International Index of Erectile Function [IIEF] 5 > 20), the erectile function rate was 64% for the bilateral nerve-sparing technique and 43% in unilateral nerve-preserving surgery.

Oncological Results

Histopathological exam of the prostate revealed similar characteristics in both groups. The positive margin rate of both approaches is similar (13% transperitoneal vs 17% extraperitoneal). In our experience, we have seen that as the surgeon's experience increases, the rate of positive margins decreases (Table 5). This occurred both in the transperitoneal approach and later with the extraperitoneal approach, until they reached a plateau. It is logical to observe that in both groups, as the tumor volume increases, the positive margins also increase. In both groups, the positive margin rate was higher in the pT3 than the pT2 patients (Table 5).

Concerning the postoperative PSA values, in the extraperitoneal approach, the follow-up is still too short to make any assumptions. However, in the transperitoneal group, we have observed that the actuarial PSA at 3 years is less than 0.1 ng/ml in 90.5% of our patients. In patients with a good prognosis, with a Gleason score of less than 7 and preoperative PSA lower than 10 ng/ml, the actuarial PSA at 3 years is less than 0.1 ng/ml in 97.5% of these patients. Finally, it is important to mention that to date, we have not had any port site metastasis [14, 15].

Controversies

Which approach is best for a laparoscopic radical prostatectomy continues to be currently debated [16]. In a prospective comparative study, we concluded that there are advantages and disadvantages to both approaches; however, the quality of the surgery depends on the surgeon's experience and standardization of the procedure. This is why we consider that there is no gold standard in terms of a technique or approach, but rather success depends on the surgeon's experience [17, 18].

However, we do consider that, as mentioned earlier, the extraperitoneal approach might reduce direct bowel injury. Nevertheless, the risk remains and it is important to always place the ports under visual control. Another possible advantage is the visualization of the epigastric vessels, which, although it does not reduce the risk of injury, it does allow easy coagulation with bipolar forceps.

There are some reports that mention fewer rectal injuries with the extraperitoneal approach [19]. In our experience, the risk remains, although it may change the clinical presentation.

Another area of discussion is the possible tension during the vesicourethral anastomosis, the result of a partial dissection of the bladder in the extraperitoneal approach compared to the transperitoneal [20]. In our experience, various maneuvers can reduce bladder traction, for example, leveling the operating table, emptying the bladder, further dissection of the bladder, enlarging the bladder neck anteriorly and lowering the pneumoperitoneal pressure.

In brief, we consider that the extraperitoneal approach can be slightly faster with easier management of minor complications (hematoma or urine leak), while preserving the oncological results observed with the transperitoneal approach. However, it is important to keep in mind that the extraperitoneal approach can be difficult if the patient has a history of previous mesh hernia repair, the anastomosis can involve more tension, and the working space might be slightly smaller when compared to the transperitoneal approach.

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6.7 Handling Complications in Laparoscopic Radical Prostatectomy

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Contents

Laparoscopic radical prostatectomy is becoming the gold standard for the treatment of localized prostatic carcinoma in many urological departments worldwide. Thousands of operations will be performed during the coming years and we have to be prepared to prevent, recognize and handle the complications that will inevitably appear. Most of them will happen during the performance of the first 50–100 cases, during the learning curve. Tables 1 and 2 summarize the complications reported in the English literature.

The most common complications in order of frequency are:

1. Intraoperative or postoperative haemorrhage requiring transfusion
2. Prolonged urine leakage from the vesicourethral anastomosis
3. Postoperative surgical revision
4. Conversion to open radical prostatectomy
5. Rectal injury
6. Ileus
7. Anastomotic stricture

We will review some of the complications related to the surgical technique and present some real-life clinical cases.

Prolonged Urine Leakage from the Vesicourethral Anastomosis

This is a complication related to the performance of a poor-quality vesicourethral anastomosis in most cases. It appears more frequently in *large prostates* where the bladder neck reaches the pelvic floor and urethra with more tension. The first sutures, which are usually the posterior ones, might be knotted loose allowing for persistent urine leakage. This also happens more often in obese patients with a BMI *over 33* and also probably more frequently when using the extraperitoneal access, because the bladder dome remains attached to the anterior abdominal wall by the urachus and umbilical arteries (Fig. 1). In these cases, the first stitches of the anastomosis should include abundant periurethral tissue and the angle of the Trendelenburg position should be reduced to diminish traction at the anastomosis and avoid disruption of the urethra.

In large prostates and prostates with *large median lobes* it is also more difficult to preserve the bladder neck and watertight anastomosis is more difficult to achieve. It is often necessary to close the bladder neck with an anterior or posterior tennis racket suture or

Table 1. Most frequent complications of laparoscopic radical prostatectomy

	Montsouris [1] $n = 567$	Heilbronn [2] $n = 180$	Berlin [25] $n = 125$	London [26] $n = 100$	Madrid (L. Martínez-Piñeiro, personal communication) $n = 200$	Creteil [27] $n = 137$	Total 1,309
Transfusion							
First 100 cases	13 (13%)	52 (43.3%)	10 (10%)	3 (3%)	25 (25%)	4 (2.9%)	107/582 (18.4%)
Rest	16 (3.5%)	15 (25%)	–	–	9 (9%)	–	40/627 (6.4%)
Anastomotic leak	57 (10%)	7 (4%)	–	–	3 (1.5%)	5 (3.6%)	72 (5.5%)
Haemoperitoneum/ pelvic haematoma	5 (0.9%)	29 (16%)	–	–	–	4 (2.9%)	38 (2.9%)
Postoperative surgical revision	20 (3.5%)	8 (4.4%)	–	–	4 (2%)	–	32 (2.4%)
Conversion to open surgery	16 (2.8%)	8 (4.4%)	–	1 (1%)	4 (2%)	–	29 (2.2%)
Rectal injury	8 (1.4%)	3 (1.7%)	3 (2.4%)	1 (1%)	7 (3.5%)	2 (1.4%)	24 (1.8%)
Ileus	6 (1%)	5 (5%)	4 (3.2%)	1 (1%)	4 (2%)	4 (2.9%)	24 (1.8%)
Anastomotic stricture	–	11 (6%)	2 (1.6%)	2 (2%)	–	–	15 (1.1%)
Bladder injury	9 (1.6%)	–	–	–	4 (2%)	–	13 (1%)
Trocar hernia	4 (0.7%)	1 (0.5%)	–	1 (1%)	2 (1%)	1 (0.7%)	9 (0.7%)
Deep vein throm-bosis	2 (0.3%)	–	3 (2.4%)	2 (2%)	1 (0.5%)	2 (1.4%)	10 (0.7%)
Ureteral injury	3 (0.5%)	–	1 (0.8%)	–	–	1 (0.7%)	5 (0.4%)
Ileum-sigmoid injury	3 (0.5%)	–	1 (0.8%)	–	1 (0.5%)	–	5 (0.4%)
Epigastric artery injury	3 (0.5%)	–	–	–	2 (1%)	–	5 (0.4%)
Neuropraxia	2 (0.3%)	–	–	1 (1%)	1 (0.5%)	–	4 (0.3%)
External iliac vessel injury	–	–	1 (0.8%)	–	1 (0.5%)	-	2 (0.1%)
Obturator nerve injury	1 (0.2%)	–	–	–	–	–	1 (0.1%)
Obstructive anuria	1 (0.2%)	–	–	–	–	–	1 (0.1%)
Pneumothorax	–	–	–	–	1 (0.5%)	–	1 (0.1%)

Table 2. Re-operations to correct complications

	Montsouris [1] $n = 567$	Heilbronn [2] $n = 180$	Madrid (L. Martínez-Piñeiro, personal communication) $n = 200$	Total $n = 947$
Postoperative haemorrhage or pelvic haematoma	5	5	2	12 (1.3%)
Trocar hernia repair	4	–	2	6 (0.6%)
Intestinal perforation (sigmoid-ileum)	3	–	1	4 (0.4%)
Anastomotic leak	1	3	–	4 (0.4%)
Epigastric artery injury	2	–	1	3 (0.3%)
Rectal fistula	2	1	–	3 (0.3%)
Ureteral lesion	2	–	–	2 (0.2%)
Ureteral obstruction by suture	1	–	–	1 (0.1%)
Ileus-peritonitis	1	–	–	1 (0.1%)

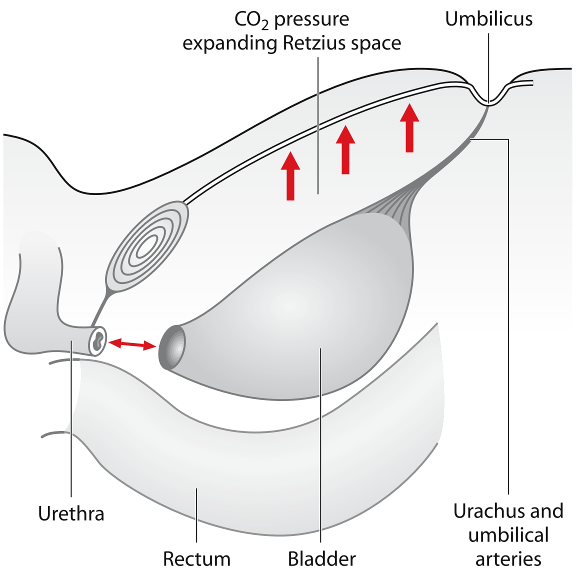


Fig. 1. The bladder neck reaches the pelvic floor and urethra with more tension in some cases with the extraperitoneal technique, because the bladder dome remains attached to the anterior abdominal wall by the urachus and umbilical arteries

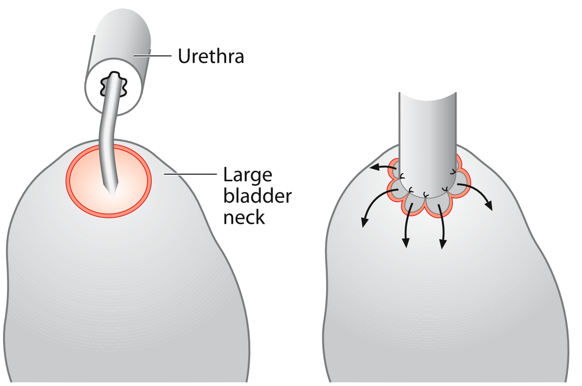


Fig. 2. Asymmetric anastomosis requires putting the bladder neck stitches more separated, in a parachute manner, a factor that facilitates urine leakage through the anastomosis

to perform an asymmetric anastomosis, putting the bladder neck stitches more separated, in a parachute manner, a factor that facilitates urine leakage through the anastomosis (Fig. 2).

Vesicourethral anastomosis using running suture theoretically provides more possibilities of a watertight anastomosis than suture with interrupted stitches. The problem with the running suture is that if not enough traction is applied while it is sewn, part or the whole suture line might remain loose, especially the posterior aspect, which cannot be inspected after the suture is finished. This can also happen if the thread is crossed inadvertently in one of the stitches. In this case, traction will not allow the thread to slide correctly and part of the suture will remain loose. In many cases the surgeon does not recognize these pitfalls (the anastomosis seems watertight even when filling the bladder with 120 cc of saline), and it is only during the postoperative period or when the first cystourethrography is performed that massive extravasation is detected. Management is usually conservative with antibiotic coverage, prolonged bladder catheterization and maintenance of the drainage. Guillenneau et al. [1] had to perform one open surgical revision out of 567 cases and Rassweiler et al. [2] in three out of 180 cases (Table 2).

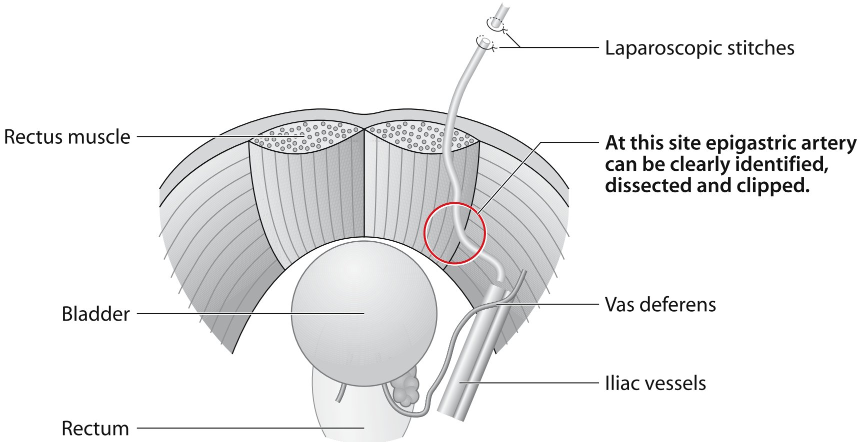
Intraoperative or Postoperative Blood Loss

Haemorrhage requiring transfusion is more frequent during the learning curve (Table 1). During the first 100 cases, blood transfusion is required in about 18% (3%–43%) of cases. This rate falls to about 6% (3%–25%) once the surgical technique has been standardized. Blood loss is more frequent in patients with large prostates because prostate vascularization is greater, and also because the working space in the deep pelvis is occupied partly by the gland and operating is more uncomfortable and difficult [2].

With the descending technique, bleeding occurs mainly during the transection of the prostatic pedicles. Haemostasis can be achieved with metallic clips, bipolar cautery or ultrasonic scissors. Section of the preprostatic venous complex is usually straightforward, causes little bleeding and is very often controlled with bipolar cautery only. In larger prostates, a stitch might be necessary to control bleeding and to avoid postoperative anaemization.

With the combined retrograde-descending technique, Santorini's plexus is sectioned at the beginning of the surgery and adequate haemostasis with a stitch is absolutely mandatory.

Re-operation due to postoperative haemorrhage or pelvic haematoma was necessary in five out of 567 patients in Montsouris, five out of 180 cases in Heil-



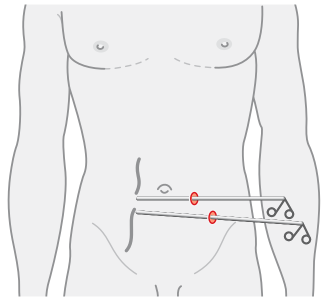


Fig. 3. Lesion of the epigastric artery during trocar insertion can sometimes be controlled with a figure-eight laparoscopic stitch through two ports situated opposite the damaged epigastric artery. The stitch can be placed immediately distal and proximal to the trocar site or close to the exit of the epigastric artery from the external iliac artery. At this site, the epigastric vessels can be clearly identified, dissected and clipped or ligated

bronn and two out of 200 cases in Madrid [1, 2; L. Martínez-Piñeiro et al., personal communication].

Re-operation and haemostasis can be performed laparoscopically, although evacuation of blood clots may require insertion of open surgery suckers through the trocar sites. A thin laparoscopic sucker is often not enough to evacuate organized blood clots.

Lesion of the epigastric artery during trocar insertion can produce an unexpected haemorrhage. The bleeding can be sometimes controlled with a figure – eight laparoscopic stitch through two ports situated opposite the damaged epigastric artery (Fig. 3). The stitch can be placed immediately distal and proximal to the trocar site or close to the exit of the epigastric artery from the external iliac artery. At this site, the epigastric vessels can be clearly identified, dissected and clipped or ligated.

Another way of dealing with a lesion of the epigastric artery is to pass a transfascial haemostatic stitch around the vessels from outside, above and below the trocar site using a Reverdin or Carter-Thomason needle under laparoscopic view (Fig. 4).

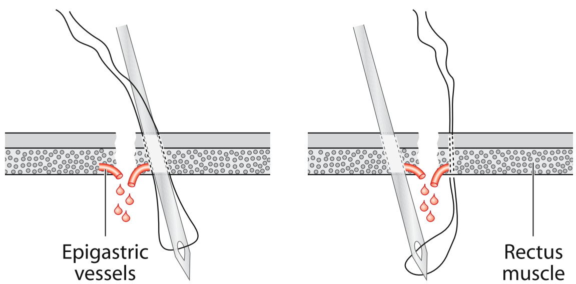


Fig. 4. Transfascial haemostatic stitch around the epigastric vessels from outside, above and below the trocar site with the help of a Reverdin or Carter-Thomason needle under laparoscopic view

Rectum and Bowel Injuries

Rectal injury occurs in about 2% of cases. Generally it is produced near the prostatic apex and in pT3 cases where the prostate can be adhered to the anterior rectal wall. In some patients, the prostate may be adherent to the Denonvilliers fascia, not as a result of an advanced local stage, but because of prostatitis or an inflammatory reaction secondary to prostatic biopsies.

In the descending technique, the injury occurs just before the removal of the prostate, once the lateral pedicles are controlled and the venous plexus and urethra have been transected. At this stage, the prostate remains attached to the anterior rectal wall by means of the Denonvilliers fascia. The majority of rectal injuries occur after transection of this fascia and while separating the last attachments to the prostate (Fig. 5). Traction on the prostate to expose its posterior surface pulls on the rectum, which can be torn during this ma-

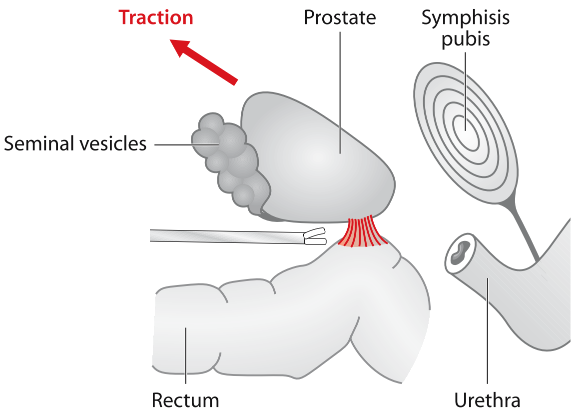


Fig. 5. In the descending technique, the rectal injury occurs just before the removal of the prostate, once the lateral pedicles are controlled and the venous plexus and urethra have been transected

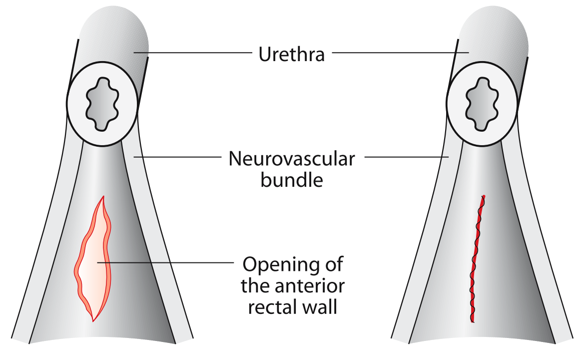


Fig. 7. The rectal opening is generally immediately recognized during surgery and can be easily repaired with a watertight running suture. A second layer with interrupted stitches is optional. If there is doubt of a rectal lesion or if the surgeon wants to check the water tightness of the suture, a rectal catheter can be inserted and saline or diluted methylene blue solution instilled

noeuvre. In the retrograde approach, however, the rectal injury occurs after transecting the urethra, while trying to develop the retroprostatic space (Fig. 6).

In both cases, the rectal opening is generally immediately recognized and can be easily repaired with a watertight running suture (Fig. 7). A second layer with interrupted stitches is optional. If there is doubt of a rectal lesion or if the surgeon wants to check water tightness of the suture, a rectal catheter can be inserted and saline or diluted methylene blue solution instilled. Another way of checking water tightness is to fill the pelvic cavity with saline and inject air

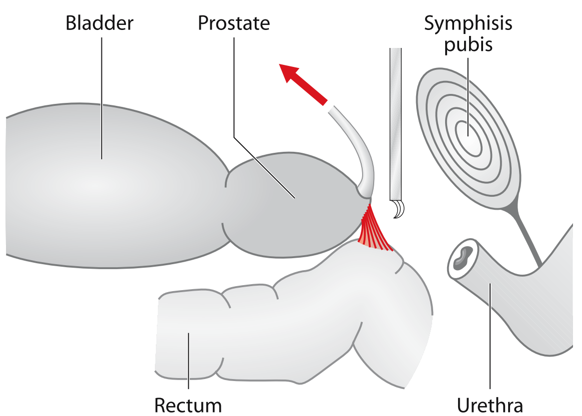


Fig. 6. In the retrograde approach, the rectal injury occurs after transecting the urethra, while trying to develop the retroprostatic space

through the rectal catheter watching for the appearance of air bubbles.

Rectal opening usually does not change the postoperative course of the patient. Antibiotics against Gram-positive, Gram-negative and anaerobic bacteria have to be given intraoperatively and maintained at least for 3 days. The patient starts on a liquid diet the day after the operation and continues on soft diet 1 or 2 days later. The drain should be maintained until the first stool deposition. In order to avoid rectourethral fistula, the first cystourethrography is not performed until the 14th postoperative day.

Rectal injury can occur due to *necrosis* secondary to excessive dissection of the anterior rectal wall, due to *thermal injury* during surgery and in some cases it can be an accidental *direct opening* of the rectal wall. In most cases, independently of the mechanism of injury, it is produced inadvertently and the first sign of laparoscopic postoperative peritonitis syndrome appears within 3 days after surgery [3]. Postlaparoscopic peritonitis can also be the first sign of small-bowel injury. Patients do not present with the typical abdominal rigidity, leukocytosis and fever. The abdomen is usually slightly distended and tender, and bowel peristalsis can be present. Patients usually mention abdominal discomfort, trocar site pain closest to the bowel injury and have diarrhoea.

Depending on the mechanism and size of the rectal injury, the symptoms vary. Thermal lesions present later than nonthermal injuries. In some cases, the first symptom may be the passage of urine through the rectum, which can appear later than 1 week after the operation. In most cases of rectal injury, however, the first sign is a light blood-stained discharge from the rectum, together with hypogastric discomfort within the first 3 postoperative days. In some cases, rectal digital examination may allow palpation of the rectal defect and assessment of its size. Some patients will only develop a perirectal abscess that manifests itself with low-grade fever, anorexia, diarrhoea, hypogastric pain and low or normal white blood cell count. Initial management includes broad spectrum antibiotics, absolute diet and parenteral nutrition. Drainage, if still in place, should not be removed until the rectal discharge stops and parenteral nutrition has been maintained at least 7 days. If rectal discharge of peritoneal secretions or urine persists after several days or it increases, open or laparoscopic surgical revision should be considered.

In order to reduce the possibility of a rectal thermal injury, the surgeon should avoid excessive use of bipolar or harmonic scalpel at the anterior rectal wall. Bipolar energy should be kept below 30 W.

Ileus

Between 1% and 5% of the patients that undergo transperitoneal laparoscopic prostatectomy suffer ileus in the immediate postoperative period. Three factors may contribute to the cessation of bowel peristalsis:

- Bowel irritation due to CO_2
- Bowel irritation due to bowel manipulation
- Bowel irritation due to urine leakage

In most cases, absolute diet, insertion of a nasogastric tube and maintenance of intravenous fluids will resolve the ileus in 2 or 3 days. If the ileus does not resolve, bowel injury or persistent urinary leakage should be ruled out.

Bladder Injury

Bladder opening is a minor complication during laparoscopic radical prostatectomy if it is identified during surgery. Closure of the bladder defect with a single running 2/0 or 3/0 absorbable suture is usually enough and quite easy to perform. In these cases, the bladder catheter should be maintained for at least 7 days. In order to detect inadvertent bladder lesions as well as to check the quality of the vesicourethral anastomosis, it is advisable to always fill the bladder with 120 cc of saline at the end of the surgery.

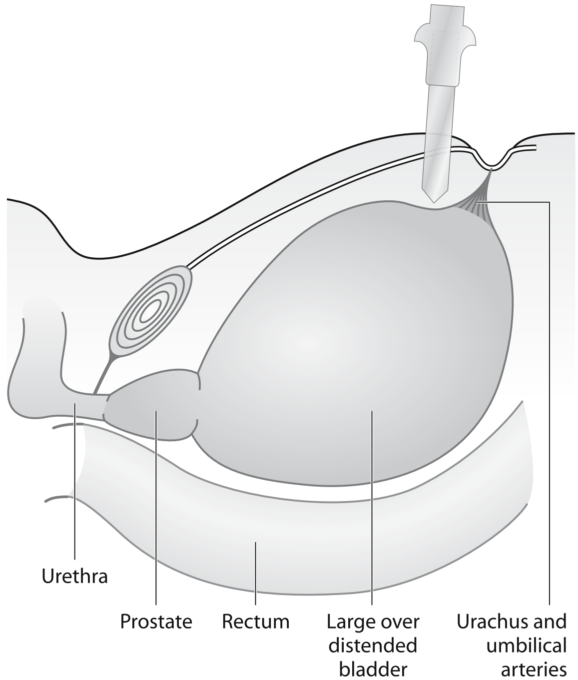


Fig. 8. Injury of the bladder dome can occur during the insertion of the first infraumbilical trocar in patients with large, overdistended bladders

Bladder injury can occur during different steps of the procedure:

1. During *the insertion of the first infraumbilical trocar* in patients with large, overdistended bladders damage of the bladder dome can occur. In some cases, the bladder opening occurs during the transection of the urachus and umbilical arteries if it is done too caudally (Fig. 8).
2. Dissection of the seminal vesicles *at the rectovesical pouch*. Posterior bladder wall can be penetrated if the dissection is started in the midline and too anterior. The first step to start the dissection of the seminal vesicles is to identify the vas deferens at the lateral aspect pouch of Douglas. If identification of the vas deferens at this site is difficult, it can be found very easily where it crosses the iliac vessels. Thereafter it can be easily followed until the seminal vesicles are reached (Fig. 9).

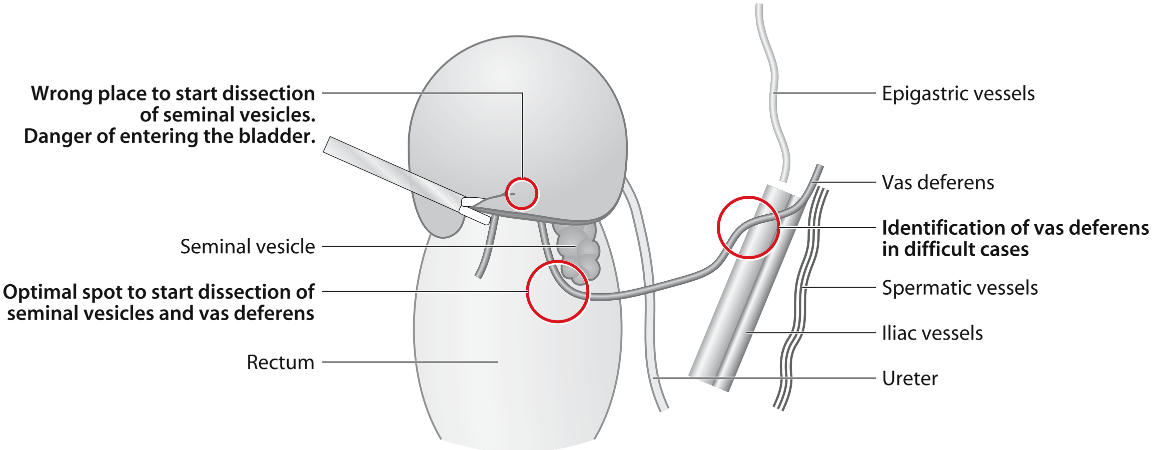


Fig. 9. The posterior bladder wall can be sectioned if the dissection of the seminal vesicles is started in the midline and too anterior. The first step to start the dissection of the seminal vesicles is to identify the vas deferens at the lateral aspect of the pouch of Douglas. If identification of the vas deferens at this site is difficult, it can be found very easily where it crosses the iliac vessels

3. *During creation of the Retzius space*, injury of the anterior bladder wall occurs mainly in patients with previous pelvic surgery, in which the anterior bladder wall adheres to the abdominal wall and pubic bone.
4. After transection of the posterior aspect of the bladder neck and *during the creation of the retroprostatic space*. At this stage, the trigone can be entered, resulting in a very large bladder neck that requires closure with a posterior tennis racket suture, similar to the one used in some cases of retropubic radical prostatectomy (Fig. 10). To avoid this problem, the surgeon should try to enter the retroprostatic space bluntly and lateral to the bladder neck both left and right, and medial to the prostatic pedicles. Once this important step is accomplished, transection of the posterior aspect of the bladder neck can be done safely and the formation of the retroprostatic space is straightforward (Fig. 11).

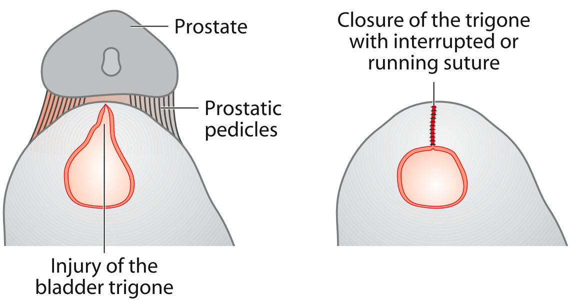


Fig. 10. After transection of the posterior aspect of the bladder neck and during the creation of the retroprostatic space, the trigone can be entered inadvertently, resulting in a very large bladder neck that requires closure with a posterior tennis racket suture

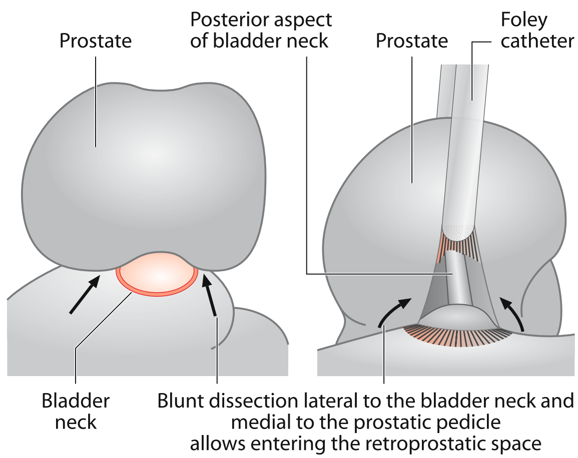


Fig. 11. To avoid trigone lesion, the surgeon should try to enter the retroprostatic space bluntly and lateral to the bladder neck both left and right, and medial to the prostatic pedicles. Once this important step is accomplished, the posterior aspect of the bladder neck can be transected safely and the formation of the retroprostatic space is straightforward

Ureteral Injury – Ureteral Obstruction

The ureter can be sectioned or ligated during laparoscopic prostatectomy.

Ureteral Injury

Ureteral section can occur during dissection of the vesiculodeferential junction at the pouch of Douglas. The ureter runs more lateral and anterior to the vas deferens at the tip of the seminal vesicles. In obese patients, identification of the vas deferens may be difficult and if the dissection is done too lateral the ureter may be burned with bipolar electrocautery or sectioned (Fig. 12). The ureter can also be damaged during dissection of the lateral vesical peritoneum. If the injury is detected immediately, the ureter can be repaired laparoscopically by terminoterminal ureterography over a ureteral stent. If the ureteral damage is done inadvertently, the first sign is persistent urine output through the drainage or urinary ascites [1]. The injury can be treated endourologically with a double-J stent or by conventional ureterovesical reimplantation in complete sections or extensive ureteral damage.

False Ureteral Injury

In some cases, the ureteral orifices end up very near to the vesicourethral anastomosis. If the balloon of the Foley catheter is kept under slight traction it may cause a false anuria associated with persistent urine output through the drainage, mimicking a bilateral ureteral section. Partial deflation of the balloon, reinsertion and fixation of the Foley catheter resolves this problem immediately and without sequelae.

Clinical Case

The following clinical case was provided courtesy of Dr. Pilar Laguna, Academic Medical Center, University of Amsterdam, The Netherlands.

A 61-year-old patient presented with a PSA of 6.2 ng/ml and a positive biopsy of both prostatic lobes (Gleason 3+3). Digital rectal examination showed T2b, clinical stage T2b G2 Nx M0 disease. This patient had no risk factors or previous abdominal operations.

Laparoscopic radical prostatectomy proceeded without problems. The operating time was 6 h, blood loss approximately 700 ml. During the operation, wide excision of both neurovascular bundles was performed and the bladder neck was not preserved. Both ureteral orifices were conserved and inspected during the operation, confirming their patency on both sides.

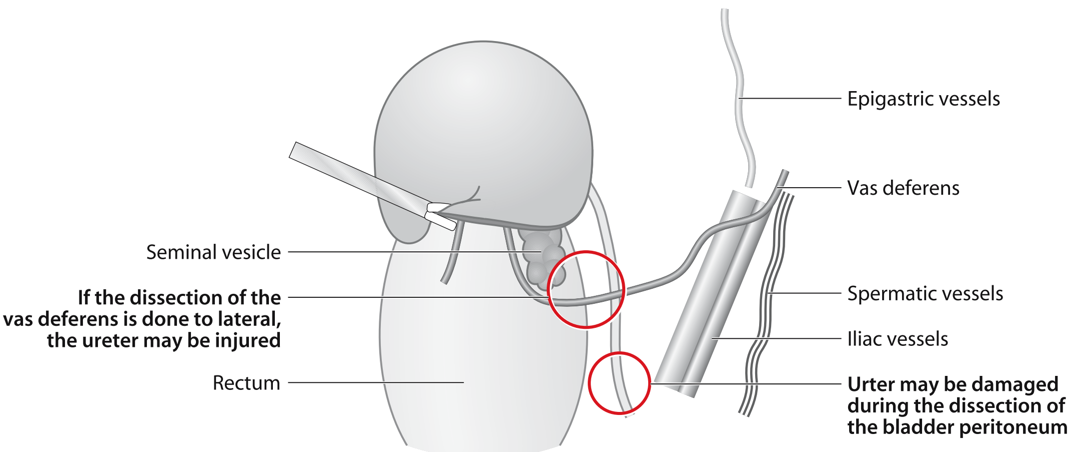


Fig. 12. The ureter runs more lateral and anterior to the vas deferens at the tip of the seminal vesicles. In obese patients, identification of the vas deferens may be difficult and if the dissection is done too lateral the ureter may be burned with bipolar electrocautery or sectioned. The ureter can also be damaged during dissection of the lateral bladder peritoneum

Fig. 13. Symmetric and early function of both kidneys

Fig. 14. Ureters are not dilated and can be followed to the lower portion of the bladder. A few drops of contrast can be seen around the catheter balloon. There is early leakage at the suture line

Vesicourethral anastomosis was performed with a single continuous running suture using Byosin 2/0 (one-knot suture). The bladder neck was closed with an anterior racket suture of approximately 1 cm. An 18F transurethral bladder catheter with a 10-cc balloon was left in place. Drainage was done with a silicon 18F tube.

In the immediate postoperative period, all the urine output was via the drainage. The bladder catheter output was 0 cc. A retrograde cystourethrography showed that the bladder catheter was well positioned and minimal leakage was present. Intravenous pyelography showed a normal upper urinary tract (Figs. 13, 14), but immediate leakage through the suture line was observed without any filling of the bladder.

Suspecting that both ureters were very close to the suture line, an occlusive effect of the balloon over the ureteral orifices was deduced. The balloon was deflated and the catheter fixed externally to the penis. Immediately following this manoeuvre, the urethral catheter began draining urine and the drainage remained dry. After 24 h, all the urine output came via the bladder catheter. The patient lost the Foley catheter unintentionally 6 days later during a Valsalva manoeuvre and reinitiated micturition normally, without incontinence.

Great Vessel Injury

Initial trocar placement is a very important step in all laparoscopic procedures. A key principle is to minimize the force needed to introduce the trocar; therefore the skin incision should be wide enough to allow easy passage of the outer trocar sheath into the subcutaneous tissue. Too small a skin opening may result in obstruction of the sheath by the skin edge, causing the surgeon to exert undue force on the abdominal wall. If the trocar then suddenly passes into the abdomen a major vessel or bowel can be injured (Fig. 16).

There are two ways of facilitating placement of the trocars: increasing the pneumoperitoneum pressure temporarily and elevating the abdominal wall close to the trocar insertion site with blunt forceps inserted through another trocar.

If damage to the aorta or common iliac vessel occurs, no time should be wasted trying to establish haemostasis. The vessels are covered by retroperitoneal fat, peritoneum and sometimes bowel, which might be injured at the same time. There is no way of putting a clamp or a vessel loop there to control the bleeding. Immediate reconversion to an open access

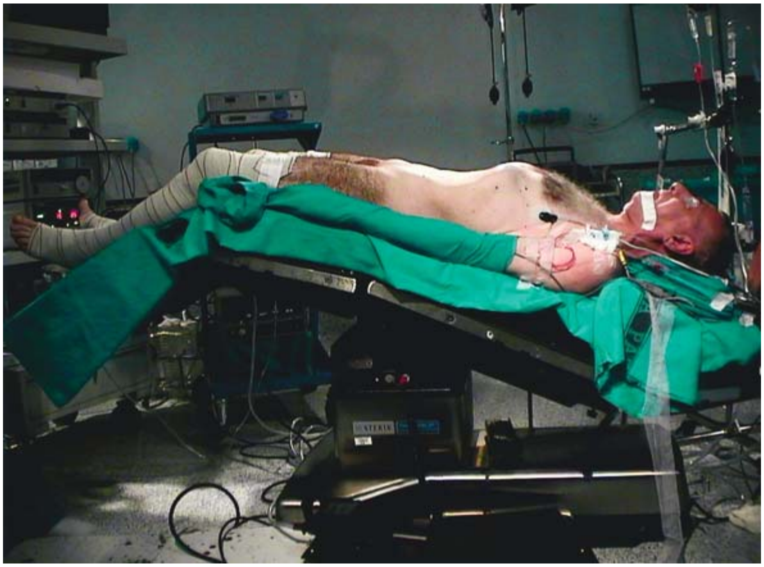


Fig. 15. Slight flexion of the knees in the Trendelenburg position allows the surgeon to have a better view of the laparoscopic tower. It also improves arterial circulation to the legs by decreasing the calf-heart height difference. Care must be taken to avoid compression of the popliteal region, as it may produce nerve lesions and facilitate deep vein thrombosis

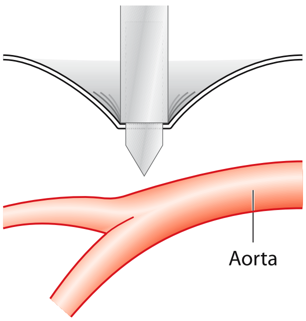


Fig. 16. The skin incision should be wide enough to allow easy passage of the outer trocar sheath into the subcutaneous tissue. Too small a skin opening may result in obstruction of the sheath by the skin edge, causing the surgeon to exert undue force on the abdominal wall. If the trocar then suddenly passes into the abdomen a major vessel or bowel can be injured

will make it possible to stop the bleeding simply by compressing the site with a finger. This will give the surgeon time to dissect the vessel and clamp it or perform a vascular suture. In these cases, it is important to inspect not only the anterior but also the posterior walls of the vessels as they may be injured as well. Bowels that lie over the injured vessel can be lesioned simultaneously, so careful inspection of the ileum is mandatory.

The external iliac vein can be injured during lymphadenectomy. If this should occur an attempt must be made to grasp both ends of the tear with an atraumatic grasper and to close the defect with a running suture. Alternatively, a gauze pad may be passed through a trocar or trocar site and used to apply pressure on the venotomy for 5 min [4].

Neuropraxia – Compression Injuries

Careful patient positioning on the operating table is of utmost importance in order to avoid compression injuries. Usually a steep Trendelenburg position with arms alongside the body is required. Extreme caution has to be taken with all the retractors or robotic arms that are fixed to the operating table in order to avoid inadvertent compression of the arms or hands.

If shoulder supports are used they should only make contact around the acromion processes. If positioned too medially, they compress and injure the cervical plexus.

Some surgeons like to operate with the patient in extended Trendelenburg. In this position, hyperlordosis of the lumbar and thoracic spine is induced. If the extension is exaggerated and the surgery prolonged, damage to the spinal cord can occur [5].

Slight flexion of the knees in the Trendelenburg position gives the surgeon a better view of the laparoscopic tower. It also improves arterial circulation to the legs by decreasing the calf-heart height difference, which may help prevent the development of a lower compartment syndrome in high-risk patients (Fig. 15). Care must be taken to avoid compression of the popliteal region as it may produce nerve lesions and facilitate deep vein thrombosis.

Lower Limb Compartment Syndrome

A total of 16 urological patients with lower limb compartment syndrome (LLCS) have been described in the world literature [6]. The common denominator is patient positioning in the lithotomy or hemilithotomy position. The basic and triggering factor of the pathophysiology of the LLCS is lower limb ischaemia during prolong operations. Ischaemia leads to the depletion of intracellular energy stores and secondary to tissue oedema. Tissue oedema increases the pressures within the four lower limb compartments limited by fixed fascial boundaries. This causes venous outflow obstruction, a decrease in local arterial and capillary blood flow and an increase in capillary permeability. Further elevation of intracompartmental pressures follows, finally leading to tissue infarction [7].

Progressive muscle ischaemia causes rhabdomyolysis and metabolic acidosis, which in turn promotes myoglobinuric renal failure, multisystemic organ failure and death in the most severe cases. In less severe cases, if treatment is initiated early enough, or in subclinical compartment syndrome, there is the risk of long-term neuromuscular deficit of the lower limbs, which may present as foot drop, ankle equines, equinovarus, cavus foot and claw or hammer toes or paresthesia.

Predisposing Factors

An increased risk of lower limb ischaemia and the development of compartment syndrome is associated with limb position, with ankle height above heart level (lithotomy position and/or Trendelenburg position), some leg holders, use of compressor boots or intermittent pneumatic calf compressors [8], intraoperative hypotension, and prolonged procedure time, specially in patients with peripheral arterial insufficiency.

During laparoscopic radical prostatectomy, the Trendelenburg position and the prolonged procedure time during the learning curve can lead to LLCS. Lower extremity pressure has been shown to decrease by 0.78 mmHg for each 1 cm of ankle elevation above the right atrium [9]. Patients with greater body mass index are also at increased risk of suffering LLCS, as more important decreases in ankle pressure have been described in this subset of patients [10]. Surgery in this population tends to be longer, more difficult and with higher blood loss, which might facilitate hypovolaemia [2].

Symptoms – Diagnosis

The typical postoperative presentation includes leg pain, paresthesias, hypoesthesia or weakness of toe flexion. Calf swelling may be present and distal pedal pulses are generally normal. This condition may be misdiagnosed as deep vein thrombosis. A venous duplex scan usually shows a decrease in venous outflow in tibial veins, although it may be reported as normal unless the radiologist has a high index of clinical suspicion [11].

Arterial pulses in the lower extremities may be present even in established compartment syndrome cases, and pulse oximetry of the toes can be normal [12, 13]. Measurement of serum creatinine kinase is very helpful for the diagnosis and monitoring of LLCS. The MM-CK isoenzyme begins to rise 2 h after the onset of muscle injury and peaks within 1–3 days. Myoglobin in plasma and urine also increases after rhabdomyolysis, stains the urine brown and can be detected early with a dipstick.

Intracompartmental pressure measurement is another way of diagnosing LLCS. It requires the percutaneous insertion of small electronic transducer-tipped catheters in the lower limb compartments. Normal compartment pressure is 0–10 mmHg. Fasciotomy should be considered when pressures rise over 30 mmHg [14, 15].

Treatment

If LLCS is suspected, administration of mannitol is mandatory. It induces osmotic diuresis, decreasing compartment pressures and acting as a free radical scavenger. It can avoid the need for fasciotomy in some patients [16]. Correction of metabolic acidosis and restoration of fluid volume are also standard treatments. Established LLCS must be managed with fasciotomy in order to decompress all four lower compartments. After fasciotomy, delayed skin closure usually requires skin grafting. Fasciotomy wounds significantly impact the patient's quality of life, causing tethered scars in 26%, muscle herniation in 13% and tethered tendons in 7% of cases [17]. Renal failure due to myoglobinuria is treated initially with sodium bicarbonate and forced diuresis to prevent further precipitation of urate and myoglobin; however, dialysis is frequently necessary.

Conclusion

LLCS is a life-threatening complication of prolonged operations and lower limb ischaemia, which can lead to severe lower limb sequelae, amputation or even death in the most severe cases. The best way to prevent it during radical laparoscopic prostatectomy is to avoid prolonged surgeries in the forced Trendelenburg position, especially in patients with lower limb arterial insufficiency. If the anticipated procedure duration is beyond 4 h and the patient is at high risk, the Trendelenburg position should be corrected every 2 h for short periods of time to prevent reperfusion injury. It will also allow the surgeon to take a break and restart surgery in better conditions.

Clinical Case

The following clinical case was provided courtesy of Dr. J. Rubio, Valencia, Spain.

A 65-year-old obese patient with type II diabetes, hypertension, myocardial infarction 6 years before, with coronary stent placed 3 years before because of angina pectoris, hyperlipaemia and smoker of ten cigarettes a day. An appendicectomy had been done in the patient's youth. There was a past history of vertebral fracture (T7 and T12). The patient was treated with 125 mg salicylic acid, 10 mg bisoprolol, 50 mg 5-mononitrate isosorbide and 25 mg captopril.

The PSA was 5 ng/ml and cT2a on digital examination. The patient was diagnosed with prostate adenocarcinoma, Gleason 2 + 2 by transrectal biopsy. He was offered brachytherapy, radiotherapy and surgical excision by open or laparoscopic approach. He chose laparoscopic radical prostatectomy. This was done in forced Trendelenburg position following the Montsouris technique. Operative time was 7 h, placing eight anastomotic sutures. Blood loss was 600 cc.

In the recovery room, he presented with hypercapnia and severe hypertension despite correct mechanical ventilation parameters. He had urine output of 2,500 cc during the first 24 h, dramatically dropping to severe oliguria, which did not respond to fluids and furosemide. Total creatine kinase (CK) of 82.850 UI/l on postoperative day (POD) 1 and myoglobin of 69,000 ng/ml was observed. Haemodialysis was started on POD 3 by right femoral catheter. Serum CK decreased progressively and on POD 15 was 893 UI/l.

Due to a decreased level of consciousness and abdominal distension, whole-body CT was performed POD 4 showing no relevant abdominal findings except aortoiliac atheromatosis and three hypodense areas (ischaemic lesions) in the cerebellum, left occipital lobe and caudate lobe, with old calcifications in the occipital and the cerebellar cortex and caudate lobes suggesting old ischaemic lesions.

He recovered spontaneous respiration on POD 11 with partial recovery of consciousness. On POD 16, abdominal CT showed partial regression of the CNS lesions and a heterogeneous increase in the size of the left psoas-iliac muscle, suggesting intramuscular haematoma or abscess (Fig. 17). On POD 18, after the ninth haemodialysis session, he developed rapid desaturation, which required raising FiO_2. After 12 h, legs and abdominal bruises appeared and a cardiopulmonary arrest occurred. The patient did not respond to cardiopulmonary resuscitation. The family did not allow a postmortem. Pulmonary thromboembolism was suspected as the final cause of death.

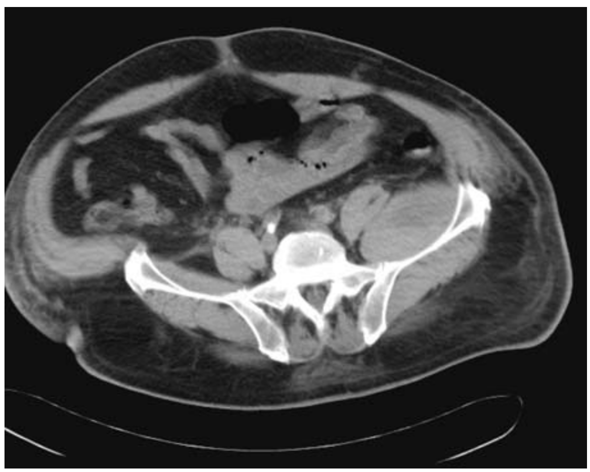


Fig. 17. Heterogeneous increase in size of the left psoas-iliac muscle, suggesting intramuscular haematoma

Anaesthetic Management of Laparoscopic Prostatectomy Complications

The anaesthesiologist is called upon to prevent, diagnose and treat a host of intra- and postoperative complications that inevitably occur when a large number of interventions is performed in increasingly complex patients. The laparoscopic approach requires modifications of the anaesthetic technique in order to effectively deal with increased intra-abdominal pressures, changes in pulmonary mechanics and specific patient positioning as well as restricted visibility and working space for the surgeon. In addition to routine patient monitoring and provision of adequate anaesthesia, analgesia and muscular relaxation, the anaesthesiologist must confirm that intra-abdominal pressures do not exceed 15 mmHg, that endotracheal tube (ETT) displacement does not occur and that pneumothorax or gas embolism does not develop. Only in cases of dramatic clinical instability will it be necessary to release the pneumoperitoneum to permit cardiopulmonary resuscitation. Even then, when stabilization has been achieved, cautious reinsufflation will usually be permitted. Conversion to an open approach is seldom indicated by the anaesthesiologist.

Major incidents occurring during the operation may all have similar clinical presentation, even when the underlying causes vary. The most feared are hypoxia, hypercapnia and cardiovascular collapse. Optimal anaesthetic care, including continuous clinical vigilance, appropriate monitoring and a systematic approach to differential diagnosis, assure the best possible outcome. The most frequent complications are profound vasovagal response, cardiac dysrhythmias, excessive intra-abdominal pressures, acute or inadvertent haemorrhage, myocardial dysfunction, pneumothorax, severe respiratory acidosis, venous gas embolism, cardiac tamponade and adverse anaesthetic drug reaction.

Cardiovascular Complications

The cardio vascular system (CVS) is affected by the choice of the anaesthetic technique (general, combined general + epidural), patient positioning (Trendelenburg, hyperlordosis), pneumoperitoneum and CO_2 insufflation. During short operations, with low intra-abdominal pressures, in the healthy and young, haemodynamic repercussions are routinely corrected by adequate intravascular volume replacement (colloids and/or crystalloids) as well as adjustments of mechanical ventilation parameters. In prolonged, complicated operations, when high intra-abdominal pressures are applied in elderly patients with co-existing diseases (morbid obesity, cardiovascular or pulmonary pathology) difficult-to-manage instability may occur. The most frequent CVS complications are changes in blood pressure (BP) and cardiac rhythm.

The initial response to peritoneal insufflation is a fall in the BP caused by a decrease in cardiac output (CO) secondary to decreased venous return from the compressed vena cava and augmented systemic vascular resistances. Peritoneal distension leads to parasympathetic stimulation and bradyarrhythmias (sinus bradycardia, A-V dissociation, nodal rhythm and asystole), which usually respond well to atropine. As CO_2 absorption takes place, the developing hypercarbia causes increased pulmonary and decreased systemic vascular resistances, sympathetic stimulation with rise of the BP and further arrhythmias (extrasystoles, tachycardias).

Endocrine system changes related to the renin-angiotensin-aldosterone system (activated by rising $PaCO_2$ levels), and antidiuretic hormone secretion (stimulated by the pneumoperitoneum) also contribute to a rise in the BP. Renal blood flow diminishes as a consequence of augmented intra-abdominal pressures, leading to decreased renal filtration rate and oliguria, which is further aggravated by ADH secretion [18, 19].

Pulmonary Complications

Changes in pulmonary function include reduction of lung volumes, increased airway pressures, decrease in lung compliance and augmented minute ventilation (Vm) requirements. Complications share common clinical presentations such as hypoxia (ventilation/perfusion [V/Q] mismatch, intrapulmonary shunting, hypoventilation, decreased CO), hypercapnia (excessive CO_2 absorption, hypoventilation, V/Q mismatch, CO_2 embolism, subcutaneous emphysema, pneumothorax, malignant hyperthermia) and changes on auscultation (unilateral loss of breath sounds – endobronchial intubation, mucus plug, pneumothorax).

Insufflation provides a pressure gradient which favours CO_2 absorption by the highly vascularized peritoneum. Since CO_2 is very soluble in the blood, a significant rise in the $PaCO_2$ occurs initially, reaching equilibrium 20–30 min following establishment of the pneumoperitoneum. If late $PaCO_2$ elevation is observed or its level rises 15%–30% above the patient's basal, a complication should be suspected. The anaesthesiologist corrects this phenomenon by adjusting mechanical ventilation parameters to increase the Vm and maintain an acceptable end tidal CO_2 ($EtCO_2$). Patients with lung and/or heart disease pose a challenge as their habitual V/Q mismatch is aggravated and uncontrolled hypercapnia with severe respiratory acidosis may develop. Other factors which predispose to this complication are inadequate mechanical ventilation technique, intra-abdominal pressures over 15 mmHg, prolonged operation, retroperitoneal access and subcutaneous emphysema [18, 20, 21]. Severe hypercapnia and respiratory acidosis have multiple pathophysiological repercussions. Although directly they induce systemic vasodilatation, activation of the sympathetic nervous system provokes to vasoconstriction. In the pulmonary vasculature, vasoconstriction predisposes patients with risk factors to develop clinically significant pulmonary hypertension and right heart strain. There is marked vasodilatation of the cerebral circulation, which results in increased intracranial pressures. High $PaCO_2$ levels produce postoperative nausea and vomiting, are epileptogenic and cause cortical depression. The anaesthesiologist will usually not extubate a patient until acceptable CO_2 blood levels can be maintained without the support of mechanical ventilation [19, 21].

Pneumothorax or Capnothorax

Pneumothorax and capnothorax are rare but potentially life-threatening complications. Their origin may be found in the chest (barotrauma, ruptured emphysematous bullae) or in the abdomen (capnothorax associated with congenital defects or iatrogenic diaphragmatic tears, pre-peritoneal cannulation, subcutaneous emphysema). Statistically, these complications are seen more frequently during prolonged operations, with high intra-abdominal pressures and an $EtCO_2$ greater than 50 mmHg.

The clinical presentation varies from a minimal increase in peak airway pressures, through desaturation, to total circulatory collapse. It is accompanied by hypoxia despite high inspired fraction of oxygen (FiO_2), increased airway resistances and changes in the $EtCO_2$ together with unilateral diminished or abolished breath sounds. Definitive diagnosis by radiography is usually not available and not practical, so a high degree of suspicion is required to enable prompt diagnosis and therapeutic action. Management will depend on the severity of the associated cardiopulmonary dysfunction; persistent instability makes the placement of a chest drain necessary in order to prevent morbidity and mortality and to permit the operation to proceed. Pneumomediastinum and pneumopericardium have also been described and their pathogenesis is thought to be similar. The signs are those of cardiac tamponade and rapid diagnosis and decompression can be life-saving.

Capnography is a fundamental monitoring tool and its use is mandatory during laparoscopic surgery. The shape of the capnogram and the absolute $EtCO_2$ values permit the clinician to diagnose, monitor the progression and assess the efficacy of the treatment of many pulmonary and haemodynamic complications. For example, a high $EtCO_2$ with a high $PaCO_2$ implies that the Vm is insufficient to eliminate the CO_2 absorbed; if associated with high airway pressures, it is characteristic of a capnothorax. A low $EtCO_2$ with high $PaCO_2$ typically occurs when pulmonary blood flow is insufficient to permit effective gas exchange as in low cardiac output states (pneumothorax, cardiac tamponade, circulatory collapse) or pulmonary embolism [18, 22, 23].

Gas Embolism

This complication is not frequent but potentially associated with significant morbidity and mortality. Generally, it occurs at the beginning of a laparoscopy and is more frequent in patients with prior abdominal operations. It is caused by the passage of gas bubbles via an open vessel directly to the blood stream. More rarely it is a consequence of inadvertent insufflation into a viscus. Subclinical gas embolism has been documented by various echographic and Doppler studies. Symptomatology depends on the number and on the size of the gas bubbles. It is recommended that peritoneal insufflation be done slowly (< 1l/min) in order to permit early detection of the problem. Nonuniform abdominal distension, hypotension, hypoxia, dysrhythmias and heart failure may all occur. Precordial or trans-oesophageal echography confirm the clinical suspicion, while direct aspiration of gas from a central venous access line is both diagnostic and therapeutic. Intraoperative management includes hyperventilation with high FiO_2 and maintenance of haemodynamic parameters with volume expansion and vasopressors. Positioning the patient in the head-down, left lateral decubitus may be helpful, as it favours the pooling of the gas at the cardiac apex and prevents pulmonary and/or paradoxical systemic embolization. Treatment of these complications may require the use of hyperbaric O_2 [18, 19, 24].

Subcutaneous Emphysema

A ubiquitous complication of laparoscopic surgery, subcutaneous emphysema usually is clinically not relevant. Only in very few cases (inadvertent subcutaneous/preperitoneal/retroperitoneal insufflation) does it become a problem. Morbidity arises from the increased surface area for CO_2 absorption, which induces hypercapnia and respiratory acidosis. The gas may progress, dissecting along low-resistance fascial planes from the abdomen to the chest wall, neck, head and face. It may also track along the thorax, producing pneumothorax and/or pneumomediastinum. The diagnosis is by palpation of crepitus associated with increased airway pressures. No specific intervention is needed except in the most severe cases where prolonged mechanical hyperventilation becomes necessary to correct the increased $PaCO_2$. Prevention of this complication with proper peritoneal insufflation technique is fundamental [18, 23].

Endotracheal Tube Displacement

This is a frequent incident associated with patient position changes. The steep Trendelenburg position and high intra-abdominal pressures favour cephalad displacement of the bronchial tree with the risk of inadvertent endobronchial (main stem) intubation. Hypoxia, increased airway pressures and unilateral loss of breath sounds are again the clinical signs. Repositioning of the ETT promptly resolves all the manifestations [18].

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7 Laparoscopic Retroperitoneal Lymph Node Dissection for Testicular Tumors

Gunther Janetschek

Contents

Introduction

Testicular cancer, although relatively rare, is the most common malignancy in men in the 15- to 35-year age group and evokes widespread interest for several reasons. The combination of effective diagnostic techniques, improved tumor markers, effective multidrug chemotherapeutic regimens, and the modifications of surgical technique has led to a dramatic improvement in patient management and a decrease in patient mortality from more than 50% before 1970 to less than 5% in 1997 [1].

The fact that testicular cancer spreads in a predictable and stepwise fashion, with the notable exception of choriocarcinoma is the basis of its modern surgical treatment principles.

Staging is considered the first step in the management of testicular cancer patients; after radical orchiectomy. A convenient division for staging systems is those patients with seminomas and those with nonseminomatous tumors. Patients with pure seminoma are usually staged by clinical means, whereas staging in patients with nonseminomatous germ cell tumors (NSGCTs) sometimes employs surgical techniques such as retroperitoneal lymph node dissection (RPLND) as well. The extent of staging is determined in part by decisions for therapy; for example, if surveillance protocols are to be considered, every effort should be made to exclude patients with any evidence of retroperitoneal disease. If retroperitoneal lymphadenectomy is likely to be elected as the primary treatment for low-stage, nonseminomatous tumors, efforts should be directed toward delineation of regional and nodal vs distant metastases.

Indications

Nonseminomatous Germ Cell Tumors

Clinical Stage I

To date, three treatment options are available and considered by urologists for the management clinical stage I nonseminomatous testicular cancer: surveillance, risk-adapted chemotherapy and retroperitoneal lymph node dissection.

Of patients with clinical stage I disease, 25%–30% have occult lymph node metastases, which cannot be diagnosed by the most sensitive imaging techniques available [2, 3]. This group of patients will be victimized if surveillance strategy is followed, as they will be diagnosed later after the tumor has substantially increased in size, thereby requiring a higher dose of chemotherapy for treatment. Furthermore, as the patient's compliance is usually not perfect, some tumor-bearing patients might be lost during follow-up. Surveillance without prior lymph node dissection has a relapse rate of 19%–40% [4–6] vs 5%–10% for pathological stage I testicular cancer after retroperitoneal lymph node dissection [7–10]. Moreover, the most serious drawback of surveillance is not only the high relapse rate but the associated death rate of approximately 10% among those patients who do relapse [3].

The primary advantage of surveillance was the avoidance of retroperitoneal lymph node dissection and its attendant morbidity, as before the introduction of modified unilateral dissection and nerve-sparing techniques, the majority of patients suffered ejaculatory disturbances with resultant loss of fertility [11].

Recently risk-adapted chemotherapy has been introduced as a measure to overcome the above-mentioned problems [12]. However, there is no general consensus about risk factors and their clinical relevance, except for vascular invasion and embryonal carcinoma [13]. We have performed a retrospective analysis on 88 consecutive patients undergoing RPLND. Because the definition of risk factors varies greatly, the patients were evaluated using a highly specific risk factor (70% or more embryonal carcinoma together with vascular invasion) as an example of the many possibilities of calculating the risk. Even though the risk factor used was specific (present in 25% of the patients), 52% of patients who would have been considered candidates for chemotherapy did not have retroperitoneal tumors. On the other hand, 50% of patients with retroperitoneal tumors would have been considered low risk and left without treatment. Another staging study has also shown that 20% of patients with suspicious findings on CT actually have pathologic stage I disease [14], and therefore might suffer the side effects of adjuvant chemotherapy: the acute ones (nausea, mucositis and nadir sepsis) as well as the long-term more morbid ones (pulmonary fibrosis and impaired spermatogenesis) [15, 16], in vain.

RPLND is the only reliable method permitting the verification of small positive lymph nodes and the exclusion of false-negative ones. However, the morbidity of open RPLND is too high for a diagnostic procedure: the short-term morbidity of major intra-abdominal surgery and the long-term ones, which is much less tolerated, including loss of antegrade ejaculation and a life-long scar that impairs the quality of life of a usually young patient.

Since knowledge of the definite lymph node status is a prerequisite for adequate stage-adapted treatment, RPLND is retained as a diagnostic and in a way therapeutic tool, but, at the same time, its morbidity is substantially reduced by the use of laparoscopy.

Our recent data, as well as data of other centers, show that laparoscopy shares the same efficacy of open RPLND. Relapse rates after open RPLND alone are as high as 8%–29% for stage IIa tumors [17, 18] and 34%–55% for stage IIb tumors [18, 19]. This rate falls to as low as 0%–1% if two cycles of adjuvant chemotherapy are given [19, 20]. Laparoscopic RPLND, therefore, reduces the high morbidity of the combination of open RPLND and adjuvant chemotherapy in node positive patients.

Clinical Stage II

Neither retroperitoneal lymphadenectomy [17–19, 21] nor chemotherapy [22, 23] can be expected alone to be curative in all patients in this stage. A combination of both is expected to achieve the most effective results. Most urologists prefer the strategy of primary chemotherapy followed by RPLND for residual masses. In this case, RPLND is performed in a diagnostic intent, i.e., to exclude that the residual mass contains active tumor, but sometimes can be curative, i.e., if mature teratoma is found and removed.

Again, the advantage of laparoscopy here rises by reducing the double morbidity of chemotherapy and open surgery. In an attempt to further reduce the morbidity of this combined treatment, we have reduced the dose of chemotherapy to two cycles for stage IIb, which is obviously the minimum dose required for complete tumor control [24]. However, this approach is experimental at present, which makes the evaluation of the effect of chemotherapy by laparoscopic RPLND mandatory in each patient.

RPLND can be performed as a first step in a therapeutic intent. In this case, it has to be done bilaterally to remove not only the primary landing site but also all possible sites of tumor spread. By laparoscopy, bilateral RPLND is only feasible as a staged procedure, which decreases efficiency and increases morbidity. Other studies have found that laparoscopic RPLND should not be recommended for residual masses owing to the intense desmoplasia in the vicinity of the great vessels after chemotherapy [25], but our results have shown it to be technically feasible not only in stage IIb, but also IIc. However, in the latter stage, the risk of contralateral tumor spread is high and as laparoscopy allows for unilateral dissection only, we have now restricted it to stage IIb [24, 26].

Seminoma

Since the morbidity of carboplatinum monotherapy is low and its efficacy is very high, we feel there is no place for laparoscopy in the management of stage I seminoma [27]. The only exception we consider is the removal of residual masses after chemotherapy.

Template for Retroperitoneal Lymph Node Dissection

Weissbach and Boedefeld have described templates that include practically all the primary landing sites of lymph node metastases [28]. If all the metastatic tissue is resected within these templates, there is only minimal risk of metastases to be overlooked. The templates for the left and right sides differ substantially; only the templates for right-sided tumors include the interaortocaval tissues (Fig. 1).

There is, however, still some controversy on whether to remove the tissues behind the lumbar vessels, the vena cava and the aorta. There is currently no study available investigating whether this area is among the primary landing sites of lymph node metastases. The authors have developed a laparoscopic split-and-roll technique that enables transection of all lumbar vessels and enables the authors to perform the same radical dissection as with open surgery. Meanwhile, the authors have investigated the primary landing sites as regards to their ventrodorsal location. All solitary metastases, and at least one multiple metastasis, were detected ventral to the lumbar vessels. Therefore, it can be concluded that the primary landing sites are invariably located ventrally, whereas dorsal metastases result from further tumor spread [29]. Consequently, the authors no longer routinely transect the lumbar vessels to remove the tissues behind them, it is not required in diagnostic RPLND for clinical stage I tumors. This makes the laparoscopic procedure considerably easier, faster and safer.

In clinical stage IIb disease following chemotherapy, all the tissues in which the tumor was detected before chemotherapy were removed and the ipsilateral template is dissected in the same fashion as in clinical stage I disease.

Technique

Bowel preparation, including a clear liquid diet and oral laxatives, is performed 1 day preoperatively. All patients receive low-dose antibiotic coverage. Typing and cross-matching are performed for two units of blood as a preventive measure to prevent chylous ascites, which was observed in some patients after postchemotherapy laparoscopic RPLND. Preoperative preparations now also include a low-fat diet for 1 week that is continued 2 weeks postoperatively. The authors have not seen this complication since.

Standard laparoscopic equipment used including a three-chip video camera and a 30° laparoscope. The laparoscope is held and maneuvered by a robotic arm

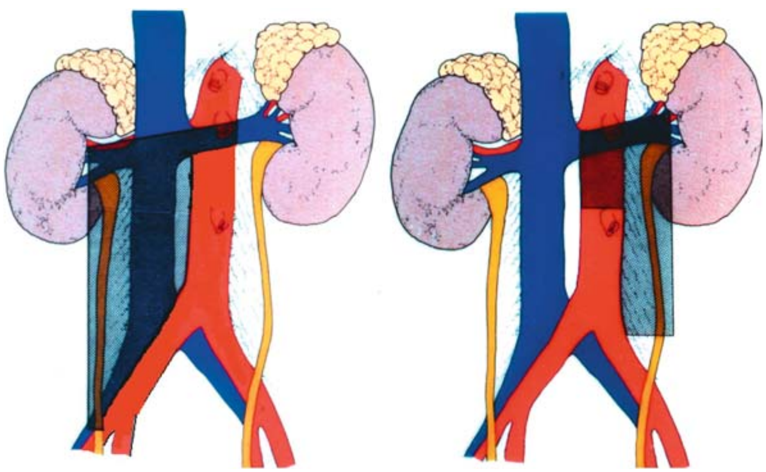

Fig. 1. Templates for right-sided dissection (right side of figure) and left-sided dissection (left side of figure)

(Computer Motion, Santa Barbara, CA). This has the advantage of providing stable video images even in lengthy procedures. An insufflation with a high flow rate has proved helpful because it prevents the pneumoperitoneum from collapsing during suction. A small surgical sponge held with an atraumatic grasper is used for retraction, dissection and hemostasis. A right-angled dissector (Aesculap, Germany) is applied for dissection of the vessels. The author prefers the use of reusable clips because their small branches allow for more precise placement of the clips.

Clinical Stage I: Right Side

The patient is placed on the operating table with the right side elevated 45° upward so that by rotating the table the patient can be brought into a supine or lateral decubitus position without repositioning. In addition, the table is flexed at the umbilicus. If necessary, the Trendelenburg or anti-Trendelenburg position is used.

A Veress needle is used for the initial stab incision to create the pneumoperitoneum; whereas the Hasson cannula is preserved for patients who have previously undergone abdominal surgery. Only 10-mm trocars are used. The first trocar for the laparoscope is placed at the site of the umbilicus. Two secondary trocars for the surgeon are placed at the lateral edge of the rectus muscle approximately 8 cm above and below the umbilicus. One more trocar is positioned in the anterior axillary line to facilitate retraction.

Wide access to the retroperitoneum is a prerequisite for laparoscopic RPLND. Excellent access can be gained by wide dissection of the right colon and the duodenum in the plane of Toldt. As a first step, the peritoneum is incised along the line of Toldt from the cecum to the right colic flexure. This incision is then carried cephalad parallel to the transverse colon and lateral to the duodenum along the vena cava all the way up to the hepatoduodenal ligament. Caudally, the incision is carried along the spermatic vessels down to the internal inguinal ring. Next, the colon, the duodenum, and the head of the pancreas are reflected medially until the anterior surface of the vena cava, the aorta and the left renal vein at its crossing with the aorta are completely exposed.

At this point, the entire template described by Weissbach and Boedefeld for right-sided tumors is accessible. This template includes the interaortocaval lymph nodes, the preaortic tissue between the left renal vein and the inferior mesenteric artery, and all the tissue ventral and lateral to the vena cava and the right iliac vessels between the renal vessels and the crossing of the ureter with the iliac vessels. The template is bounded laterally by the ureter. As mentioned above, the tissues behind the lumbar vessels and the vena cava are no longer removed. The spermatic vein is then dissected along its entire course starting from the internal inguinal ring.

Special care must be taken while dissecting its opening into the vena cava because at this point the vein is liable to rupture. Cranially, the spermatic artery takes a separate course; it is clipped and transected at its crossing with the vena cava, whereas its origin from the aorta is approached later.

Next the lymphatic tissue overlying the vena cava is split open from cranial to caudal and its anterior and lateral surfaces are dissected free. Both renal veins are freed.

It is important to dissect the lower border of the left renal vein at this point of the procedure. When dissecting the interaortocaval package from caudal in the acephalad direction, the left renal vein can be easily injured if it is not clearly visible (Fig. 2). The lymphatic tissue overlying the common iliac artery is incised up to the bifurcation and further to the origin of the inferior mesenteric artery. In this area, the lymphatic tissue is very dense and care must be taken not to injure the mesenteric artery. Cephalad to the artery, the lymphatic tissue is split along the left border of the aorta so that the ventral surface of the aorta is completely freed. The spermatic artery is now clipped

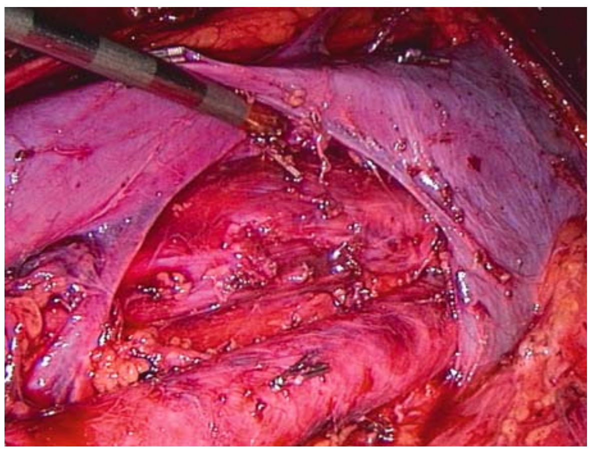

Fig. 2. Right RPLND: interaortocaval dissection

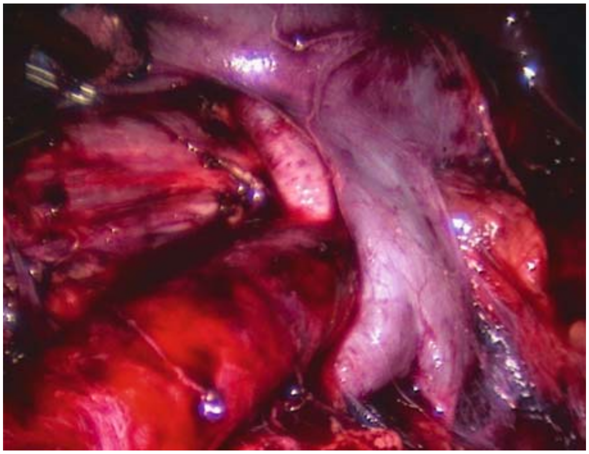

Fig. 3. Right RPLND: interaortocaval space, right renal artery and left renal vein

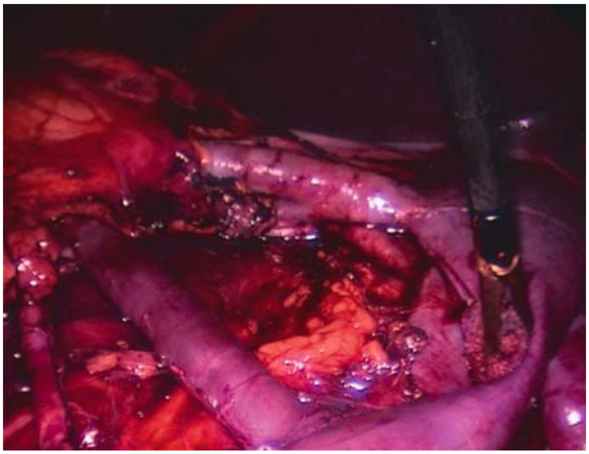

Fig. 4. Right RPLND: main renal vessels, lower polar artery and vein

and transected at its origin from the aorta. When dissecting the cranial portions of the template, the liver has to be retracted with a fan retractor. Now the right renal artery can be identified as it courses above the interaortocaval space, and the cranial border of the dissection is well delineated (Fig. 3). The dissection is carried down to the lumbar vessels and the interaortocaval package is removed step by step.

The ureter, which defines the lateral border of the dissection, is usually identified during excision of the spermatic vessels. It is separated from the nodal package down to its crossing with the iliac artery. This point delineates the distal border of the dissection, and the lymph node package is clipped and transected.

From here, the lymph nodes are dissected free in a cephalad direction. The lumbar veins are exposed, but they are transected in exceptional cases only to facilitate removal of the lymph nodes. Cranially, the ureter enters Gerota's fascia, which can also be differentiated clearly from the lymphatic tissue (Fig. 4). In addition to the right renal vein, the right renal artery is exposed lateral to the vena cava, which delineates the cranial border of the dissection.

Now, the nodal package is completely free and can be removed inside a specimen retrieval bag. A drain is not required. Finally the colon and the duodenum are returned to their anatomic positions and secured with one suture, which is tied extracorporeally.

Left Side

The patient is in a right decubitus position. The trocars are placed as for right-sided tumors but in a mirror image array. Usually three or four 10-mm trocars will suffice because the bowel has to be retracted in rare cases only.

The peritoneum is incised along the line of Toldt from the left colic flexure to the pelvic brim and distally along the spermatic vein to the internal inguinal ring. It is also essential to incise the splenocolic ligament.

The dissection of the colon must be continued until the anterior surface of the aorta is exposed completely in the plane of Toldt. Normally, the colon falls away from the operative site because of gravity, and a retractor is required only in a few exceptional cases.

Then the spermatic vein is dissected free along its entire course from the internal inguinal ring to its opening into the renal vein and removed (Fig. 5). The ureter, which defines the lateral border of the template, is identified and separated from the lymphatic tissue. Care must be taken to preserve the connective tissue that provides the blood supply of the ureter. At this time, the renal vein can be freed completely. Next, the lymphatic tissue overlying the common iliac artery is split open. The dissection is started at the crossing of the artery with the ureter, which delineates the distal border of the template. From there, the dissection is continued cephalad. The inferior mesenteric artery is circumvented on the left and preserved. Directly above the mesenteric artery, the dissection is

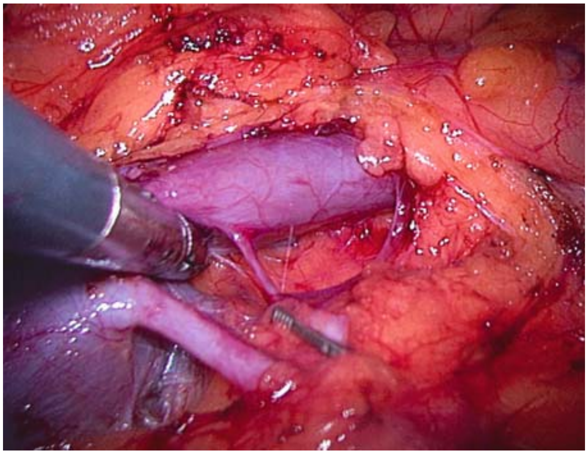

Fig. 5. Left RPLND: left renal vein with the entrance of spermatic vein and a small additional vein

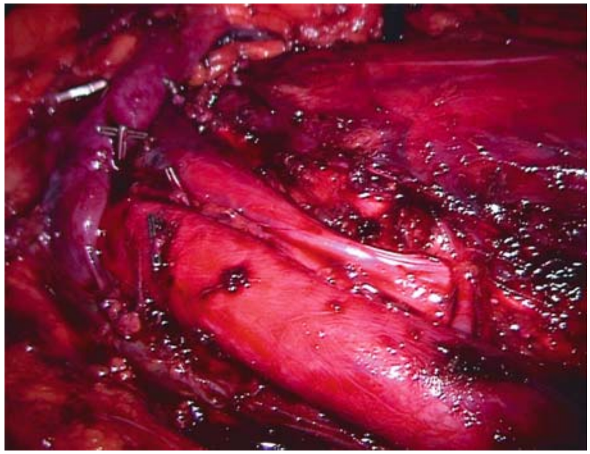

Fig. 7. Left RPLND: after completion of dissection

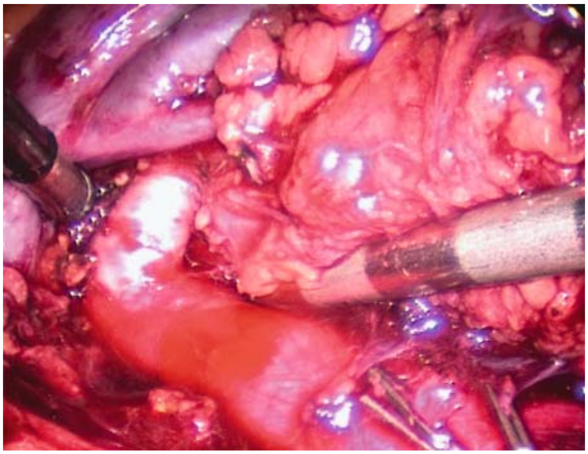

Fig. 6. Left RPLND: left renal artery and vein

continued along the medial border of the aorta up to the level of the renal vein, which has been identified before.

The spermatic artery is secured with clips at its origin from the aorta and transected. The lateral surface of the aorta is dissected down to the origin of the lumbar arteries. Next, the lumbar vein, which passes caudal to the left renal artery, is approached as it enters the renal vein and transected between clips. This provides access to the renal artery, which lies directly underneath (Fig. 6). As a last step, the lumbar vessels are separated from the lymphatic tissue to the point in which they disappear in the layer between the spine and the psoas muscle.

Directly lateral to that point, the sympathetic chain is encountered. The postganglionic fibers, although readily identified in most cases, are not preserved. Now, the nodal package is completely free and can be retrieved (Fig. 7). Finally the colon is returned to its normal anatomic position and secured in place with one extracorporeally tied suture.

Laparoscopic Retroperitoneal Lymph Node Dissection for Stage II After Chemotherapy

Unilateral RPLND is performed within the same template as is used for clinical stage I disease. Bilateral RPLND is not attempted; in all of the authors' 58 patients, the residual tumor was located within the unilateral template. Displacement of the bowel was feasible in all cases, although chemotherapy rendered identification of the tissue layers more difficult. Mature teratoma is usually well delineated, whereas tumor-free residuals after embryonal carcinoma may be tightly adherent to the surrounding structures (Figs. 8, 9). This is particularly true for the vena cava. Small venous branches draining the tumor have to be meticulously dissected before they are clipped and transected.

Dissection and Hemostasis Technique

The most useful tools for achieving bloodless dissection and adequate hemostasis are bipolar coagulation

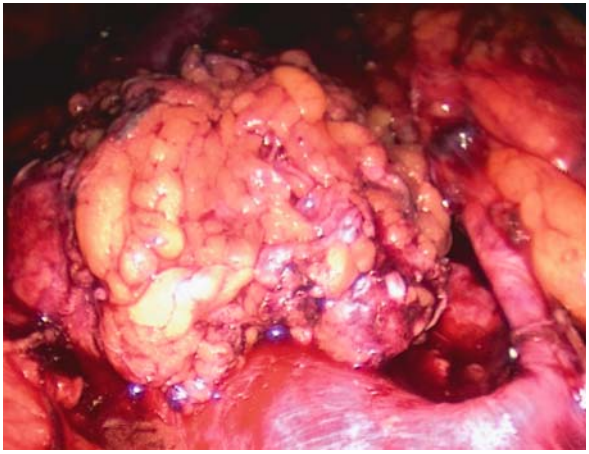

Fig. 8. Left RPLND: residual mass after chemotherapy

Fig. 9. Left RPLND: operative field after excision of mass

and the harmonic scalpel (Ethicon). Because the authors have been using these tools, dissection has become easier, safer, and faster. A small clamp for bipolar coagulation (Johnson & Johnson, New Brunswick, NJ, USA) allows for meticulous dissection of delicate structures whereas broader bipolar forceps provide highly efficient hemostasis. In the authors' hands, these tools have proved very efficient.

In open surgery, acute bleeding can be stopped instantaneously with the index finger of the surgeon. In laparoscopy, a small surgical sponge that is held with a traumatic grasper can be used to substitute for the surgeon's finger.

Once the bleeding has been stopped with this technique, the surgeon need not act in a hurry but has plenty of time to undertake the necessary steps. Furthermore, the authors' animal studies and clinical experience have shown that most venous bleedings, including those resulting from small leaks in the vena cava, can be stopped with the help of fibrin glue (Baxter-Immuno, Deerfield, IL, USA). A special laparoscopic applicator is available from the manufacturer with two separate channels for the two components of fibrin glue. The edges of larger defects are approximated with a grasper or clips and then sealed with fibrin glue. In addition, a strip of oxidized regenerated cellulose or other hemostatic agents can be used to enhance the tightness of the repair.

Owing to these hemostatic techniques, only three out of 162 laparoscopic RPLNDs had to be converted to open surgery. No late bleeding was observed.

Results

Between August 1992 and June 2004, 162 consecutive patients underwent laparoscopic RPLND. No patients were excluded because of body habitus or previous operations (see Tables 1 and 2).

Stage I

RPLND was performed for 103 patients with clinical stage I testicular tumor. The mean age was 29.9 years (16–51). In 64 patients, the tumor was located on the right side and in 39 on the left side. Patient selection was not based on assessment of risk factors or histologic findings.

Table 1. Clinical data RPLND

	Clinical stage I	Stage II after chemotherapy
No. of patients	103	59
Mean age	29.9	29.2
Tumor side	Right: 64 Left: 39	Right: 32 Left: 27
Operative time	Overall: 276 min (140–360) After 1st 30 cases: 217 min (140–300)	IIb: 216 min (135–300) IIc: 281 min (145–360)
Blood loss	144 ml (10–470)	165 ml (20–350)
Conversion rate	3/103 (2.9%)	No conversion
Hospital stay	3.6 days (2–8)	3.8 days (3–10)

Table 2. Follow up data RPLND

	Clinical stage I	Stage II after chemotherapy
Mean follow-up	62 months (6–113)	53 months (10–89)
No. of patients	98/103	59/59
No. of relapses	5 (4.9%)	2 (3.4%)
Antegrade ejaculation	100/100 (100%)	57/59 (96.6%)

Surgical Efficacy

Laparoscopy is a technically challenging procedure, which requires a steep learning curve. However, once this obstacle is overcome, its results are comparable to and sometimes even better than open surgery. This can be demonstrated by our operative time, which fell from an average of 276 min to 217 min on exclusion of the first 30 patients. This time is now shorter than the mean operative time reported for open RPLND [33] and comparable to operative time in other series [30, 31]. Mean blood loss was 144 ml (range, 10–500), not including 2,600 ml in a converted patient with horseshoe kidney. We had three conversions, one due to injury of a small aortic branch, another due to injury of renal vein in a horse-shoe kidney and the third due to injury of a left renal vein ventral to the aorta (conversion rate, 2.9%). Four other minor intraoperative complications were encountered including vena caval, renal and lumbar vein injury. All were controlled laparoscopically with either clips or fibrin glue; a left renal vein injury was controlled via laparoscopic suturing. Few minor complications occurred postoperatively including three asymptomatic lymphoceles, a transient irritation of the genitofemoral nerve and a spontaneously resolving retroperitoneal hematoma. Other groups have reported ureteral stenosis following ureteric stenting, which was abandoned later on, as well as the need for temporary ureteric drainage in some cases [30]. Mean postoperative hospitalization was 3.6 days (2–8 days).

Oncologic Efficacy

Histologic findings were positive in 26 of the 103 patients (25%). Some groups have reported the number of resected lymph nodes but this does not appear practical, since to our knowledge there are no data to indicate how many lymph nodes a specimen must contain to prove the completeness of the dissection in a given template.

When assessing the results of laparoscopy and comparing them to open surgery, one should take into consideration several factors, primarily, the efficacy of the surgery in controlling the disease, which is most important, when dealing with malignancy.

Follow-up data are available on 98 of our 103 clinical stage I patients. Of 77 pathological stage I patients on a mean follow-up of 62 months, five patients were lost during the follow-up and five relapses were reported. One retroperitoneal recurrence occurred on the contralateral side outside the surgical field. Further investigations revealed that the tumor in the primary landing site had been removed at surgery but was missed on histologic examination. This patient was cured with two cycles of chemotherapy and contralateral laparoscopic RPLND. Three other patients developed lung recurrences during the follow-up. Another patient had elevation of his tumor markers without an identifiable recurrence site. A sixth patient with NSGCT clinical stage I treated in another center by two cycles of primary chemotherapy (BEP) developed retroperitoneal relapse after 1 year of follow-up with negative tumor markers. Laparoscopic RPLND was performed on this patient and the pathology revealed mature teratoma with ectodermal elements. Therefore this patient was treated with two cycles of adjuvant chemotherapy and he was free of recurrence for the 16 months of follow-up. No further relapses occurred, which clearly demonstrates the oncologic efficacy of the procedure. Rassweiler et al. and Gerber et al. also reported pulmonary relapses in four cases, but no retroperitoneal relapses [30, 32].

The rate of retroperitoneal relapse after open RPLND was 6.8% in 88 clinical stage I patients. Thirty-seven of the 88 patients had pathologic stage I lesions [32]. The relapse rate in our series is comparable to that of open surgery.

The mean follow-up in 26 clinical stage I pathologic stage II patients who received two cycles of adjuvant chemotherapy (all except one patient with mature teratoma) is currently 62 months. Over this period, no relapse has been seen.

Stage II After Chemotherapy

Between February 1995 and June 2004, 59 patients with clinical stage II disease underwent laparoscopic RPLND after primary chemotherapy (42 stage II b and

Table 3. Histopathological findings in stage II patients

Stage II after chemotherapy: Postoperative pathology	No. of patients
Total number	59 patients
Necrosis	36 cases (61%)
Mature teratoma	21 cases (35.6%)
Active tumor	1 case (1.7%)
Seminoma	1 case (1.7%)

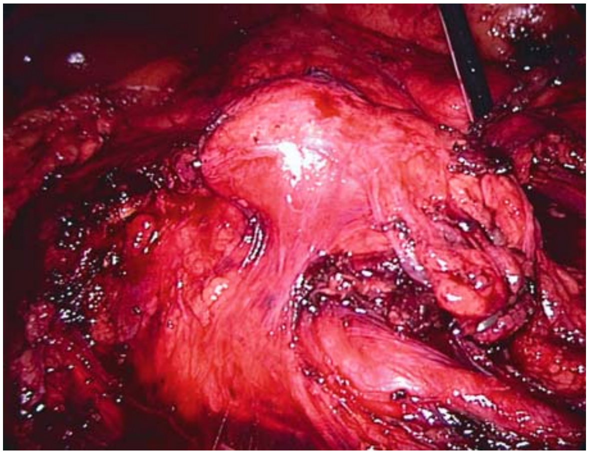

Fig. 10. Seminoma: residual mass after chemotherapy

17 stage IIc). The mean age was 29.2 years (15–56). The procedure was performed on the right side in 32 patients and on the left in 27. The mean operative time was 234 min (135–360) and the mean blood loss was 165 ml (20–350). No conversion occurred and the spectrum of complications were almost the same as stage I patients, with a higher incidence of chylous ascites in stage II. The postoperative hospital stay averaged 3.8 days (3–10 days).

Histologic analysis of the specimen revealed necrosis in 36, mature teratoma in 21, active tumor in one patient and seminoma in another (Table 3). To date, this was our only seminoma case for which RPLND was done. The patient had a residual tumor 6 cm in size following three cycles of chemotherapy (20% of the original tumor size). The PET scan showed no reduction in size between the second and third course and no signs of vital tumor (Fig. 10). RPLND was performed on the left side; the procedure was quite difficult owing to large tumor mass and numerous venous interconnections. Histology revealed small foci of vital tumor.

On a mean follow-up of 53 months (10–89), relapse was detected in two patients. One patient with stage IIb disease had recurrence after 24 months of follow-up, which was outside the surgical field at the external iliac lymph nodes. The other patient with stage IIc disease had recurrence within 18 months of follow-up at the retrocaval lymph nodes outside the surgical field.

Antegrade Ejaculation

Loss of antegrade ejaculation is the major morbidity encountered after RPLND. This drawback can be overcome either by performing a template dissection as described by Weissbach [28] or by nerve sparing RPLND [7]. The template dissection, however, downscales the operative field yet maintains acceptable sensitivity and more importantly does not increase relapse. We have followed this strategy in our work and in 100 of our stage I patients, the antegrade ejaculation rate was 100% (three patients were lost during follow-up). In stage II patients, antegrade ejaculation was preserved in 57 out of 59 patients (see Table 2).

With the introduction of nerve-sparing RPLND, Donohue was able to improve the ejaculation rate from 70% to almost 100%. However, Donohue did not only introduce nerve-sparing dissection but also simultaneously limited the dissection to the unilateral template [7, 11]. It has been known since 1964 that destruction of the sympathetic chain on one side does not result in aspermia as long as the contralateral side is intact [34]. Therefore, nerve-sparing in addition to a unilateral dissection is not necessary at all and cannot improve the already good results. Recently, Peschel et al. have published the results of laparoscopic nerve-sparing RPLND in five patients showing an operative time of 3.2 h on average, a blood loss of 66 ml and a hospital stay of 3.7 days (results comparable to the standard procedure). This required meticulous dissection and identification of the sympathetic chain and the postganglionic fibers in the retrocaval, the interaortocaval and the para-aortic regions. However, as we mentioned, antegrade ejaculation is routinely preserved when a nerve-sparing dissection is limited to a unilateral template, yet the development of a unilateral laparoscopic nerve-sparing technique is a step towards bilateral laparoscopic dissection [35].

Quality of Life

A major issue to be considered when comparing various treatment modalities is the patient's quality of life thereafter. Thus, a quality-of-life study has been performed in coordination with a psychiatric group at our center. A questionnaire was distributed to 119 patients and completed by personal interviews in 118 (the open group included 53 patients and the laparoscopic group 59). The questionnaire included questions about the patient's satisfaction with the information about the disease, how they experienced treatment and its side effects. Patients were asked about the time it took them until they were able to perform gentle physical exercise, return to normal activities and were free of symptoms. Other questions regarding sexual activity, whether the patient felt lovable, experienced any problems in his partnership, psyche, or social life and whether he was anxious about losing his job or had emotional problems associated with the loss of the testicle or the RPLND procedure were also addressed. Surprisingly, the patients tolerated better not only laparoscopic RPLND, but also open RPLND, than chemotherapy. Open RPLND was found to impair the quality of life more than laparoscopic RPLND. There is not a single item where open RPLND was superior to laparoscopy. The patients who participated in the study preferred RPLND to all other treatment modalities [36].

Cost Effectiveness

Although costs are not a primary issue yet, they have to be taken into consideration. In our series, the surgery per se was found to be less expensive if done by open surgery rather than laparoscopy, but adding the hospital stay to the surgical costs brings the latter down so that the total hospital costs in both groups are almost equal. Another factor that has not been taken into consideration in most studies is the time to convalescence, especially considering that most of our patients are young productive individuals. If this factor was to be added, laparoscopy definitely was found to be on the winning side [24].

Extraperitoneal Approach

Two centers have described an extraperitoneal approach for laparoscopic RPLND. One group strongly supports the procedure, arguing that it is safer to the bowel and other viscera, less liable to cause pressure scores as there is no steep Trendelenburg or lateral position, and suggesting that it provides better access to the retrovascular areas, thereby facilitating nerve-sparing dissection [37]. However, based on our experience, the risk of bowel injury is minor during transperitoneal RPLND as it is totally out of the operative field, the lateral position is not abnormal and we have successfully overcome all of its drawbacks. On the other hand, access to the retrovascular area is not really required as it is not included in the template dissection since lymph node metastases were found to be exclusively ventral to the lumbar vessels. In addition, we feel that the transperitoneal route gives a better access to the interaortocaval area, which is difficult to access but is the most important area in right-side RPLND. Although this first group did not report any incidence of lymphocele, it is expected to occur once a larger group of patients is evaluated [24]. In short, we are not convinced that retroperitoneoscopy offers any major advantage over the transperitoneal approach.

Summary

In the authors' hands, laparoscopic RPLND has demonstrated its surgical and oncologic efficacy. The morbidity and the complication rate are low. Adherence to the templates previously described allows for preservation of antegrade ejaculation in virtually all patients. It is a difficult procedure indeed, but once the long and steep learning curve has been overcome, operative times are equal to or even shorter than those of open surgery. Thereafter, the costs will be in the range of open surgery. Survival and tumor recurrence rates after laparoscopic RPLND are at least as low or equal to that of open surgery and chemotherapy. Patient satisfaction, however, is clearly higher with laparoscopic RPLND, which the authors demonstrated in a recent, extensive quality-of-life study.

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8 Morcellation or Intact Extraction in Laparoscopic Radical Nephrectomy

Yoshinari Ono, Yohei Hattori

Contents

Introduction

Laparoscopy provides for the dissection of diseased tissue or organs with the same beneficial results for both benign and malignant disease as in open surgery while not deteriorating the patient's quality of life. The laparoscopic procedure has a minimally invasive nature; it does not require a long incision, offers less postoperative pain, and earlier convalescence and recovery to normal activity. Extraction of the dissected organ was initially a troublesome issue since intact removal required an additional incision that could compromise the nature of laparoscopy. This was resolved by morcellation and removal of the dissected organ without an additional incision, as developed by Clayman et al. [1]. However, in oncological surgery the dissected organ must be removed from the body for a complete cure as well as for an accurate pathological diagnosis. So, while intact removal requires an additional incision but provides an accurate diagnosis, morcellation removal provides minimal invasiveness but precludes an accurate diagnosis.

Extraction of the dissected specimen is one of the controversies in urologic laparoscopy for malignant diseases, especially for renal cell carcinomas. In laparoscopic nephroureterectomy for transitional cell carcinoma of the kidney and ureter, the intact removal of the specimen has been the general procedure since morcellation or fractionation of the dissected specimen provides the histology of the tumor but obfuscates the pathological staging which significantly influences any decision for further treatment. Intact extraction has also been used generally in laparoscopic radical prostatectomy for prostate cancer. Since the dissected specimen is small in size, an additional incision is not required for its removal. In prostate cancer, pathological findings play a significant role in the decision for further treatment for transitional cell carcinoma of the upper urinary tract. In laparoscopic radical nephrectomy for renal cell carcinomas, the dissected specimen is large, $12 \times 8 \times 6$ cm in size, and requires at least a 6- to 7-cm-long additional incision for intact removal, which could compromise the nature of laparoscopy. Morcellation removal, however, does not provide an accurate pathological staging.

Histological Aspect

In the early period of laparoscopic radical nephrectomy for renal cell carcinomas, we extracted the specimen intact through an additional 5-cm-long incision between two ports. This provided a complete pathological examination indicating both the histology of the tumor and an accurate pathological stage of disease and possibly prevented tumor spillage into the working space and port sites [2]. Clayman and colleagues also used intact removal for laparoscopic radical nephrectomy [3]. In the late 1990s, Clayman and colleagues, and Barrett et al. adopted morcellation of the dissected specimen for extraction without an additional incision [4, 5]. This did not deteriorate the minimally invasive nature of laparoscopy, but, however, had the risk of dissemination of the tumor cells into the working space and their seeding to the port sites. Some authors reported tumor recurrence in the working space and port sites [6, 7]. Rassweiler et al. applied fractionation removal of the dissected kidney from the working space without an additional incision [8]. We also adopted fractionation removal for the kidneys with a less than 5-cm-diameter disease, but intact removal for the kidneys with disease that is 5 cm or more in diameter [9]. Fractionation of the kidney into 10–15 pieces also has the risk of dissemination of tumor cells into the working space and of seeding to the port site, but provides a pathological staging without an additional incision in small disease. On the other hand, Abbou et al., Janetschek et al. and Gill et al. used intact removal in laparoscopic radical nephrectomy for renal cell carcinomas [10–12].

Operative Procedures: Intact Removal, Fractionation and Morcellation

Entrapment of Dissected Specimen

The first step for removal is entrapping the dissected specimen. For intact removal, LapSac (Cook Urological Inc. Spencer, IN, USA) and Endocatch II (US Surgical, Norwalk, CT, USA) are used as devices for entrapment. LapSac is a reinforced nylon pouch with an integral polyurethane inner coating, impermeable, very strong, and comes in four different sizes, from 2×5 to 8×10 in. [13]. An 8×10 inch sack is usually used. For both fractionation and morcellation removal, double LapSac sacks, in which one sack is placed inside the other, are used to contain any damage caused by the morcellator or scissors. The mouth of the LapSac sack is equipped with a hydrophilic guidewire (Terumo Co., Tokyo, Japan) and can open wide in the working space because of its inherent elasticity. The dissected specimen is then easily manipulated into the sacks, the mouth pulled out through the

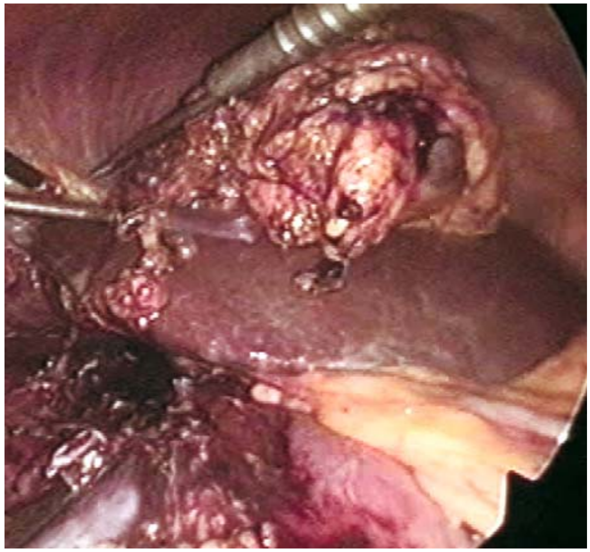

Fig. 2. The mouth is pulled out through the original incision for the first port

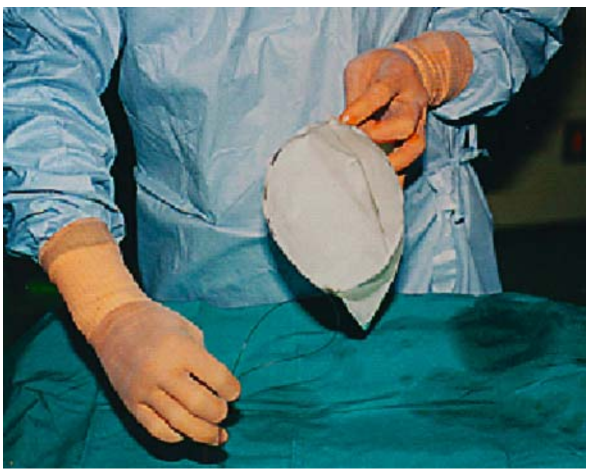

Fig. 1. Double LapSac equipped with hydrophilic guidewire at the mouth

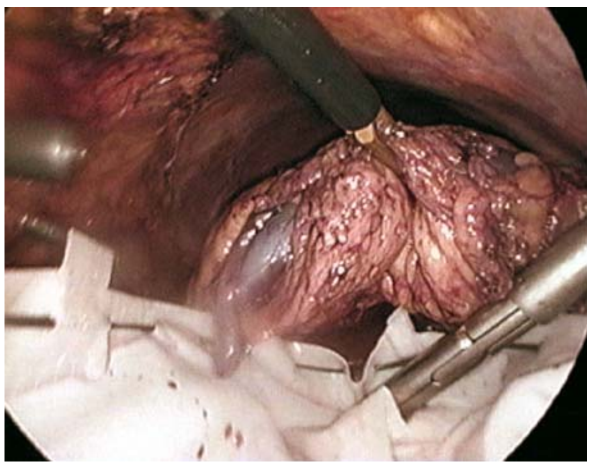

Fig. 3. The dissected specimen was moved on the liver in right nephrectomy

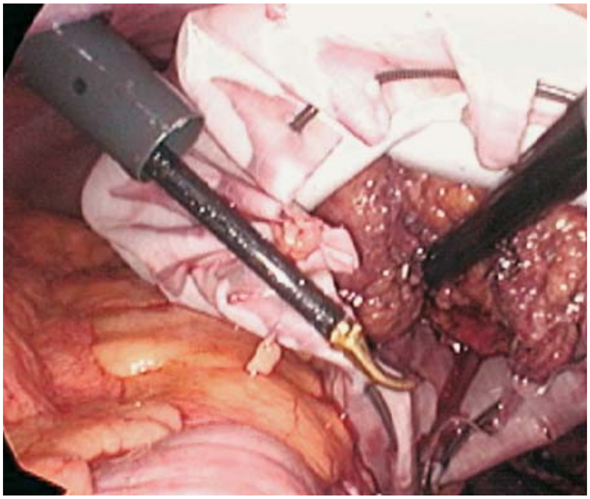

Fig. 4. The dissected kidney is maneuvered into a double LapSac equipped with a hydrophilic guidewire that opens the mouth of the sacks in the working space

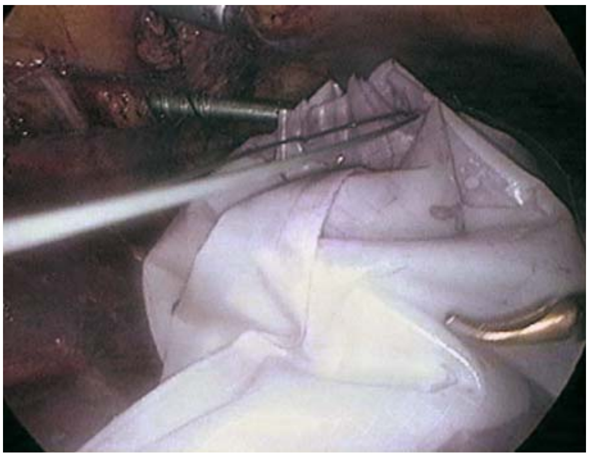

Fig. 5. Entrapment of the dissected specimen

original first port incision and the guidewire removed [9, 14] (Figs. 1–6). Endocatch II is used for intact removal of the dissected specimen and is placed into the working space through a 15-mm-diameter port. By pushing the handle, the mouth of the sack is opened wide and the dissected specimen is easily manipulated into the sack. After entrapping the specimen, the mouth is closed by pulling the handle. The sack with the intact specimen is then removed through the additional incision (Figs. 7, 8).

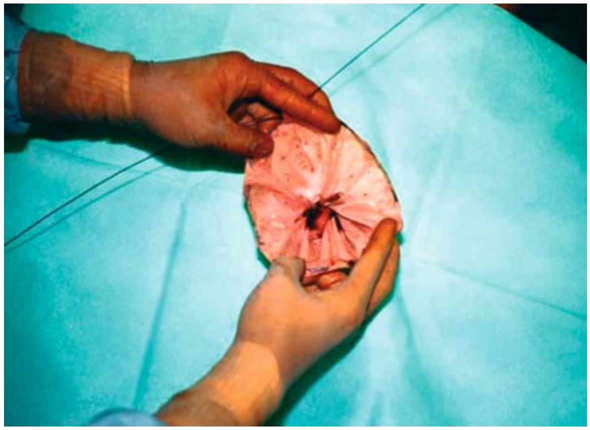

Fig. 6. The mouth is closed by pulling the hydrophilic guidewire after entrapment of the specimen

Fig. 7. Endocatch II

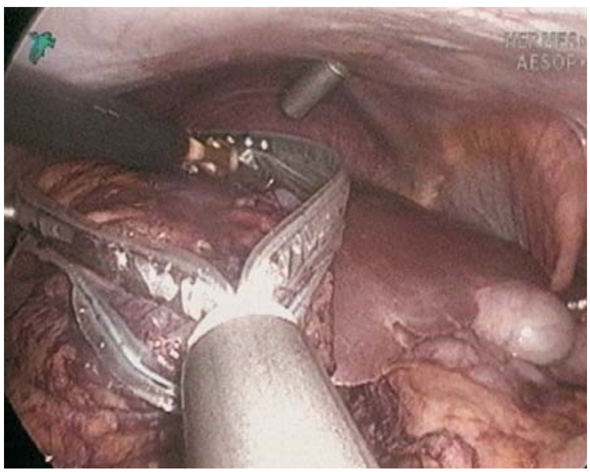

Fig. 8. The mouth of Endocatch II is opened and the specimen is entrapped into the bag

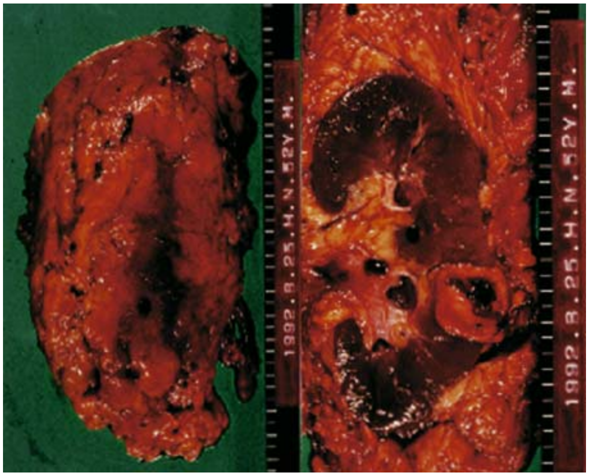

Fig. 9. The specimen removed by intact removal

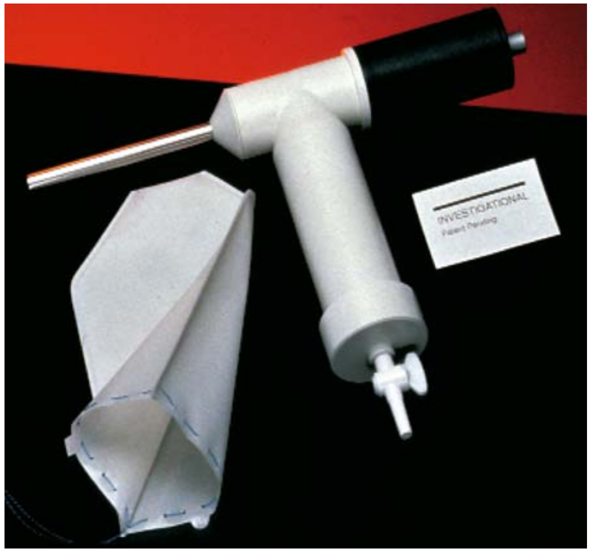

Fig. 10. Morcellator

Fig. 11. Use of morcellator

Intact Removal

The sack with the intact dissected specimen is taken out through an additional 5- to 7-cm-long incision between the two ports or by extending the original trocar incision [12, 15]. The incision length depends on the size of the dissected specimen. A muscle-slitting incision is recommended for an earlier recovery (Fig. 9).

Morcellation

The mouth of the double LapSac sacks is pulled out through the original trocar incision after the trocar and sutures are removed. An electric tissue morcellator in combination with a vacuum (Cook Urological Inc. Spencer, IN, USA) is introduced through the mouth of the specimen-containing sacks and the specimen is morcellated and aspirated from within the sacks [1, 13] (Figs. 10, 11). The empty sacks are then removed. This is completed without an additional incision and takes less than 15 min.

Fractionation

The mouth of the sacks is also pulled out through the original trocar incision after the trocar and sutures are removed. The original incision and skin are covered by a drape. The specimen is cut into 10–15 pieces within the sacks using a Kelly clamp through the mouth of the sacks under direct vision. The small pieces are taken out of the sacks, and the sacks are removed through the original incision [9]. This takes 15–20 min (Fig. 12).

Benefits and Risks of Each Method

Intact removal provides for a complete pathological examination indicating important information such as the histology, staging, positive/negative margin and positive/negative vascular and lymphoid invasion. Intact removal is time-saving, with less risk of tumor dissemination into the working space and tumor im-

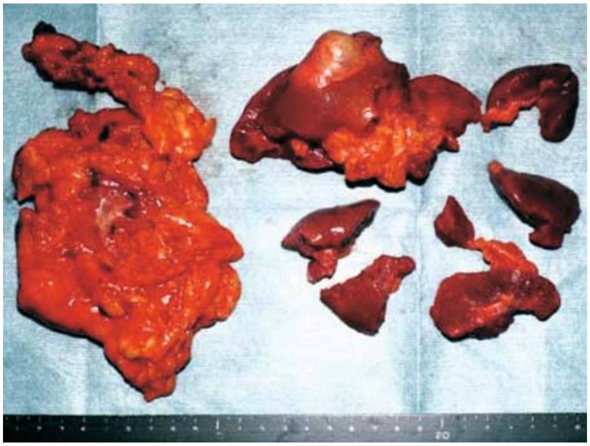

Fig. 12. The specimen removed by fractionation removal. The tumor mass is intact and available for pathological examination

plantation at the port sites, but requires an additional incision, which might compromise the nature of laparoscopy. However, we reported a comparison of postoperative incisional morbidity between intact removal and fractionation removal in 60 patients treated with laparoscopic radical nephrectomy [9, 15]. Intact removal was performed on 26 patients undergoing a transperitoneal approach (Group I; $n=11$) and a retroperitoneal approach (Group II; $n=15$), and fractionation removal was done in the remaining 34 patients undergoing fractionation specimen removal after transperitoneal laparoscopic radical nephrectomy (Group III). Postoperative dosage of analgesics for the initial 4 days was 41 mg, 29 mg, and 29 mg, and convalescence was 22.4 days, 22.7 days, and 23.3 days, respectively. There was no significant difference between the intact removal group and fractionation removal group. Gill et al. referred to our data and described no apparent significant difference in patient morbidity between intact extraction and morcellation or fractionation [12]. On the basis of these findings, they now use intact extraction in laparoscopic radical nephrectomy. To minimize cosmetic morbidity, they currently remove the specimen through a muscle-splitting low Pfannenstiel incision located at or below the pubic hair line in male patients and through the vagina in female patients (Table 1).

Morcellation removal provides extraction of the dissected specimen without the additional incision that might compromise the less invasive nature of laparoscopy, but offers only limited pathological findings in terms of the histology and grade of the tumor cells, and no information indicating stage, margin, and vascular and lymphoid invasion. Other risks are tumor dissemination into the working space and tumor implantation at the port sites. Clayman and his colleagues and Barrett et al. adopted a tissue morcellator for removal of the specimen with no incision [4–7, 16, 17]. Dunn and Clayman analyzed data of 61 patients undergoing laparoscopic radical nephrectomy and demonstrated that there was a definite trend toward higher analgesics use in the intact removal group and a slightly longer hospital stay [4]. Walther and Clayman analyzed the data of 11 patients undergoing laparoscopic cytoreductive nephrectomy and demonstrated reduced postoperative analgesics and shorter hospital stay for morcellated-kidney patients compared with those who had undergone intact removal

Table 1. Operative outcome of laparoscopic radical nephrectomy

	No. patients	Removal of specimen	Operation time	Blood loss	Conversion	Complication	Return to Normal Activity
Barrett et al. [5]	72	Morcellation	2.9 h	(–)	6 (8%)	2 (3%)	(–)
Dunn et al. [4]	61	Intact/ morcellation	5.5 h	172 ml	2 (3%)	21 (34%)	25 days
Abbou et al. [10]	50	Intact	2.3 h	150 ml	3 (6%)	4 (8%)	19 days
Janetschek et al. [11]	73	Intact	2.4 h	168 ml	0 (0%)	9 (12%)	(–)
Gill et al. [12]	100	Intact	2.8 h	212 ml	2 (2%)	14 (14%)	29 days
Chan et al. [17]	67	Intact/ morcellation	4.3 h	289 ml	1 (2%)	10 (15%)	(–)
Our series	252	Intact/ fractionation	4.5 h	300 ml	10 (4%)	36 (14%)	23 days

[16]. Clayman and his colleagues described that for these patients, intact removal and pathological stage would only be of value if adjuvant therapy were planned, which is not the case for renal cell carcinomas at present. They offer a purer laparoscopic approach and morcellate the specimens. Chan and Kavoussi also reported the outcome of their 61 renal cell carcinoma patients who underwent laparoscopic radical nephrectomy, and described that 40 patients underwent morcellation removal and the remaining 27 patients underwent intact removal [17]. They described that two of the 40 morcellated specimens involved stage pT3 disease, while one tumor each with perinephric fat and intrarenal renal vein invasion involved stage pT3a and pT3b disease, respectively, and morcellation may be performed under direct vision. When accurate pathological staging is desired, specimens can be removed intact through an additional incision.

Another risk of morcellation is tumor spillage. Fenti and Barrett, however, reported that of 85 patients no dissemination occurred in the working space in the one patient who had seeding of tumor cells at the port site [5, 6]. Fugita et al. also observed one patient who had port site seeding after morcellation removal in laparoscopic radical nephrectomy for renal cell carcinoma [7]. However, Dunn et al. described no dissemination in the working space or seeding to the port sites in the 39 morcellation patients, and Chan et al. also described no dissemination or seeding in 40 morcellation patients [5, 17].

Fractionation removal also provides extraction with no additional incision, and the possibility of a pathological examination indicating stage, margin, and vascular and lymphoid invasion as described later. However, there is the risk of the dissemination of tumor cells into the working space and their seeding to the port sites. We have used fractionation of specimens for 93 patients with less than a 5-cm-diameter tumor since January 1997 [9, 18–20]. Neither seeding of the tumor cells at the port sites nor dissemination in the working space was found. In addition, no damage to the sacks was caused by the Kelly clamp. As to the pathological examination of the specimen removed by fractionation, a histopathological examination was possible of all 93 specimens in our series. Six patients were indicated as having pathological 3 a disease and diagnosed as having clinical T1N0M0 disease [19]. Fractionation removal often provided intact tumor mass in patients with less than 5-cm-diameter tumors.

Future Aspects

Since the first success of laparoscopic radical nephrectomy for renal cell carcinoma in 1992, the procedure has been performed worldwide in over 2,000 patients with renal cell carcinomas. It is still unclear whether intact removal or morcellation/fractionation removal is better for patients undergoing laparoscopic radical nephrectomy. The controversy will continue until a new ideal extraction method is developed. At the present time, extraction of the dissected specimen is the surgeon's preference.

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9 Focusing Our Attention on Trocar Seeding!

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Contents

Introduction

Over the last decade, modern laparoscopic equipment and techniques have dramatically increased, expanding the indications to malignancies [1]. This fact introduces a new potential complication: the risk of tumor seeding. Port site recurrences have been reported after laparoscopic surgery to indicate local tumor seeding [2–4]. Implantation has occurred at the Veress needle, laparoscopic trocar port sites and also in the form of peritoneal dissemination [5]. The risk of tumor seeding came from the consolidate experience of laparoscopic procedures in general and gynecological surgery.

The initial descriptions of port site recurrences were after gynecological procedures for ovarian tumors. The first report dates back to 1978 and concerned diagnostic laparoscopy in one patient with carcinomatosis ascites [6]. Afterward an increasing number of port site metastases in laparoscopy for neoplastic diseases was reported: in 1985 Stockdale et al. for ovarian adenocarcinoma [7], in 1990 Cava et al. for gastric adenocarcinoma [8] and Russi et al. in 1992 for liver carcinoma [9]. Trocar port metastases have been described in the literature after laparoscopic biopsy for hepatocellular carcinoma [9], laparoscopic cholecystectomy for an undiagnosed pancreatic carcinoma [10] and after laparoscopic resection of unsuspected or low malignant ovarian cancer [2]. Johnstone reported 23 cases of port site recurrences after thoracoscopic procedures for lung neoplasms [11]. From these series of reports we realize that both diagnostic or operative laparoscopy can develop tumor seeding.

Laparoscopy has become the most frequently performed operation, as an effective diagnostic tool for evaluation of acute abdominal gynecological conditions, especially in young women. When suspicious excrescences are detected on the surface of ovarian masses by diagnostic laparoscopy, it is common sense in gynecology to change laparoscopy in exploratory laparotomy and excision of the masses. Biopsy should not be performed on these papillary masses during laparoscopy examination. This conservative view is based on an extensive review of the literature with evidence of the potential of tumor implantation after laparoscopic biopsy made during a diagnostic procedure [3].

Laparoscopic cholecystectomy appears to be the most common and codified procedure in general surgery indications. From a review made on 117,840 patients who underwent laparoscopic cholecystectomy, 409 presented nonapparent gallbladder cancer, with a real incidence of 0.35%. In this series, the overall incidence of port site metastases was 17%. In contrast, data show that wound recurrence following open cholecystectomy for primary nonapparent carcinoma of the gallbladder must be an exceptional event. Paolucci did not find any of these complications in the literature between 1960 and 1997 [4].

The same concern also exists for colorectal surgery. In 92 laparoscopic resections for colon carcinoma, Fingerhut reported an overall incidence of port site recurrence of 3.2%. Prasad et al. reported a 4% incidence of port site recurrence in a series of 50 patients. Berends et al. noted three port metastases in 14 patients, corresponding to 21%. Ramos et al. found three wound recurrences, two of them with peritoneal carcinomatosis, a 1.4% rate. We believe that the incidence of this complication in colorectal laparoscopy is 2.5%, calculated as an average of the results achieved from the reports mentioned above. Many other cases of tumor seeding have been described for other indications such as esophageal carcinoma and lung adenocarcinoma [3].

From this review, it seems that there is a specific laparoscopy risk for intraoperative tumor cell seeding and implantation. Moreover, the probability of developing abdominal wall metastasis is higher after laparoscopy for cancer than after open surgery.

Recurrence of Port Site Metastasis in Laparoscopic Urology

Since the first nephrectomy performed by Clayman in 1990 (Clayman 1991), there has been considerable growth in laparoscopic urological surgery, slowly at first and then much more rapidly over the last 5 years with the development of adrenal gland, kidney and prostate cancer surgery.

The laparoscopic lymphadenectomy (LPLND) in the staging of prostate cancer was one of the first laparoscopic indications in the field of urology. At the same time, the indications for staging lymphadenectomy were extended to transitional cell carcinoma (TCC) of the bladder. The first urological tumor seeding reported was during a laparoscopic lymphadenectomy for a bladder tumor, reported by Stolla et al. [12]. After that in the following 4 years, two tumor seedings were reported after laparoscopic biopsy for bladder TCC and one after staging lymphadenectomy. Finally, only one case of prostate cancer seeding was reported after a laparoscopic staging lymphadenectomy [13]. Now we can state that the real incidence after LPLND for prostate cancer is 0.1% and for TCC it is 4% [14]. Tumor seeding during LPLND seems to

Table 1. Trocar tumor seeding after urological laparoscopy in malignancy after lymphadenectomy

Author	Year	Age (years)	Diagnosis	Procedure	Time presentation (months)	No. of implants	Follow-up (months)	Stage and grade (G)
Stolla et al. [12]	1994	58	Bladder TCC	LL	9	1	Died 9	pT3N0M0/G2
Bangma et al. [13]	1995	66	Prostatic carcinoma	LL	6	1	Died 8	pT3N1M0/G2
Andersen [57]	1995	61	Bladder TCC	LB	–	1	Died 12	pT3N1M0
Elbahnasy [14]	1998	63	Bladder TCC	LL	3.5	1	Died 3	pT3N1M0/G2

C carcinomatosis, *LL* laparoscopic lymphadenectomy, *LB* laparoscopic biopsy

Table 2. Trocar tumor seeding after urological laparoscopy in malignancy after radical nephrectomy and nephroureterectomy

Author	Year	Age (years)	Diagnosis	Procedure	Time presentation (months)	No. of implants	Follow-up (months)	Stage and grade (G)
Shaikh et al. [27]	1998	66	TCC upper tract	LNU	8	1	–	pT2N0M0/G?
Barret and Fantie [23]	1999	76	RCC	LN	25	1	–	PT3N0M0/G4
Otani et al. [28]	1999	74	TCC upper tract	LNU	3	1	–	pT2N0M0/G?
Landman and Clayman [25]	2001	72	RCC	LN	5	multiple	Died 8	pT1N0M0/G2[a]
Landman and Clayman [25]	2001	32	RCC	LN	12	1	–	pT1N0M0/G2[a]

LN laparoscopic nephrectomy, *LNU* laparoscopic nephroureterectomy
[a] Fuhrman grade

be much more common for bladder TCC than for other urinary tract malignancies because TCC is more aggressive than other urological tumors (Table 1). With the exception of laparoscopic lymphadenectomy as mentioned before, laparoscopic urological surgery in the beginning was dedicated mostly to treating benign disease such as simple nephrectomy. The first two reports describing laparoscopic radical nephrectomy for renal cell carcinoma (RCC) were published in 1993 and a total of five cases were reported [15, 16]. Subsequently, most centers throughout the world started radical laparoscopic nephrectomy and results from a bigger series state the feasibility and reproducibility of this procedure [17–19]. The same occurred for laparoscopic nephroureterectomy (NU); the first case report was performed in 1991 at Washington University [20]. Since then several limited series have been reported, demonstrating the safety and efficacy of the procedure [22, 23]. The use of these minimally invasive techniques with or without morcellation for specimen extraction is associated with potential port site metastasis (Table 2).

In 1999, Barret and Fantie reported a laparoscopic nephrectomy in a patient with T3N0M0 grade IV RCC and a 862-g pathological specimen who had a solitary port site recurrence at 25 months of follow-up. The specimen was entrapped in the Cook LapSac and fragmented with the Cook electrical mechanical morcellation tool [24]. Castilho et al. reported a case of abdominal wall metastases following laparoscopic radical nephrectomy for a clinical stage T1N0M0 renal cell carcinoma. The specimen was retrieved en bloc by mechanical morcellation in an intact plastic bag [25]. Afterwards Castilho reported another case of port site tumor recurrence in a 32-year-old woman with a right renal mass of 4 cm 12 months after surgery. Laparoscopic radical nephrectomy was performed without complications and the pathological study revealed low Fuhrman grade 2 renal cell carcinoma.

The efficacy of laparoscopic radical nephroureterectomy for upper-tract TCC has been well documented [26]. Up to 1998, the literature did not report any tumor seeding or port site metastasis despite morcellation of some the nephroureterectomy specimens within an impermeable entrapment sack. In 1998, Shaikh et al. reported the first case of port site recurrence after laparoscopic nephroureterectomy 8 months after the surgery [27]. Then Otani reported a second case of port site metastasis following laparoscopic nephrectomy for tuberculous atrophic kidney and unsuspected TCC 3 months after surgery [28]. The last trocar tumor seeding reported in the urological literature was after a lymphadenectomy for retroperitoneal metastases of an epidermoid carcinoma of the testis [29].

Experimental Studies

What are the mechanisms involved in trocar site recurrences?

Recent studies review the current knowledge on laparoscopic mechanisms of cancer dissemination and addresses to experimental models of cancer dissemination in animals [30]. Several authors have investigated the neoplastic cells pre-existing in the peritoneum, the increased exfoliation of tumor cells resulting from greater manipulation near the tumor or at the tumor itself by laparoscopic instruments as possible causes of wound implantation [31, 32]. Recently, Juhl et al., using immunocytological methods, found neoplastic cells in the peritoneal cavity in 27% of the patients with colorectal tumors, 43% of patients with gastric cancer and 58% of the patients suffering from pancreatic cancer [33]. Some authors have investigated the local factors and specific factors that allow neoplastic cell adhesion and the growth at the trocar site (Table 3).

The first mechanism studies is the aerosol ability of the pneumoperitoneum and several in vitro models are contradictory. Whelan et al. recovered no free melanoma cells injected into the abdominal cavity under pressurized CO_2 in the abdomen [34]. In contrast, Knolmayer et al. reported recovery of exfoliated peritoneal cells after various levels of intra-abdominal

Table 3. Specific factors connected with laparoscopic surgery

Laparoscopic instruments
Exfoliation and adhesion to laparoscopic instruments
Trocar cannulas
Local wound adhesion and seeding of neoplastic cells located in the cannula surface
Neoplastic tissue retrieval
Tight and narrow port site
Pneumoperitoneum
Closed system with an increased concentration of neoplastic cells gaseous turbulence, chimney effect along trocar cannulas, modification of tumor cell biology by CO_2
Facilitation of cell adhesion by wound factors (fibroblast, collagen, proteoglycans, platelets)

pressurized carbon dioxide [35]. Other authors suggested that smoke particles can act as carriers of clumps of neoplastic cells and can be recovered when exhaled by the trocar orifices due the high intra-abdominal pressure [36]. This finding could explain the implant at trocar sites.

Other authors have studied intra-abdominal cell kinetics after injection of free cells in the abdominal cavity during laparoscopy or open surgery. In an in vivo porcine model, after the filtered exhaust of the trocars only in one case tumor cells was found. More importantly, cells were recovered in 20% of trocar and 40% of instruments [37]. The introduction of gasless laparoscopic surgery seems to be an important factor in establishing the role of pneumoperitoneum as a vector of tumor seeding. Watson et al. observed a reduction in port site metastases, from 83% to 25%, respectively, with gasless or CO_2 laparoscopy after manipulation of tumor of the abdominal wall induced with injection of breast cancer cells [38]. Other studies have been designed to observe the pattern of late dissemination of cancer cells after inoculation in the abdomen. Tsuvian et al. did not find a different pattern of dissemination after intra-abdominal RENCA cell inoculation: there were similar growth rates and implants, and finally he stated that the pneumoperitoneum does not facilitate port site metastases [39].

The ability of tumor cells to adhere to the intact or disrupted peritoneum was tested. Using bladder cancer cells in a mouse model, these authors showed that after instillation of tumor cells in the abdomen with an intact or injured peritoneum, the carcinomatosis rates were 50% and 63%, respectively; but if heparin was added simultaneously the presence of implants fell to 17% and 31%, respectively. These experimental studies in animal models evaluated the implant of heparin and the pentapeptide Gly-Arg-Gly-Asp-Ser (GRGDS) and TCC inoculated in the peritoneal cavity, with prevention of tumor implantation [40]. Recently, Lewis et al. demonstrated the therapeutic potential use of Copper-64-pyruvaldehyde-bis(N(4)-methylthiosemicarbazone) in inhibiting cancer cell implantation and growth at doses well below the maximum tolerated dose, with no signs of toxicity to hamsters [41]. This washing trick seems to achieve the target of reducing the possibility of tumor implantation. Other authors reported the effect of intraperitoneal irrigation with taurolidine and octreotide on port site and liver metastasis after staging laparoscopy in a chemically induced pancreatic adenocarcinoma. The number of liver metastases per animal was increased after saline irrigation compared to taurolidine or octreotide. Port site metastases were found in 36.8% after saline, in 37% after octreotide and 0% after taurolidine irrigation [42].

From experimental studies, it appears that a laparoscopic approach has potential advantages and disadvantages. In a recent review of experimental studies, Canis et al. affirmed that the risk of dissemination appears high when a large number of malignant cells are present in peritoneum and adnexal tumors with external vegetations, and bulky lymph nodes should be considered as contraindications to CO_2 laparoscopy. Depending on the model used, controversial results have been reported on the incidence of trocar site metastasis when comparing CO_2 laparoscopy and laparotomy [43]. We believe that more experimental study is necessary to consolidate the effective risk of tumor seeding during laparoscopy.

Discussions

Reports of tumor implantation after laparoscopic procedures in patients with intra-abdominal malignancies are a source of increasing concern and the most important factor precluding widespread employment of laparoscopy in the treatment of malignant disease. In general surgery and gynecology, some reports concluded that laparoscopic surgery should not be performed when cancer is suspected, but in controlled studies until there are sufficient data on the clinical importance of this complication [44]. The radical nature of the procedure is not crucial for the risk of tumor seeding. Gynecologists were the first reporting tumor seeding after laparoscopic biopsy of ovarian carcinoma. It is common sense among gynecologists to convert to open surgery when suspicious excrescences are detected on the surface of ovarian masses during diagnostic laparoscopy. No biopsy should be performed on these papillary masses during laparoscopic examination. This conservative view is based on an extensive review of the literature with clear evidence of tumor implantation after laparoscopic ovarian biopsy [3]. Other case reports from general surgery describe port site metastasis after diagnostic laparoscopy for gastric adenocarcinoma, liver carcinoma and pancreatic carcinoma [8–11]. The real mechanism of tumor seeding during diagnostic laparoscopy is not clearly understood, but probably it is related to tumor cell exfoliation at the biopsy site. This situation can be worse if the tumor is very aggressive.

In laparoscopic colorectal surgery, reports on tumor implantation and portal seeding are fairly discordant. As a result of reviews in colorectal oncology, the percentage of tumor seeding ranged from 3.2% to 21% [13–15]. At the same time, the overall incidence of port site metastases after laparoscopic cholecystectomy for gallbladder cancer is 14%–30% [45]. In an effort to obtain more knowledge on the impact of surgical technique on the prognosis of gallbladder cancer, in 1997 the Surgical Endoscopy Working Group of the German Society of Surgery started a registry of all cases of cholecystectomy, laparoscopic as well as open, with a postoperative incidental finding of gallbladder carcinoma. Results will be available in 5 more years [45].

The laparoscopic benign cholecystectomy appears the most common and codified procedure in general surgery indications. From a recent survey on 117,840 cases, was reported an incidence of 0.35% of nonapparent gallbladder cancer, and in this series the overall incidence of port site metastases is 17%. In contrast, data show that wound recurrence following open cholecystectomy with primary nonapparent carcinoma of the gallbladder must be an exceptional event. Paolucci did not find any of these complications in literature between 1960 and 1997 [4]. It is clear that laparoscopy makes the difference, but the actual cause is still not well understood. The last decade witnessed major shifts in popularity of laparoscopic procedures for the therapy of urological disease. The pioneering work of Ralph V. Clayman in 1990 prompted an explosion of interest in laparoscopic techniques, which was soon tempered by the realization that the benefits attributed to laparoscopic procedures vs open surgery [46] had to be offset by the disproportionate time and financial investments required for the acquisition of technical skills, their maintenance and upgrading. A second change of the winds has occurred in the last few years, after the demonstration that such techniques could safely be used in the therapy of neoplastic disease of the kidney and the prostate. These days laparoscopic surgery as therapy for urological oncology can be roughly divided in three main categories: widely accepted, controversial and experimental. Reviewing the laparoscopic urological literature, the main oncological indications are renal, adrenal and prostate cancers.

Laparoscopic urological surgery in malignancy presents tumor seeding complications as well as in general and gynecological surgery. The first tumor seeding reports were described after five laparoscopic lymphadenectomy or nodal biopsy for four bladder cancer patients and one prostate cancer patient. Moreover, all were advanced cancer, none used entrapment sac and all were isolated case reports. Four of five were TCCs, considered an extremely aggressive tumor. Kavoussi et al. reviewed 372 cases of LPLND in patients with prostate cancer, and in this survey there were no cases of tumor seeding [47]. Moreover, Vallancien et al. performed 813 laparoscopic radical prostatectomies and 177 LPLNDs and reported no tumor seeding [1]. What is particularly disconcerting is that there are already four reports of metastases after laparoscopic diagnostic procedures for bladder TCCs, but large series of LPLND for bladder cancer are not reported in prostate cancer [14].

Laparoscopic radical nephrectomy is considered safe and oncologically appropriate for patients with RCC [48]. To date, laparoscopic surgery for localized RCC has not been associated with an increased risk of port site, intra-abdominal or retroperitoneal recurrences or metastatic disease [17–19, 49]. TCC of the upper urinary tract represents 5% of all urothelial tumors and 5%–10% of renal tumors [50]. Complete removal of the upper urinary tract with a bladder cuff requires exposure of the retroperitoneum adjacent to the kidney, ureter and bladder. It is well known that laparoscopic NU is a less invasive alternative to open NU and the principles of surgical oncology can be maintained [26, 51]. A total of five tumor seeding metastases secondary to renal cancer (three RCCs and two TCCs) are reported. In four cases Endobags were used for specimen extraction. In only one case of NU was the specimen removed intact through a small transverse incision by extending one of the ports laterally. All RCC specimens were morcellated inside a LapSac and removed through one of the trocars (Table 4). All these reports seem pertinent with oncological asepsis, but a few comments should be highlighted. Barret and Fantie operated on a large specimen that weighed 862 g, an aggressive Fuhrman grade IV/IV and sarcomatoid elements. In one of two cases, Castilho et al. reported the presence of ascites, which can be a cause of tumor cell dissemination [2]. The other case was performed with strict adherence to oncological principles. Considering that TCC is the most aggressive renal cancer, the specimen should be placed in an entrapment sac, a condition that was not respected by Ahmed et al. Tumor seeding reported by

Table 4. Use of Endobag and morcellation in renal cancer

Author	Cancer	Endobag	Morcellation
Barret and Fantie [23]	RCC	Yes	Yes
Landman and Clayman [25]	RCC	Yes	Yes
Landman and Clayman [25]	RCC	Yes	Yes
Ahmed [27]	TCC upper tract	No	No
Otani et al. [28]	TCC upper tract	Yes	No

Otani et al. occurred from an unsuspected TCC, because the patient underwent a simple nephrectomy for tuberculous atrophic kidney.

The last trocar tumor seeding reported in the urological literature describes a case report of a lymphadenectomy to treat retroperitoneal metastases of an epidermoid carcinoma. Sebe et al. describe extraction of the kidney inside a entrapment sac, but how lymph an nodes were extracted was not described.

Many experimental studies have been designed to understand the risks of laparoscopic surgery in cancer. Regarding surgical access, controversial results have been published in solid tumor models, and trocar site metastases were significantly more common after laparoscopy [52, 53]. After an intraoperative injection of cells, two studies showed a higher incidence of wound metastases after laparotomy [54, 55]. In animal models, the effect of CO_2 pneumoperitoneum seems to have correlation with the volume of cells injected, but high pressure of CO_2 insufflation does not increase the risk of implantation of malignant cells [56]. Experimental studies have documented very well that traumatic handling of the tumor and trauma to the trocar site increases the incidence of port site metastases [32, 33]. Taurolidine with or without heparin seems very important in order to decrease the number and the volume of peritoneal metastases [41, 42].

Further experimental studies should be conducted to evaluate the risk of tumor dissemination. By now a few clear-cut rules appear mandatory: remove the whole specimen inside an entrapment sac and without morcellation, avoid trauma to the trocar site, avoid gas leakage around the trocar, select the case (no advanced and aggressive cancer), minimize tumor manipulation.

Conclusion

Port site metastases are secondary to a number of factors, including the technical skill of the surgeon's no touch technique, biological properties of the tumor, and local environmental aspects. Undoubtedly, laparoscopy can favor dissemination of aggressive tumors. The use of a plastic bag for specimen retrieval is a logical method to avoid contact between malignant tissue and peritoneum or skin. This measure must be considered mandatory for extraction of suspected or assessed cancer tissue, assuming that this precaution does not exclude an intraperitoneal or trocar site recurrence.

Tumor seeding following laparoscopic surgery in malignancies seems a minor concern in urology compared to gynecology and general surgery. The reasons are not clearly understood, but they are possibly related to different tumors' biological properties and anatomy. Further research is warranted in this field.

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10.1 Anticoagulation Therapy During Laparoscopic Surgery

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Contents

An invasive diagnostic or therapeutic urological procedure may be needed in patients receiving chronic oral anticoagulation therapy for complex medical problems that predispose to venous or arterial thromboembolism. However, the ability to control intraoperative bleeding and prevention of postoperative bleeding in such patients on anticoagulation therapy have to be safely balanced [1–3].

Recommendations for appropriate perioperative management of patients receiving long-term warfarin therapy remain debated. Anticoagulation therapy should be customized to patient risk factors and type of laparoscopic procedure planned. In this chapter we provide risk assessment and management guidelines for use of warfarin in patients undergoing laparoscopic surgery.

Synopsis of Anticoagulation Physiology

Oral anticoagulants (e.g., warfarin or Coumadin) inhibit vitamin K-dependent γ-carboxylation of the procoagulant factors II (prothrombin), VII, IX, and X, as well as the anticoagulant proteins C, S, and Z [4]. Factors VII, X, and II have a half-life of 4–6 h, 40–60 h, and 48–96 h, respectively. Four to 5 days are required for warfarin to achieve a full anticoagulant effect. After discontinuation of oral anticoagulants or vitamin K1 therapy, time for carboxylated coagulant factor restoration is proportional to their respective half-lives. The prothrombin time reflects plasma activities of factors II, VII, and X [5].

Heparin inhibits coagulation by enhancing antithrombin (AT) physiological regulation of hemostasis. Procoagulant enzymes such as thrombin, Xa, IXa, Xia, and TF/VII(a), are inhibited by AT. Unfractionated heparin (UFH) consists of highly sulfated glycosaminoglycans (porcine or bovine origin) of 3,000–30,000 Da. Low-molecular-weight heparin (LMWH, 1,000–10,000 Da) are prepared using chemical or enzymatic processes. UFH has both anti-Xa and anti-IIa activity, while LMWHs preferentially inactivate Xa [6].

The Anticoagulated Patient

Oral anticoagulants are commonly indicated for patients with mechanical prosthetic heart valves, chronic nonvalvular atrial fibrillation (AF), and venous thromboembolism (VTE). Other indications for chronic anticoagulation include mitral stenosis, left ventricular aneurysm, congestive heart failure with left ventricular dilation, severe coronary artery disease, presence of inferior vena cava filter, and synthetic peripheral arterial bypass graft [5].

Whenever a patient with these indications requires elective or emergency surgery, even temporary discontinuation of anticoagulants may lead to complications such as systemic emboli or occlusive thrombosis of mechanical heart valves, and increased risk of stroke in patients with AF [7, 8]. Further, the risk of recurrent VTE or pulmonary embolism (PE) within 3 months following acute deep vein thrombosis (DVT) is lower in patients receiving anticoagulation therapy (13% and 3% at 1 and 3 months, respectively) vs patients with no therapy (40% and 10% at 1 and 2 months, respectively) [9].

Patients with clotting and/or bleeding tendencies are challenging problems for surgeons. In fact, the surgical risk is increased in patients with congenital deficiencies in thrombosis inhibitors, (e.g., protein C, protein S, antithrombin III, dysfibrinogenemias, or dysfibrinolysis) or acquired (e.g., pregnancy, thrombocythemia, erythrocythemia, systemic lupus erythematosus) hypercoagulation conditions. By allowing early postoperative ambulation, laparoscopic surgery may decrease thrombogenic risks in such patients [10]. However, particularly during the initial learning phase of laparoscopic procedures, this benefit may be limited by longer duration of patient immobility. In addition, decreased central venous return secondary to CO_2 pneumoperitoneum used during laparoscopy may potentially increase thrombogenic risks.

Bleeding related to anticoagulation may also develop as a result of therapy overdose, or drug interaction, which can interfere with normal hemostasis. Acetylsalicylic acid, some cephalosporins (cefamandole, cefmetazole, cefoperazone, and cefotetan), and NSAIDs interfere with warfarin metabolism and increase the risk of bleeding [11].

Appropriate and individualized management of such patients can be defined by quantifying the patient's risk of thrombosis and bleeding associated with planned surgery, and the absolute indications for anticoagulant therapy. Surgical management options are strongly influenced by the location and extent of surgery, and the accessibility of compressive or physical means of bleeding control (i.e., packing, suturing, cautery, topical coagulant or antifibrinolytic) [12].

Regimens for Reversing Oral Anticoagulation

Vitamin K1 (phytonadione) is a specific pharmacological antagonist to warfarin and other anticoagulants. Therapeutic levels of oral anticoagulation can be reversed within 24–36 h by administering small doses of intravenous fat-soluble vitamin K_1 (phytonadione), e.g., 1.5 mg over 60 min [13]. Alternatively, vitamin K can be administered orally. A similar result will likely be obtained with a 2.5-mg oral vitamin K_1 dose [14]. Normal pancreatic and bowel function are required for absorption of vitamin K1 (fat-soluble). As such, patients with malabsorption who require an urgent procedure should be given intravenous vitamin K_1. However, larger doses of vitamin K might markedly delay postoperative therapeutic oral anticoagulation recovery, and can cause anaphylactoid reactions. Subcutaneous vitamin K_1 has erratic absorption, and intramuscular injection has increased risk of hematoma. Thus, these two administration routes should also be avoided [15].

Oral anticoagulation overdose without evidence of active bleeding can be managed with temporary discontinuation or dosage reduction of oral anticoagulants. Long-acting warfarin derivative overdose (INR >4.5) can be partially antagonized using low doses of vitamin K_1 (1–2 mg). In presence of minor bleeding, warfarin derivatives should be discontinued and 1–5 mg of vitamin K_1 administered. Major bleeding treatment requires administration of vitamin K_1 (10–20 mg) and prothrombin complex concentrates (PCC) at a dose of 1 IU PCC/kg body weight (with a loading dose of 30 IU PCC/kg bw) [16].

Urgent Reversal of Chronic Oral Anticoagulation

For life-threatening bleeding or urgent surgery, coagulation factor replacement therapy with fresh frozen plasma (FFP) is necessary [5]. As such, the required volume of transfused FFP units can be assessed by estimating the plasma volume (plasma volume [ml] $\approx 40 \times$body weight [kg]) and the targeted net increase in plasma coagulant factor activity required. A typical FFP unit volume is 200–250 ml. In an average-sized individual, approximately six or seven units of FFP (15 or 16 ml/kg) will significantly reduce INR. However, factor VII's plasma half-life is short (4–6 h); therefore several hours are needed following FFP transfusion for prothrombin time (PT) to prolong. Risk of intravascular volume overload, and transfusion transmitted infection are the most important limitations of FFP therapy. Virally inactivated prothrombin complex concentrate and restriction of such treatment to patients with life-threatening bleeding or urgent need for surgery minimizes risk of infection.

Perioperative Anticoagulation Management

The most common complication of oral anticoagulation is hematuria, followed by nasopharyngeal hemorrhages, and, less frequently, gastrointestinal, intracranial, and pulmonary bleeding [17–20]. Major and minor bleeding episodes occur in 1%–3% and 6%–10% of anticoagulated patients per year, respectively, and require interruption of therapy [6]. In order to achieve near-normal hemostasis during surgery, a procoagulant factor plasma activity ≥40% (INR ≤1.4) appears to be adequate. After stopping oral anticoagulants, approximately 4–5 days are required for the INR to reach 1.5 or less [21]. Once the INR reaches 1.5, surgery can be safely performed [9].

Preoperative Management. For high-risk patients already on warfarin therapy, current preoperative protocols recommend both prophylaxis with low-dose heparin, pneumatic compression, and good hydration, in addition to preoperative oral warfarin discontinuation 2–3 days prior to surgery [22]. According to these guidelines, the patient should be admitted 24 h after the last dose of warfarin, and intravenous heparin started. Activated partial thromboplastin time (aPTT) should be repeatedly checked until a level of 1.5–2.5 times control is reached. Heparin should be stopped 12–24 h prior to surgery, and both INR and aPTT rechecked 1 h before surgery to confirm normal values.

Due to the availability of effective alternatives to IV heparin and preadmission programs designed to reduce hospitalization costs, (Preadmission Clinics and "hospital in the home" programs), patient hospitalization 3–4 days before elective surgery for conversion of warfarin therapy to a titratable intravenous (IV) heparin regimen has been replaced by low-molecular-weight heparin (LMWHs) use [23]. Due to LMWHs pharmacokinetics and pharmacodynamics, LMWH serum levels after subcutaneous administration are predictable and correlate closely with antithrombotic activity (anti-Xa) [24]. Enoxaparin and dalteparin are most commonly used. At low doses (20–40 mg/day), enoxaparin is an effective antithrombotic agent with no anticoagulant effects. Effective anticoagulation is gained at higher doses (1.0–1.5 mg/kg/day), and LMWHs are a therapeutic alternative of unfractionated heparin IV. Due to incomplete reversal (60% of anti-Xa at a dose of 1 mg protamine per milligram of enoxaparin) of LMWH effects, LMWHs are potentially less safe than UH [25]. However, a 10- to 12-h interval following prophylactic doses up to 40 mg/day, and a 24-h interval following therapeutic doses of 1 mg/kg/day between the last dose of enoxaparin and surgery minimizes the risks of perioperative abnormal bleeding [26].

Intraoperative Management. A preoperative hematologic consultation before the laparoscopic procedure is advised for operative safety in patients with complex bleeding or thrombogenic tendency. If effectively reversed preoperatively, this condition does not contraindicate laparoscopic surgery. Patients should be prepared with adequate hydration, discontinuation of medication as outlined above, or with FFP as needed. Intraoperatively, increased bleeding tendency by oral anticoagulation therapy may obscure visualization of the operative field, leading to further hemorrhage, blood transfusions and risk of iatrogenic visceral injuries [27].

General advantages of laparoscopy include small incision, minimal pain, short hospital stay, and quick recovery [28]. Although a small incision reduces the actual area in which bleeding can occur from the abdominal wall [29], the procedure performed within the abdomen remains the same. Attention to every surgical step is crucial. Blunt dissection should be replaced by sharp hemostatic dissection using bipolar electrocautery, the harmonic scalpel, or vascular clips and staplers when suitable. Application of surface hemostatic agents such as fibrin glue can provide additional hemostasis. Meticulous hemostasis and inspection of the surgical field after 10–15 min of no pneumoperitoneal pressure and removal of laparoscopic trocars under direct visualization is imperative. Early mobilization of the patient helps to prevent venous thrombosis [10]. Therefore, the perioperative management of anticoagulated urological patients may benefit from the minimally invasive nature of laparoscopy.

Postoperative Management. Postoperative resumption of LMWH depends on achieving effective intraoperative hemostasis and on procedure-specific bleeding risks [30]. Following procedures associated with moderate to low risk of postoperative bleeding such as laparoscopic radical nephrectomy, adrenalectomy or pyeloplasty, low-dose LMWH treatment prophylactic may be started the evening after surgery, and the full, therapeutic LMWH dose may be restarted 24–48 h postoperatively. After procedures associated with an elevated risk of postoperative bleeding, such as laparoscopic partial nephrectomy or laparoscopic renal cryoablation, 1–2 postoperative days have to be observed with no signs of bleeding before a low-dose LMWH treatment is started, and the full LMWH dose may be restarted 48–72 h postoperatively.

Because of their delayed anticoagulant effect, oral anticoagulants can usually be restarted as soon as oral fluid intake is resumed following a low bleeding risk operation. Usually 3–4 days are required after resumption of warfarin therapy for the INR to reach the 2.0–3.0 range, and 4–5 days to reach a range of 2.5–3.5 [22]. Oral anticoagulants and LMWH therapy may be overlapped until the INR exceeds the lower limit of the therapeutic range on at least two measurements taken 24 h apart [5]. However, for procedures with considerable bleeding risks such as laparoscopic partial nephrectomy, the decision to initiate anticoagulation therapy is based on weighing the risks of bleeding vs the benefits of thromboembolic event reduction. Heparin can provide short-term postoperative coverage until safe warfarin use is recommended.

Minimally Invasive Procedures in the Anticoagulated Patient

Fitzgerald et al. [29] performed laparoscopic cholecystectomy in four chronically anticoagulated patients. Warfarin was discontinued preoperatively and replaced with heparin. Laparoscopic cholecystectomy and intraoperative cholangiography were completed in each

Table 1. Perioperative anticoagulation therapy guidelines

		Recommendations
Mechanical prosthetic heart valves	Minor procedure in: Low risk of bleeding Easy access for bleeding control	Reduce anticoagulation (INR = 2.5)
	Major procedure in: Isolated aortic valve prostheses Mitral stenosis Coronary artery disease Left ventricular aneurysm Congestive heart failure + left ventricular dilatation Inferior vena cava filter Synthetic peripheral arterial bypass graft	Stop oral anticoagulants 3–5 days before surgery Resume oral anticoagulants as soon as possible after surgery (no loading dose)
	Mitral valve prostheses Multiple valve prostheses Prosthetic heart valve + thromboembolic risk factors: Atrial fibrillation Congestive heart failure Cardiac chamber enlargement Intracardiac thrombus	Oral anticoagulation reversal + Heparin anticoagulation (aPTT = 1.5–2.5X) Stop heparin 4–6 h before surgery Resume heparin as soon as possible after surgery (until oral anticoagulation can be safely resumed)
Nonvalvular atrial fibrillation	Low risk patient	Stop oral anticoagulants 3–5 days before surgery Resume oral anticoagulants as soon as possible after surgery (no loading dose)
	High risk patient	Stop oral anticoagulants 3–5 days before surgery LMWH bridging therapy Resume oral anticoagulants as soon as possible after surgery (no loading dose)
Venous thromboembolism	VTE > 3 months before surgery	Stop oral anticoagulants 3–5 days before surgery Prophylaxis
	VTE < 3 months before surgery	LMWH bridging therapy

Adapted from: Heit [5]
LMWH low-molecular weight heparin, *VTE* venous thromboembolism, *aPTT* activated partial thromboplastin time

patient without resulting hemorrhagic complications. Thus, the feasibility of a laparoscopic procedure in patients receiving anticoagulants was assessed.

Denzer et al. [31] assessed the safety of mini-laparoscopy with guided biopsy as a diagnostic approach in patients in whom percutaneous liver biopsy was contraindicated because of marked coagulopathy (INR >1.5, thrombocytopenia < 50 nl, or both; von Willebrand disease/hemophilia). The laparoscopic approach was preferred because of the possibilities of direct visualization during biopsy, and direct control of bleeding complications. Diagnostic mini-laparoscopy was performed in 61 patients. Macroscopic evaluation of the liver was possible in 60 out of 61 patients. Liver biopsy was feasible in 58 patients. There was no persistent postbiopsy bleeding. One patient with fulminant hepatic failure had self-limiting bleeding from the abdominal wall.

Conclusion

Anticoagulation therapy should be carefully considered for patients with a high risk of thromboembolic complications. However, associated risk of hemorrhage should be carefully assessed. Table 1 summarizes the recommended anticoagulation therapy guidelines for common clinical indications.

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10.2 Laparoscopy in the Obese

Peter Liao, Stephen C. Jacobs

Contents

Introduction

Obesity is becoming more prevalent in society, in both affluent cultures and Third World countries. It is estimated that about 90 million adults in the United States are either overweight (BMI 25–29.9 kg/m^2) or obese (BMI >30 kg/m^2) [1]. The prevalence of obesity is increasing by approximately 10% of the population each decade [2]. Therefore, if the current expansion of obesity continues, a majority of surgical patients will be obese soon. Obesity appears to increase the incidence and mortality of numerous malignancies. Germane to this chapter are the increase in renal carcinoma and prostate cancer seen with increasing body mass [3]. Combined, these two trends predict that the future holds more cancers in heavier patients.

Concurrent with the increase in obesity, surgical techniques have improved. Both the techniques and the technology of laparoscopy have advanced tremendously in the last 10 years. In the initial experiences with of laparoscopic procedures, obesity was considered a contraindication. However, it is becoming apparent that we cannot ignore the large number of patients with obesity as one of their comorbid conditions. To complicate the surgical management of the obese, there are other medical conditions that often coexist with obesity. Cardiovascular disease, respiratory compromise, gastroesophageal reflux; and type II diabetes mellitus increase the risk of any surgical procedure.

There are many advantages to the laparoscopic approach to surgery: shortened recovery time, decreased incidence of ventral or incisional hernia, decreased wound pain and decreased hospital stay are examples. Obese patients actually have more to gain from a laparoscopic approach to a surgical procedure. Incisions need to be larger in obese patients in order to reach the peritoneal cavity; this causes increased pain and slower ambulation postoperatively. Large wounds in obese patients are more prone to postoperative infection and the possibility of increased nursing requirements for secondary wound healing. The obese suffer more postoperative wound dehiscences and hernias.

Just as open surgical procedures take a longer time in the obese, so also do laparoscopic procedures. Weight alone increases the operative time for laparoscopic surgery. Figure 1 shows the influence of body weight on laparoscopic nephrectomy operative time. Obviously there are many factors that contribute to the length of an operative procedure, but patient weight certainly contributes with a coefficient of correlation of 0.19.

The prolonging effect on operative time of body habitus is seen in both sexes. As the body mass index (BMI = weight in kg/(height in m)^2) increases above 32, the operative time increases for nephrectomy by over 30 min per case. Figure 2 shows the increase in operative time as a function of BMI. Interestingly, below a BMI of 32, lower-level obesity is an unimportant determinant of operative time. Longer operative times exacerbate the effects of obesity and pneumoperitoneum on respiration.

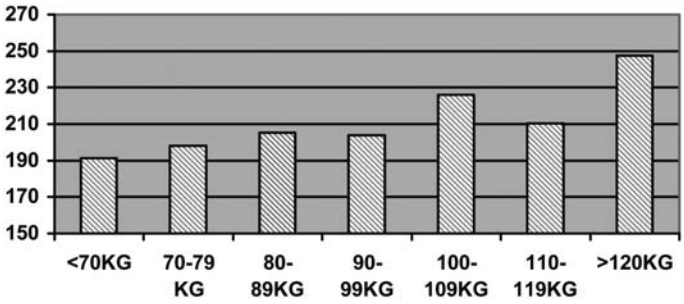

Fig. 1. The effect of weight on operative time (nephrectomy)

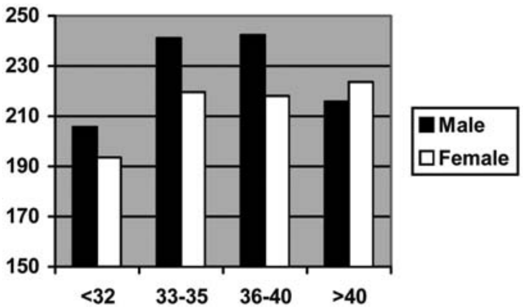

Fig. 2. The effect of BMI on operative time (nephrectomy)

Technique

Standard laparoscopic instrumentation has improved significantly over the last decade. Requirements for advanced laparoscopy include the use of a high-quality video camera with a lens rod objective and a high-intensity light source and a robust light cord. In addition, a high-flow insufflator for the creation and maintenance of pneumoperitoneum is essential. It is beneficial for teaching purposes, both for trainees and practicing physicians, to have image capture devices attached to the video camera.

Longer trocars and instruments may be beneficial; however, with experience, proper port placement reduces the need for long specialty instruments. There are times when intra-abdominal adipose tissue cannot be managed with small, thin laparoscopic instruments. At those times, paddle retractors can aid in visualization. Alternatively, hand-assist devices, which allow the introduction of a hand by the primary surgeon or the first assistant, may be employed. These hand-assist devices, though expensive and time-consuming to place and remove, may shorten the overall time required for completing the operation.

More powerful light sources now allow a great deal of laparoscopic surgery to be done through 5-mm ports. However, in obese patients it is usually prudent to begin with 10- to 12-mm trocars, as the increased light using the larger lenses really helps with visualization.

Upper Tract Malignancies

Upper urinary tract malignancies are approached laparoscopically with the patient in the flank or prone position. The full flank position has the great advantage of allowing both subcutaneous and intra-abdominal obesity to fall away ventrally. Obese patients are usually thinner in the flank and back than any other site, as Fig. 3 demonstrates.

Positioning the obese patient presents difficulties not seen in thinner patients. Rolling the anesthetized patient into position requires extra lifting help. The table is usually flexed with the kidney rest up, but in obese patients this does not seem to help as much because the subcutaneous fat takes up much of the flexion. It is important to support the neck and head so that the neck is straight. In obese patients, the neck can be extremely short and it becomes difficult to get the neck off of the dependent shoulder. A gel ring cushion is recommended for this but it may not fit. Often, extra padding in the form of sheets or blankets is necessary to ensure proper alignment of the cervical spine. Endotracheal tubes are not as secure and move more in obese patients, so great vigilance in protecting the ET tube must be maintained throughout the procedure [4]. An axillary roll should be placed to help prevent brachial plexus injury. Padding of the peroneal nerve area potentially prevents postoperative nerve palsy. There have been reports of lower extremity compartment syndrome occurring due to pressure in obese patients un-

Fig. 3. An obese patient is secured in the prone position. Note the much thinner dorsal fat compared to the ventral panniculus which bulges over the table on both sides

dergoing long laparoscopic procedures in the flank position. The patient must be taped or otherwise secured to the table. The table frequently requires tilting in attempts to move bowel or fat and there is a danger that the obese patient may not be able to be kept on the table. Large breasts should not be taped as they do not provide a secure base. The breasts should also be draped cephalad so they do not block free movement of the superiorly placed camera trocar. Both arms should be padded, as shown in Fig. 4; we prefer soft pillows for this, rather than fixed arm rests.

Port sites, extraction site incision, and a potential flank conversion incision are drawn on the patient prior to insufflation. Port sites should be at the rectus border where the ventral fat falls away, as shown in Fig. 5. The extraction site is usually suprapubic, but in obese patients this location can be difficult to close due to the lower abdominal subcutaneous fat. A good alternative extraction site is a lower quadrant Gibson incision or even an extension off of the lowest trocar site. The subcutaneous fat is often much thinner at the inferior port site, especially with the patient in the lateral position, and it is much easier to open and close the extraction incision.

Insufflation of the abdomen can be more difficult in the obese. The Veress needle may end up in subcutaneous, omental, or even mesenteric fat and cause tissue emphysema. The abdominal cavity of an obese male or nulliparous female may actually be rather small and noncompliant due to the intra-abdominal adiposity. Obese multiparous women usually have capacious, distensible abdomens.

After routine laparoscopic exploration of the abdomen, for left nephrectomy the sustentaculum coli is usually taken down first to allow medial rotation of the left colon. In obese patients, this may be hard to identify; sometimes the trocars are initially difficult to free intraperitoneally because they are under the large, fat-infiltrated sustentaculum coli. This attachment and its fat must be taken down; staying close to the anterior abdominal wall minimizes risk to the colon. On the right side, the colon is not high cephalad, nor

Fig. 4 a, b. Positioning and padding of obese patient (BMI = 35) for laparoscopic nephrectomy

Fig. 5. Obese patient positioned for left radical nephrectomy. Note well-demarcated line where abdominal fat falls medially approximately at the lateral border of the rectus abdominis. The deep cleft suprapubically makes for an overhanging ledge of fat above the incision. A longitudinal extraction incision is preferable, for example through this patient's previous lower midline scar, but there is still a large amount of subcutaneous fat to traverse

anterior, but getting disoriented in the fat anterior to Gerota's fascia risks duodenal injury.

The key to a smooth radical nephrectomy is neatly developing the plane between the colon mesentery and the anterior surface of Gerota's fascia. There is a qualitative difference in the character of the fat; this should be learned on normal patients before taking on the obese. While it is easier to get lost in the obese patient's mesentery, it is more difficult to actually cause through-and-through mesenteric rents. These rents can be dangerous as internal herniation of bowel can occur through them.

The total size of the contents of Gerota's fascia can vary enormously, as shown in Fig. 6. In general, women have less perinephric fat than men and that fat seems less dense and adherent. However, the patient's BMI does not yield a good prediction as to the amount of perinephric fat.

The radical nephrectomy or nephroureterectomy is performed in the standard fashion. Retraction of bowel or fat can be done with paddles or effective retraction can be done with an assistant' hand through the extraction site incision. We prefer an entrapment bag for specimen extraction. On occasion, the kidney and its perinephric fat are too large for entrapment and the specimen must be retrieved manually via the extraction site. Because the total surgical specimen is large, the extraction sites need to be slightly larger. Attempts to pull a very large specimen through too small an extraction site risks specimen rupture and spillage.

In obese patients, using a hand-assist port is useful. The hand can provide retraction extremely effi-

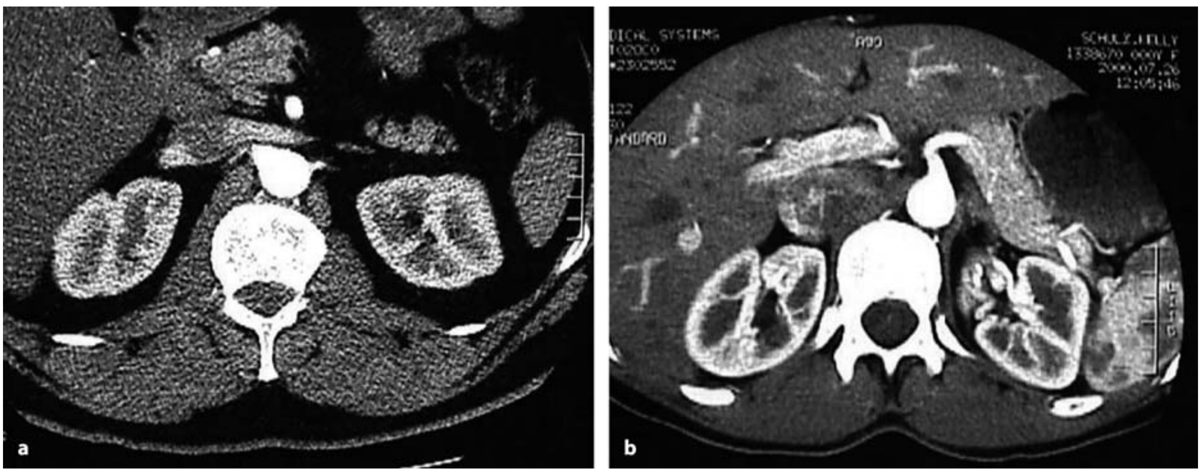

Fig. 6 a, b. Two patients with same BMI show different amounts of perinephric fat ciently and specimen extraction is easy. However, placement of the hand port is a problem. An umbilical site often requires going through a large amount of ventral fat and the operator's arm can become quite fatigued. A site at the lateral border of the rectus is more ideal, but the incision is more uncomfortable for the patient.

In nephroureterectomy in obese patients, the distal ureteral resection should be done open via the extraction site.

Retroperitoneal Lymphadenectomy

Laparoscopic retroperitoneal lymphadenectomy for testis tumor staging is routinely performed by several groups. As imaging and chemotherapy regimens have improved, the indications for the staging procedure have decreased. Janetschek [5] has shown that laparoscopic node dissection is safe and effective in stage I disease, but he has not reported any experience with the obese. The series of Rassweiler et al. [6] and Nelson et al. [7] similarly do not describe the results in obese males. Positioning for the surgery ranges from oblique to supine. With significant obesity, it is likely that the abdominal fat of truly large individuals would interfere significantly. Often, resection of residual masses after chemotherapy is required. Small residual masses after chemotherapy have been resected laparoscopically [8], but none in obese patients have been reported.

Pelvic Lymphadenectomy

Pelvic lymphadenectomy alone is being done much less frequently than a decade ago when it was the most common urological cancer operation done laparoscopically. There will be very few cases now in which the probable staging is unknown and nodal status needs to be known in advance of a planned treatment modality. Pelvic lymphadenectomy in the obese patient is more difficult primarily due to the ventral abdominal girth and the bowel pushing down into the pelvis and obscuring the dissection. The dissection itself identifies and preserves the vessels, vasa, pubic bone, ureter, bladder, and prostate and removes all the nodal tissue with a large amount of adipose tissue. In obese subjects, a full preoperative bowel prep is useful in reducing the sheer bulk of the bowel contents. Though there is little hard evidence that nitrous oxide causes bowel distention, anesthesia is requested to avoid its use. A steep Trendelenburg position helps a little with opening up the vision in the pelvis. For this reason, securely taping the patient to the table preoperatively is mandatory. Unfortunately, the steep Trendelenburg position makes ventilation of the obese patient more difficult.

Lower Urinary Tract Malignancies

Laparoscopy for lower urinary tract malignancies is much more difficult than for upper tract cancers due to the lower ventral abdominal fat, as shown in Fig. 7. Gynecological surgeons have a long-standing experience in laparoscopic extirpative pelvic surgery in obese patients [9, 10], but little experience with reconstructive procedures.

Radical cystectomy is performed by only a few groups [11], though many groups have adapted laparoscopic techniques to open cystectomy procedures. The benefit to the patient of a smaller incision is less

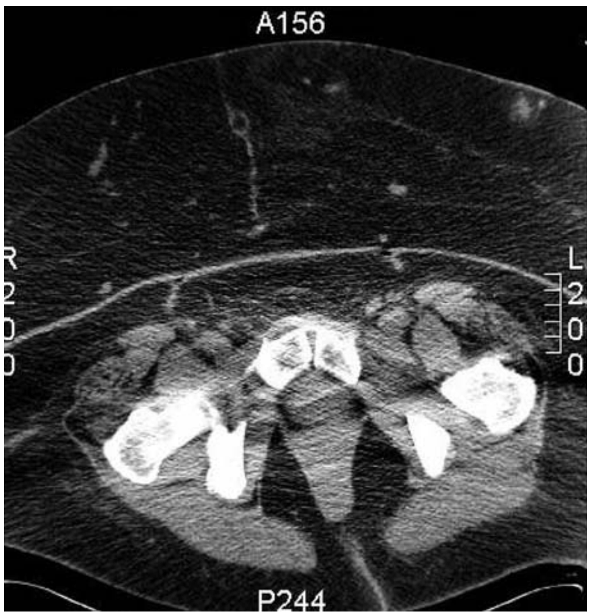

Fig. 7. CT scan of an obese patient's pelvis at the level of the upper edge of the pubic symphysis. The shortest direct distance from skin to anterior rectus fascia is 12 cm and to the bladder is 20 cm. The longest available laparoscopic trocars are 15 cm

apparent in cystectomy, because a larger extraction incision is required for specimen removal.

The most difficult, time-consuming part of the cystectomy is the urinary diversion. In obese patients, isolating the bowel segment can be quite tedious with open surgery due to the thickness and decreased mobility of the mesentery. But what almost prohibits use of the laparoscopic approach is creating the stoma. A good stoma is everted well above the skin and the skin is left flat and smooth for faceplate adherence. A thick bowel mesentery is difficult to bring through the fascial opening and thick subcutaneous fat requires the bowel to be mobilized more [12]. The creation of a Turnbull-type stoma may be required to obtain a satisfactory ostomy even in open surgery in the obese. It seems likely that new ideas and/or material will be required before conduits can be done safely and efficiently in the obese.

Laparoscopic radical prostatectomy is not done on obese patients frequently for the following three reasons.

1. Obese males in the prostate cancer age group often do not have life expectancies long enough to warrant the potential morbidity of the procedure.
2. Fewer surgeons have the broad experience required for laparoscopic prostatectomy than is the case for laparoscopic upper tract surgery.
3. Obesity makes identification of anatomical structures more difficult in the pelvis.

Patients in the American series reported by Menon et al. had an average BMI of only 27.7+2.8 SD [13]. European patients are even thinner. The largest European series of laparoscopic radical prostatectomy reports an average BMI of 25.8 ± 2.8 SD [14]. An American patient with a BMI of 38 is the most obese yet reported [13].

No particular points have yet been reported in how to handle the obese prostatectomy patient. Those surgeons who perform a transperitoneal approach first try to identify the vasa deferentia and the seminal vesicles from behind the bladder in the male cul-de-sac. With obesity, these structures cannot be seen through the overlying peritoneum; the surgeon relies upon experience and an innate sense of orientation. The entirely preperitoneal approach is employed by other surgeons. Obesity places a large amount of lateral stress on the trocars in attempting to get the correct angle to operate deep under the pubic bone.

Morbidity

An increase in the complication rate for the obese should be expected. Certainly the rate of conversion to open surgery is higher in the obese both for procedures done for benign disease and or for malignancies [15–21]. Even inducing anesthesia is more difficult due to short and thick neck, large tongue, and redundant pharyngeal and soft palate tissue. Awake fiberoptic intubation may be necessary for select patients. Cardiopulmonary problems will be increased due to both the higher rate of preoperative cardiopulmonary disease and the intraoperative increased pulmonary stress. However, the laparoscopic approach should decrease the pain of pulmonary toilet as well as the narcotic requirements compared to open surgery.

Anesthesia Effect on Pulmonary Function

Obesity has many effects on ventilation [22–26]. There is increased oxygen consumption and CO_2 production, decreased lung volumes and chest wall compliance, as well as increased work for breathing. Some of the morbidly obese will also show signs of Pickwickian syndrome. These signs include hypercarbia, hypoxemia, polycythemia, sleep apnea, pulmonary hypertension, congestive heart failure and a predisposition to airway obstruction. Obese patients may also have gastroesophageal reflux disease, complicating induction of anesthesia [27].

Oncological results should be equivalent in the obese and nonobese. There may be a tendency to try to squeeze specimens through a too small extraction site in obese patients. This may lead to a higher rupture rate of specimens and extraction bags. From a theoretical perspective, this may increase local recurrences and port site metastases.

Current Limitations

Visualization and exposure as well as the loss of tactile sensation remain problems with laparoscopic surgery. Unlike open surgery, laparoscopic surgery demands that the surgeon be as ambidextrous as possible. This is caused by constraints on the degrees of freedom necessary when operating through small ports. In obese patients, it may be necessary to add one or two more ports to aid in retraction and exposure. However, if you add too many ports, both costs and overall incision size increase.

Future Horizons

As our technology gets better, we will be able to see better with less light. Camera technology is improving rapidly. There are advances in chip technology that place the imaging sensor on the tip of the scope rather than at the end of a lens rod system. Camera sensitivity is also increasing. Light sources are also being improved to the point that they are self-contained and are more efficient. Ultrasound may be a necessary adjunct to laparoscopic surgery that will replace the sense of touch with much more sensitive, flexible and expensive instrumentation. Finally, computer-assisted surgery through robotics, information displays at the time of surgery, and robotic assistants may be helpful in laparoscopic surgery, especially in challenging patients such as the obese.

Conclusions

Obese patients benefit more from laparoscopic surgery for genitourinary malignancies than thinner patients. However, the surgical procedure is distinctly harder on the surgical team. Because the number of obese patients with genitourinary malignancy will be increasing rapidly in the coming decades, surgeons willing to undertake laparoscopic procedures will be in demand. While the most experienced laparoscopic surgeon usually takes on the obese patients, training programs teaching laparoscopy need to emphasize to trainees the magnitude of this growing population of the obese.

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10.3 Prior Surgery

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Contents

Since the first laparoscopic nephrectomy was performed by Clayman in 1990 [1], urological laparoscopy has undergone a rapid advancement. Many of the standard operations in urology can now be performed laparoscopically or with minimally invasive techniques, including simple and radical nephrectomy, partial nephrectomy, nephroureterectomy, pyeloplasty, primary and secondary pelvic and retroperitoneal lymph node dissection, antireflux operations, radical prostatectomy and even radical cystectomy plus urinary diversion. It is well accepted that laparoscopic urologic surgery is associated with a considerable learning curve, especially in technically difficult operations such as partial nephrectomy or radical prostatectomy. Despite the growing experience with laparoscopic operations, there is still some uncertainty about relative or absolute contraindications to the laparoscopic approach. Historically, previous abdominal surgery has been considered as a relative contraindication to transperitoneal laparoscopy due adhesion formation, making minimally invasive surgery even more demanding. Furthermore, adhesion formation after abdominal surgery remains a major cause of postoperative morbidity, and adhesion formation after transabdominal procedures may be completely unpredictable, making laparoscopic access and dissection difficult or impossible.

Adhesions from previous intra-abdominal surgery can be divided into two groups. The first group includes adhesions or scar tissue formations internally at the surgical site. Examples are scar tissue formation around the ileocecum following appendectomy or extensive bowel or colon adhesion after hemicolectomy. The second type of adhesion originates from the abdominal wall where the peritoneum has been incised. The formation of adhesions is an adaptive response to localized peritoneal injury and the location of the adhesions corresponds to the site of the peritoneal injury. Adhesions may extend through the entire length of the peritoneal incision, so that the external scar may not be indicative of their extent or location.

Autopsy studies showed intra-abdominal adhesions after open abdominal surgery in up to 90% of patients [2]. There are only few data available comparing adhesion formation in patients with previous open vs previous laparoscopic procedures. In contrast to historical data on open abdominal procedures, Pattaras and coworkers found adhesion formation in only 22.2% of patients with previous laparoscopic procedures [3, 4]. These data suggest that transperitoneal laparoscopic procedures may cause fewer and less severe adhesions compared to open surgical procedures. The reduced rate of adhesion formation corresponds with the finding of Fornara et al. that laparoscopy reduces operative trauma and the extent of acute-phase reactions as measured by different serum parameters such as IL-6, IL-10 and C-reactive protein [5].

While there are a number of reports on complication rates in various laparoscopic procedures in urology [6, 7], only little is known about the aspect of previous open or minimally invasive procedures in urological laparoscopy. There are few reports that previous abdominal surgery does not significantly alter the outcome of subsequent urological laparoscopy [8, 9].

Parsons and co-workers from John Hopkins reviewed their experience about the effect of previous abdominal surgery on urological laparoscopy [9]: out of 700 patients operated on between 1995 and 2001, 366 (52%) had never undergone surgery, 105 (15%) had a history of abdominal surgery in the same anatomical region and 229 (33%) had a history of abdominal surgery in a different region. The four most common laparoscopic procedures were radical nephrectomy, simple nephrectomy, pyeloplasty and renal biopsy. The authors found that a history of surgery at the same site was associated with increased operative time and increased hospitalization. Differences in operative blood loss, complications and conversion rates in patients with and without a history of surgery did not reach statistical significance. Despite the differences in operative time and hospitalization, the authors concluded that previous abdominal surgery does not appear to affect adversely the performance of subsequent urological laparoscopy.

Seifman et al. from Ann Arbor, Michigan, reviewed their experience with renal and adrenal laparoscopic procedures in patients with previous abdominal operations [10]. In their population of 76 patients, they found no differences in operation time (median, 220 vs 210 min; $p > 0.05$). However, the mean hospital stay was longer in the group of patients with previous abdominal surgery (3.8 vs 2.6 days; $p = 0.002$). Also operative and major complications rates were more common in patients who had undergone previous operations (16% vs 4%; $p = 0.009$ and 16% vs 5%; $p = 0.022$, respectively). Access and total complication rates did not significantly differ statistically. Of note, an upper midline scar or lateral upper quadrant scar was associated with a greater access complication rate, but not a higher operative complication rate. They concluded that previous open abdominal surgery increases the risk of operative and major complications, which have an impact on the length of hospital stay. The location of scars also has an impact on the access complication rate.

One report suggests a higher risk of gas embolism in patients with previous abdominal surgery [11]; however, this complication has not been noted by others. We were unable to identify a single case of gas embolism in our patient population with or without previous abdominal surgery.

Minimally Invasive Radical Prostatectomy After Previous Abdominal Surgery

Because of the above-mentioned concerns, some authors regard previous extensive transabdominal surgery or previous pelvic surgery as a contraindication for laparoscopic radical prostatectomy (LRPE) [12]. In other laparoscopic centers, previous major abdominal surgery or pelvic surgery is not a contraindication for transperitoneal LRPE [13, 14]. Due to the formation of abdominal adhesions the transperitoneal procedure is certainly more demanding, time-consuming and possibly associated with more complications, although randomized data are not available to date. In contrast, the endoscopic extraperitoneal radical prostatectomy technique (EERPE) avoids these problems in patients with prior abdominal surgery because it is a totally extraperitoneal approach [15, 16].

Many laparoscopic procedures on retroperitoneal organs have utilized a transperitoneal approach such as transperitoneal nephrectomy or transperitoneal pyeloplasty. In these cases, the transperitoneal route offers the advantages of familiarity of the approach and increased working space. However, in urological pelvic surgery, especially in prostatectomy, the limiting anatomical landmarks are the pubic arc and the pelvic floor musculature and not the abdominal cavity. Recently, it was demonstrated that the extraperitoneal approach to the prostate is equal or even superior to the transperitoneal approach in radical prostatectomy [17, 18].

Our own experiences include 500 cases of endoscopic extraperitoneal radical prostatectomy performed between December 2001 and April 2004. The patients were stratified into five groups: I no previous abdominal, inguinal or prostate surgery (322 patients, 64.4%); II previous upper abdominal surgery (13 patients, 2.6%); III a previous lower abdominal or pelvic surgery or open inguinal hernioplasty (105 patients, 21%); III b laparoscopic/endoscopic inguinal hernioplasty (nine patients, 1.8%); IV previous prostatic surgery (22 patients, 4.4%); and V a combination of groups II, III and IV (29 patients, 5.4%). Groups I and II were analyzed together since the previous operative fields in group II were distant from the Retzius space.

The mean patient age was 63.7 years (range, 42–77 years). Mean preoperative values of prostatic specific antigens (PSA) was 12.1 ng/ml (range, 1.4–67 ng/ml).

In 218 cases (43.6%), pelvic lymphadenectomy was performed depending on the preoperative Partin calculation [19].

The overall mean operative time was 149 min (140 ± 36 min without lymphadenectomy, 161 ± 41 min with lymphadenectomy). In group I, the mean operative time was 147 ± 39 min, in group II 157 ± 46 min, in group IIIa 150 ± 37 min, in group IIIb 170 ± 48 min, in group IV 162 ± 49 min, and in group V 159 ± 37 min. There was no statistically significant difference with regard to operative time between patients with or without previous abdominal or pelvic surgery.

In all 500 cases, there were no intraoperative complications that required conversion to open surgery. The transfusion rate was 0.8% (four patients; one patient in group I, and three patients in group IIIa). We had three early re-operations (0.6%) caused by bleeding on the 1st postoperative day (one patient in group I, two patients in group IIIa) and eight late re-operations (1.6%). These include four laparoscopic fenestrations and one percutaneous drainage of symptomatic lymphoceles (two patients in groups I/II and one patient each in groups IIIa, IV and V); one temporary dysfunctioning colostomy in a patient with a rectal fistula (group IV), one repair of a port site hernia (group I) and one transurethral incision of an anastomotic stricture (group V). There were no other major complications. No intra-abdominal complications (prolonged ileus, bowel injury or peritonitis) occurred that was attributable to the totally extraperitoneal approach of the procedure.

With regard to the pathological results, 161 patients (32.2%) had cancer limited to the prostate (stage pT2a in 67 patients, pT2b in 94 patients); 273 patients had histological evidence of tumor extension beyond the prostatic capsula (pT3a, 54.6%) and 62 patients had tumor infiltration into the seminal vesicles (pT3b, 12.4%). Four patients had pT4-tumors (0.8%). In 12 out of 218 patients who underwent concurrent pelvic lymph node dissection, pelvic nodal involvement was found. The rates of positive surgical margins for pT2 tumors was 10.5% (17/161 patients) and for pT3 tumors 33.4% (112/335 patients).

Endoscopic extraperitoneal radical prostatectomy can be performed regardless of patient urological history. Prior prostate surgery such as transurethral resection of the prostate or bladder neck incision is not a contraindication for EERPE. Furthermore, there is no statistically significant difference between patients with and without prior abdominal and pelvic surgery with regard to operative time and complication rates. Because of the totally extraperitoneal approach, previous abdominal surgery does not interfere with endoscopic extraperitoneal radical prostatectomy.

Minimally Invasive Radical Prostatectomy After Previous Inguinal Hernia Repair

Inguinal hernia repair is one of the most common surgical procedures. Therefore it is not surprising that many patients with prostate cancer already had previous inguinal hernia surgery. Hernia repair options can be broadly categorized into open and laparoscopic techniques. The open technique was first described in 1884 by Bassini and involved reinforcement of the inguinal floor combined with ligation of the hernia sac. In 1973, Stoppa et al. introduced the application of a large polyester prosthesis during the open procedure, placed preperitoneally, for inguinal hernia repair [20].

Laparoscopic hernia techniques can be performed transperitoneally or totally extraperitoneally. The key element in the development of the transabdominal preperitoneal repair (TAPP) or the total extraperitoneal preperitoneal repair (TEP) has been the introduction of prosthetic materials for a tension-free herniorrhaphy.

The classical methods of hernia repair only seldom lead to postoperative adhesion formation, which influences a laparoscopic procedure in the small pelvis like radical prostatectomy. Simply during totally extraperitoneal prostatectomy, the creation of the preperitoneal space can be aggravated by a fixation of the peritoneum to the abdominal wall. In special cases, a partial intraperitonealization of the procedure can be helpful. The adherent peritoneum is incised on a length of 2–3 cm to make placement of the lateral trocars possible under visual control. The resulting capnoperitoneum does not influence the further steps of the procedure and does not minimize the preperitoneal space if the patient is sufficiently muscle relaxed.

In contrast, a preperitoneally placed mesh can lead to extensive adhesions between the abdominal wall, the mesh and the peritoneum. Different authors discuss previous preperitoneal hernia repair with mesh placement as a contraindication for a laparoscopic radical prostatectomy [12]. In these cases, a perineal approach for prostatectomy is frequently recommended.

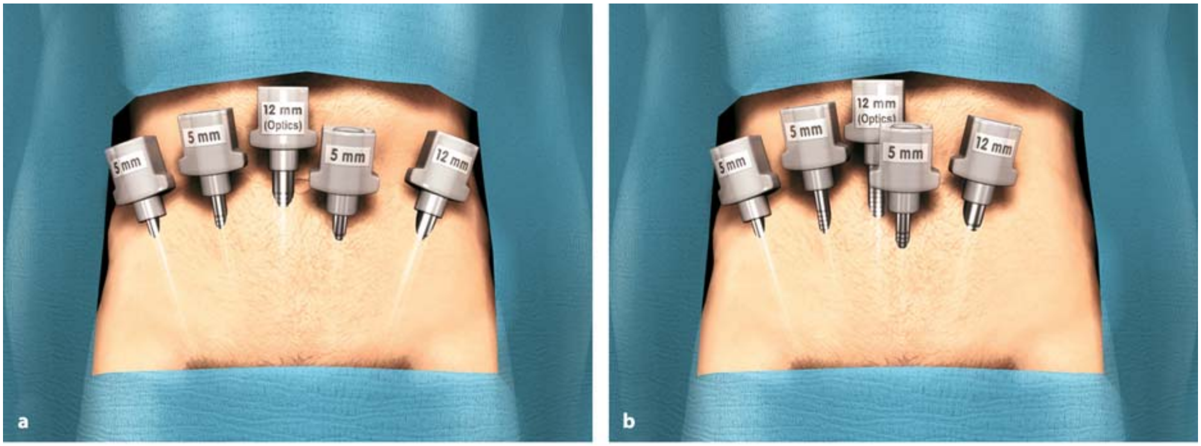

Fig. 1 a–c. Trocar placement for endoscopic radical prostatectomy (EERPE). **a** Trocar placement for standard procedure. **b** Trocar placement in patients with prior mesh placement to the left inguinal region. **c** Trocar placement in patients with prior mesh placement to the right inguinal region

Our own experiences with 70 laparoscopic radical prostatectomies and of 500 cases of endoscopic extraperitoneal radical prostatectomies show that prior mesh placement does not represent an absolute contraindication to this kind of operation. In our patient population, we had two patients with a unilateral modified Stoppa operation, four patients with unilateral TEP, one patient with bilateral TEP and four patients with unilateral TAPP procedure in their history. The preperitoneal space could be developed and the trocars could be placed as shown in Fig. 1a without problems and the operation finished successfully in the first two patients. The mesh placed into the preperitoneal space during the open procedure did not interfere with the EERPE procedure.

In patients with prior laparoscopic preperitoneal hernia repair, we use a modified trocar placement to avoid complication during trocar placement associated with mesh adhesions. In patients with a mesh in the left inguinal region, the first steps of the procedure to insert the balloon trocar and the optical (Hasson-type) trocar are similar to the classical EERPE procedure [15]. A 1.5-cm paraumbilical incision is made on the right-hand side, and preparation is carried down to the rectus abdominis aponeurosis. The anterior rectus fascia is incised, and the rectus muscle fibers are vertically separated by blunt dissection, exposing the posterior rectus fascia. The balloon trocar is introduced along the posterior rectus sheath and the balloon is slowly insufflated under direct visual control. The balloon trocar is exchanged for the optical (Hassan-type) trocar and a 5-mm trocar is placed directly in the midline half between the umbilicus and the symphysis, as shown in Fig. 1b. The preperitoneal space is carefully developed. However, no extensive adhesiolysis is performed in the left inguinal region.

The preperitoneal space is only developed to the point where safe trocar placement is possible in the pararectal line. In that way, the operator, standing on the left side of the patient, is working through a trocar in the left pararectal line and a trocar placed in the midline (Fig. 1b).

In patients with a mesh in the right inguinal region, the first 15-mm incision is made in the infraumbilical crease on the *left* side to the midline and the balloon trocar and the optical trocar are inserted as described above. A 5-mm trocar is placed in the left pararectal line (Fig. 1c) and the creation of the preperitoneal space is continued. Once the peritoneum has been completely dissected free from the left posterior aspect of the rectus muscle, a 12-mm trocar is placed approximately two fingers breadth medial to the left anterior superior iliac spine. No extensive adhesiolysis is performed in the right inguinal region to avoid injury of the peritoneum fixed to the mesh. In these patients, the right lateral trocar is renounced and a 5-mm working trocar is placed into the pararectal line 2–3 cm above the symphysis instead (Fig. 1c). The assistant, standing on the right side of the patient, is working through this trocar and a trocar placed in the pararectal line at the level of the umbilicus, as shown in Fig. 1b. This system of trocar placement usually permits a prostatectomy without technical difficulties. However, pelvic lymph node dissection may not be feasible on the side where the mesh is placed.

Recurrent Hernias

In the literature, relatively little attention is given the concomitant appearance of inguinal hernia in patients with prostate cancer. Although the coincidence of prostate cancer and inguinal hernia has not been described in clinical studies, we encounter patients with both diseases in clinical practice. Some authors describe a concomitant inguinal hernia in 13%–18% of these patients, including 3% recurrent hernias [21–23].

Total Extraperitoneal Preperitoneal Repair Technique

The preperitoneal laparoscopic approach offers several advantages, two important anatomical ones being direct access to the posterior inguinal anatomy and clear visibility of all possible hernial defects. In cases of concomitant inguinal hernia (there is no difference between primary or recurrent hernias), we use a standardized procedure for TEP hernia repair during prostatectomy. After placement of all trocars in the preperitoneal space, EERPE starts with hernia sac preparation. In direct hernias (Fig. 2d), the hernia sac is found medial to the epigastric vessels. In such cases, traction and countertraction are used to reduce the hernia sac. In indirect hernias, cautious dissection of the spermatic cord enables the reduction of the hernia sac. The hernia sac is completely dissected out of the inguinal canal and left in the preperitoneal space (Fig. 2c). Reduction of any hernias encountered allows complete exposure of the pelvic structures, which is necessary for pelvic lymph node dissection and prostatectomy. The actual hernia repair with mesh placement has to be performed at the very end of the prostatectomy, after finishing the urethrovesical anastomosis.

In recurrent indirect inguinal hernias, the key to a safe dissection is the creation of a space posterior to the epigastric vessels at a level halfway between the umbilicus and the anterosuperior iliac spine. From there, access can be gained to the transversus abdominis muscle laterally. The dissection is then continued along the lateral aspect, first in the cranial direction to place the 5-mm working trocar in the lateral iliac fossa at the level of the anterosuperior iliac spine, and second toward the inguinal ring. The hernia sac is now situated between the Retzius space medially and the space with the inserted trocar laterally. The hernia sac is then dissected away from the cord structures in a perpendicular fashion. Very seldom, mostly in cases of scrotal hernias, a sharp dissection or even cutting of the hernia sac is necessary. In that case, care has to be taken to close any defect of the peritoneum at the end of the hernia sac preparation to avoid contact between the finally placed mesh and the bowel.

At the very end of the prostatectomy, the spermatic cord is elevated and an opening is created behind the spermatic cord at the side of the inguinal hernia to allow the comfortable passage of a synthetic mesh. We prefer a Prolene mesh (8–10×13–15 cm, depending on the size of the inguinal defect), which is prepared externally (Fig. 2a, b). The mesh is incised in the middle, the length of the cut being 6 cm. At the distal end of the split, a small hole is cut into the mesh to provide sufficient space for the spermatic cord. The split is then covered by a flap (Prolene mesh, 6×5 cm) and the flap is fixed by Prolene ligature. For placement in

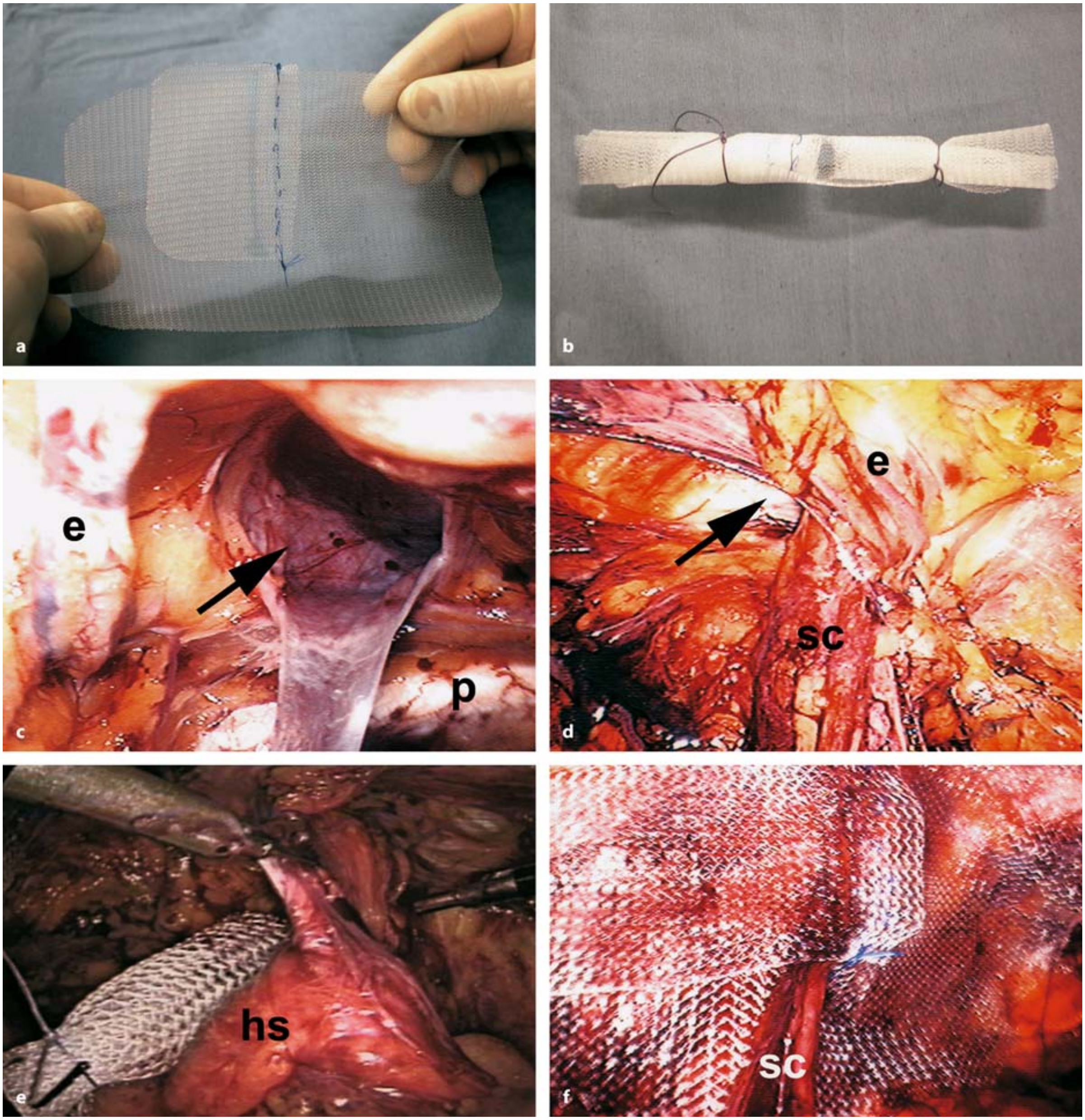

Fig. 2 a–f. Total extraperitoneal hernia repair with mesh placement into the preperitoneal space (TEP technique, left side). **a** Externally prepared Prolene mesh (8–10×13–15 cm). **b** The prepared mesh is rolled up for placement in the preperitoneal space through the 12-mm trocar. **c** Direct hernial orifice. **d** Indirect hernial orifice. **e** Placement of the mesh roll beneath the spermatic cord. **f** The mesh is systematically unfolded around the spermatic cord and the hernial orifices are completely covered by the mesh. *e* epigastric vessels, *sc* spermatic cord, *p* pubic arc, *hs* hernial sac the preperitoneal space through the 12-mm trocar, the prepared mesh is rolled up (Fig. 2b). It is then placed beneath the spermatic cord (Fig. 2e). Subsequently, the mesh is unfolded upon the epigastric vessels and the hernial orifice (Fig. 2f). The direct and indirect spaces are completely covered by the mesh. The prepared flap covers the split and the mesh is fixed by the spermatic cord. Figure 3 shows a schematic of the mesh placed in the preperitoneal space. No staples or sutures are necessary to fix the mesh.

In our series of EERPE, a total of 33 inguinal hernia defects were treated concomitantly during EERPE. Unilateral hernias were identified in 27 patients and bilateral hernias were identified in three patients. Three were recurrent hernias and four hernia defects were incidental.

The mean additional time for the hernioplasty was 12 min in unilateral hernias and 20 min in bilateral hernias. Although our follow-up has been short, there was no recurrence to date and most recurrences in hernia surgery are early. There were no specific complications attributed to the TEP procedure. These results demonstrate that the progress of laparoscopic and endoscopic techniques permits us to extend and combine the indications for its use to include complex oncological surgery such as radical prostatectomy and reconstructive surgery such as hernia repair (including recurrent hernias) if the totally extraperitoneal access is used, providing a safe and minimally invasive approach to radical prostatectomy and inguinal hernia repair.

In summary, there is little dispute that adhesion formation after previous open surgery can be extensive and in general makes subsequent open and laparoscopic surgery more difficult. While some authors regard previous open abdominal surgery as a contraindication to subsequent laparoscopic surgery, there are actually no supporting data in the urological literature. Our own experience with endoscopic extraperitoneal radical prostatectomy in patients with previous open or minimally invasive hernia repair supports the view that this kind of surgery is certainly more demanding, but technically feasible. Especially in patients with prior abdominal surgery, the benefits of a totally extraperitoneal approach in radical prostatectomy is obvious [24].

Although patients with previous abdominal surgery should be approached with caution, it would be unfortunate to deny laparoscopic or endoscopic procedures to these patients while risks can be successfully minimized by thorough understanding of the surgical anatomy and meticulous laparoscopic and endoscopic preparation and technique. In the hands of the experienced laparoscopic/endoscopic surgeon, previous abdominal or pelvic surgery is not a contraindication to laparoscopy. As in any surgical procedure, the experience of the surgeon determines the quality of the procedure and the complication rate.

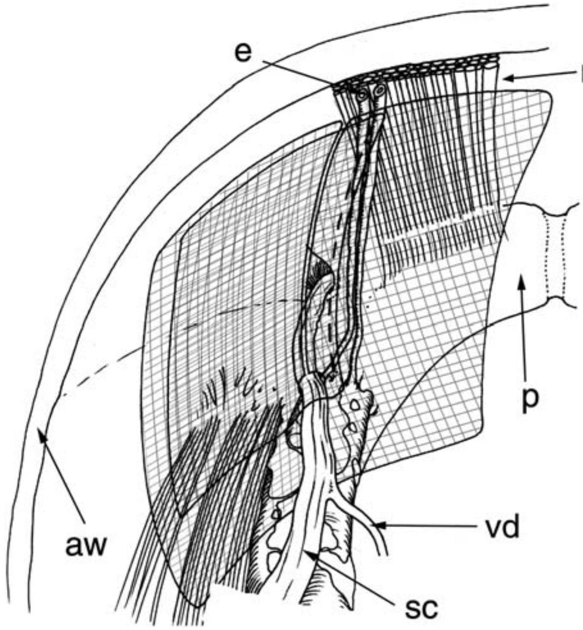

Fig. 3. Schematic drawing of mesh placement in the preperitoneal space covering the direct and indirect hernial orifices. *aw* abdominal wall, *e* epigastric vessels, *p* pubic bone, *r* rectus muscle, *sc* spermatic cord, *vd* vas deferens

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11 Training in Laparoscopy

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Contents

Introduction

Urology amongst other surgical specialties is not going to escape the great changes medicine is facing in the beginning of this century. To acquire an adequate surgical experience in a time-efficient manner is becoming more difficult than it was in the past. Besides the very well known fact that an operation performed by a trainee lasts longer and is more expensive than the one performed by a staff surgeon [1, 2], current economical constrictions and increasing demands in health care (cost reduction pressure), fiscal constraints and medical and legal considerations (increasing social demands and resident's lowered responsibility) limit the time available in the operating room and the opportunities for the trainee to practice and learn while operating on real patients [3]. Also, operating approaches are changing and in urology open surgery is increasingly replaced by endoscopy and laparoscopy, the former being essentially a one-man procedure, where teaching while assisting is more difficult than in open surgery [3] and the later being recognized as a difficult and still novel technique.

In contrast with the open technique, the laparoscopic technique brings about several changes in the way the surgeon observes and manipulates (Table 1). Particularly the combination of observation and manipulation, the eye-hand coordination, is disturbed. There are several causes for these changes; the images on the monitor are not the same as observed with the naked eye and the surgeon has to perform a 3D task viewed on a 2D screen. Furthermore, the images are presented by the camera assistant and no longer follow the head and eye movements of the surgeon; in addition, there is a disparity in the direction of movements of the surgeon's hands and the tip of the laparoscopic instrument, known as the fulcrum effect [4].

Moreover, the laparoscopic instruments do not have the same functionality as the human hand. For example, the movement is reduced from six degrees of freedom to four, due to the fixed entry point of the instruments in the abdominal wall. Since there is no contact between hands and tissue, tactile information about tissue properties is lost to a large extent. Because the hands are outside the abdominal cavity, information on the position of hand and fingers, called proprioception, does not directly support the manipulation of tissue. In addition to these disturbances, be-

Table 1. Differences between current surgical techniques

	Vision	Tactile sensation	Hand freedom
Open	Three dimensional	Fully present	6 degrees
Endoscopic	Monocular	Reduced	4 degrees
Laparoscopy	Two-dimensional	Reduced	4 degrees
Robot-assisted laparoscopy	Three-dimensional	Absent	6 degrees

cause the laparoscope is usually managed by an assistant, the images do not match the proprioceptive information of the surgeon, the direction of sight differing from that of surgeon, and even the location of the monitor may significantly influence performance [4, 5].

Time and experience are required until proficiency is reached and the new technologies are incorporated into the surgical armamentarium. In this complex scenario where traditional surgery coexists with endoscopy and laparoscopy and where robotic surgery appears as an attractive possibility, a balanced approach has yet to be reached. Learning by try and error is no longer possible and new learning approaches have to be considered.

Conversely, as the number of minimally invasive procedures rises, the urological teaching centres will face the challenge of providing residents with the surgical training that optimizes learning and provides surgeons with the possibility of maintaining skills and learning new approaches.

Surgical Education

Surgical training has traditionally been a true apprenticeship where trainees were learning while performing under the guidance of a more experienced surgeon or mentor. Progressive trainee involvement with gradual devolving of responsibility has been the method adopted for surgical training for centuries. Surgeons have learned at "the foot of the master" [6].

The educational literature refers to three domains of competence: knowledge, skills and attitudes [7].

Knowledge is reached by processing the reliable and accessible information. This information traditionally provided by books is currently expanding to multimedia and web environments.

Skills require development of a psychomotor competencies sustained by regular practice, proper motivation and a competent training program.

Attitudes relate to how knowledge and skills are combined in patient care, the professional attributes including clinical judgement, decision-making and behavioural intangible qualities of value in becoming a competent clinician [8].

Skills development is a steadily progressive acquisition of surgical dexterity and spatial orientation. Practice is the basis of surgical skills but in the current medical scenario manual and technical skills must be acquired prior to performing invasive procedures in a competent manner. A surgeon should and must be able to practice new procedures repeatedly until judged to be proficient without endangering patients. Ultimately, during the training process it would be desirable to face cases of increasing complexity in order to measure progress and improvement. Complex surgical psychomotor skills as needed for laparoscopy are in part innate and in part learned from extensive and repetitive practice [9]. The acquisition of a new psychomotor skill includes three different phases [10]. In the first phase known as the cognitive phase, the trainee learns the basic steps of the procedure. After understanding these steps, the novice progresses to the second phase or integration where a mental inventory of the different steps is transferred into psychomotor action. Nevertheless, performance remains erratic until the trainee reaches the third or automatic phase when repetitive practice perfects motor skills so that they are automatically executed with little cognitive input. The importance of the cognitive component has been fully recognized in the learning process of a new surgical skill. It is clear by now that only after a didactic session do individuals significantly improve performance. Later, the retention of a motor skill seems to be more dependent on the degree to which the skill was mastered rather than the environment in which it was learned [11]. Learning is optimized when feedback is incorporated [12].

In addition to the above-mentioned processes, the individual neuropsychological attributes of surgeons include complex visual-spatial organization, stress tolerance and psychomotor abilities. Visual spatial ability seems to be related to competence and quality of results in complex surgery. Individuals with higher visual-spatial scores seem to do significantly better in the surgical procedure than those with lower scores. However, after practice and feedback, the individuals with lower scores may achieve a comparable level of competence [13].

The goals of a surgical education programme should be: standardization of the acquisition of surgical skills and assessment of the performance in a uniform setting to ensure the maintenance of the acquisition of skills and to develop programs to teach new skills.

However, in proposing a new way of training many questions remain unsolved, the most important being the assessment of competence, i.e. how can the medical community ensure that the trainee has reached sufficient proficiency? Current assessment of the trainee's performance is subjective. The need for improving the assessment tools in a more objective way has been recognized. Possible measures to be taken are frequent feedback, mentor's evaluation of progression and remedial measures if this progression is not the expected one.

Defining Competence

Surgical competence is a complex quality that includes knowledge, decision making, dexterity and communication [7, 8]. However, defining competencies is difficult for various reasons: first of all there are no appropriate tools to assess some of the above-mentioned qualities; secondly competence reflects a given moment in a career of a surgeon without any information on the background effort required until the present moment or possible future outcomes. Lastly, the current tests assess only motor skills while we know that motor skills proficiency is only one component of surgical competence. In a simple way the assessment of technical competence comprises time (speed), errors (crashes) and economy of movement (confidence).

Few of the published literature describes accurate evaluation and assessment of the surgical resident's technical competencies. Limitations in working hours, changes in training programme duration, and differences in contents in different countries make it extremely difficult to provide a standard of core technical competencies. Minimally invasive surgery is a particularly challenging training area, requiring significant allocation of residents and faculty, time and resources with inconsistent training results.

Definition of the Learning Curve. The number of procedures an average surgeon needs to undertake in order to confidently perform in an independent way and with a reasonable outcome. The learning curve is influenced by the frequency of performing the procedure, the time taken for the procedure, the individual operative skills and the outcome. The learning curve is not only defined by the time needed to achieve a definite performance (quickness) but also by the number of cases (trials) necessary to attain proficiency [14].

Assessing Competence

It has been postulated that identifying candidates with good spatial awareness and innate ability should be a desirable goal for surgical practice in general. Consequently, measurement of these qualities should become a part of aptitude testing and training for laparoscopic surgeons. Nevertheless testing technical skills is not yet standardized, the current tools to assess individual innate abilities being limited and still insufficiently developed. Furthermore, a recent comparison of the innate spatial awareness of the urologist, trainees and controls not trained in surgery showed that about 10% in each group appeared to have deficient awareness skills without further evidence that this deficiency hinders surgical training or performance, this data questioning at least the use of evaluating some innate skills [15].

In skills assessment three tests are currently available:

- ADEPT (Advanced Dundee Psychomotor Test), which reflects (and assesses) innate psychomotor ability [16]. This test seems to correlate well with the independent consultant clinical assessment of operative skills, what is called concurrent validity. The system identifies aspects of performance that do not improve with practice (innate abilities) and thus it has been suggested that it may predict the ultimate level of operative skills. Some authors have proposed its inclusion as an aptitude tester for trainee selection in minimal access surgery and interventional radiology [16].
- OSATS (Objective Structured Assessment of Technique Skills), which measures technical ability by means of specific check lists and a global rating score. This test is meant to be highly reliable and with construct validity [17]. In some articles, global rating is a better method of assessment than the task-specific checklists discriminating between experience levels [18].
- MISTELS (McGill Inanimate System for Training and Evaluation of Laparoscopic Skills) assesses laparoscopic technical skills through a series of tasks, taking into account precision and speed of movements [19].

An objective assessment of the performance, or metrics, can only be expected in computer-based systems. Most of the assessments performed to date have been based on a subjective evaluation of the performance by experts. Moreover, assessment of performance should include not only quantitative aspects but also qualitative ones. The absence of standard assessment methods makes tracking the performance in skills maintenance programmes difficult. Finally, the assessment of competence includes much more than the simple metrics of the performance. Evidence-based studies in the field are lacking.

Simulation in Urological Laparoscopy

Simulation can be defined as a device or exercise that enables the trainee to reproduce, under test conditions, phenomena that are likely to occur in actual performance [20]. There must be sufficient realism to suspend the disbelief of the participants and to emulate critical aspects of live surgical procedures [21].

Simulation has a potential impact in all stages of a surgeon's career and can be used for assessment of competence, for training purposes, and as a tool of possible certification. Simulated training should be helpful for teaching the required skills and preparing trainees for emergency situations and can even be used as a selection or counselling tool.

In spite of its universally recognised value, important issues about simulation remain unsolved and when exploring the usefulness of simulation one has to be aware of its limitations (Table 2).

The educational objectives of a simulator in laparoscopy are:

1. To replace the two-dimensional screen representation of the anatomy by a three-dimensional spatial model.
2. To become familiar with the manipulation of the laparoscopic instruments minimizing the fulcrum effect
3. To practise individual manoeuvres to the point of automatism
4. To gain the hand-eye coordination (surgeon-assistant) and spatial awareness
5. To shorten the learning curve
6. To help maintain technical competence.

Table 2. Potential use and limitations of simulation

Use of simulation	Problem
Selection	Training involves individuals with different visual-spatial abilities
Career counselling	Competence is a complex quality impossible to measure accurately
Training	Objective assessment still developmental
Maintenance of skills	Define task and procedures of increasing complexity
Assessment of competence	Defining competence
Certification	Defining standards

The ultimate goal of a simulation should be to reduce surgical errors, improve patient safety and reduce operative time. This transfer of the action (simulated) to reality (real patient), or validation, has been shown in only a few studies, most of them involving simple surgical procedures and as yet, none have investigated current urological laparoscopic simulations.

It has been postulated that training in laparoscopy is more difficult than in open surgery, which makes a steep learning curve the main drawback of laparoscopy. This fact not only has never been proven in a comparative study, but some authors have demonstrated that the differences in learning open or laparoscopic surgery are minimal. Subramonian et al. [22] assessed medical students without previous practice in open or laparoscopic pig cholecystectomy. Both groups received intensive coaching. The evaluation score was based on direct observation by examiners at the time of surgery. The average scores for each criterion were plotted in a frequency distribution curve. There was no statistically significant difference in the overall scores by the two different techniques, but significant differences between the two techniques were found in tissue dissection, tidiness of specimens and procedure time. The students with proficiency in playing video games did not differ in open or laparoscopic skills from the others. However, in a questionnaire on the perception of their training, laparoscopy was quoted as more difficult to learn. This study suggests that learning curves for both open and laparoscopic procedures can be similar at least for inexperienced subjects; however, in terms of fine dissection, correct plane identification and two-dimensional perception, laparoscopic surgery requires more experience and surgical time in a proportion of 1.5, probably due to the absence of feedback and to the fulcrum effect [22]. Similar results have been found when comparing learning curves for open and laparoscopic hysterectomy [23].

Although we can consider the training in laparoscopic urology equal to that needed for laparoscopic general surgery or other specialties, urological laparoscopy has two major particularities: from an excision procedure it has evolved into a reconstructive technique [24] and the most challenging of the laparo-

Table 3. Types of simulation to be offered according to trainee's expertise

	Novice	Expert
Model	Low fidelity	High fidelity
Task	Part task	Complex task

scopic urological procedures, the radical prostatectomy, takes place in a deeper and more difficult anatomical field than the one in which general surgeons are used to working: the small pelvis [25]. Furthermore, there is no easy laparoscopic procedure in urology to allow for repetitive practice, as can be the case of laparoscopic cholecystectomy. Because of these characteristics, simulation may play an important role in urological laparoscopic training.

Simulation can be classified in: bench models, animal simulation and cadaveric simulation.

Testing basic laparoscopic skills on bench models, becoming familiar with the principles of dissection and haemostasis on living animals and studying surgical anatomy in cadavers should be considered indispensable and complementary elements for laparoscopic simulation and training [26]. Simulation should be graduated according to the level of training and to sustain the trainee's expectations and interest (Table 3).

Bench Simulation

Bench models are valid, with variable fidelity and allow for surgical immersion. Bench models are used as a surrogate for the human body and are increasingly used to simulate real procedures without health or safety issues.

Bench simulators are classified in physical models or inanimate simulators (model-based simulators), computer-based or virtual reality simulators and hybrid simulators or a combination of the latter two models.

In spite of enormous advances in haptic feedback, the main disadvantage of the bench simulators, whether model-based or computer-based, is the lack of duplication of human tissue.

Model-based Simulators (Mechanical)

Mechanical simulators are nonelectronic and simple. They can only simulate tasks and not the entire procedure. For laparoscopy, a range of relatively inexpensive model-based simulators, known as Pelvi Trainers, are available. They consist in a laterally open plastic box with several entry orifices in the opaque top surface to introduce the laparoscopic instruments and the laparoscope. Via the lateral opening, a model can be placed inside, and fixed with the aid of graspers to the inferior lateral walls of the box. Some of the models are equipped with a movable arm to hold the laparoscope, allowing the individual practice without the aid of a colleague. Others consist in a simple cardboard or wood box with no supportive method. In the latter, two trainees practice at same time, one handing the instruments and the second manoeuvring the laparoscopic optic. Irrespective of the box construction, for practising in this bench model a complete visual setting as in the operating theatre is required (laparoscope, camera, light source and the corresponding cables) as well as real instruments (Fig. 1).

Those models have obvious limitations; they do not recreate the human body, making the illusion of reality impossible, and they are unable to give feedback or provide objective measures of performance. More importantly, they require extensive coaching and tutor support. Nevertheless, they are economic; the maintenance can not be simpler and they recreate the real instrumental used in the operating room.

During recent years the inanimate simulator has incorporated a Pulsate Organ Perfusion system (POP, Optimist, Bregenz, Austria) that allows for a more realistic simulation. In the POP simulator en bloc animal organs with its corresponding blood supply and venous drainage can be used. Once the main artery is connected to the perfusion system, coloured water flows through the organs and simulates a real perfused organ. Even though there are no publications evaluating the concurrent and construct validity of this simulator, it is generally accepted that the dissection and haemostatic exercises are closer to the true procedures and the satisfaction of the trainees is high.

In reconstructive urological laparoscopy, suturing is a basic task. Laparoscopic suturing is probably the most difficult of the laparoscopic tasks. A high degree of wrist rotation is needed to effectively direct the needle as well as a large surgical field to allow proper positioning and the actual suturing manoeuvre. Because this rotation is hampered by the long and awkward instruments and the fixed position of the trocars, laparoscopic suturing requires special dexterity and substantial practice in the training bench [27].

Dexterity and suturing models have already been described and validated for general surgery [16].

Fig. 1. Trainee working in a model-based simulator (Pelvic Trainer)

These same models are applicable to urological laparoscopic training.

Using standardized and previously validated dexterity and suturing models, some laparoscopy skills training studies have been published with a special focus in urology [28].

The impact of laparoscopic skills training on the operative performance of urological surgeons inexperienced with laparoscopy has been assessed by Traxer [28]. Twelve residents (3rd–5th year) were randomly assigned to either training or control groups. At baseline and after study completion, the residents completed questionnaires on laparoscopic experience and perceived competence. At baseline and after 2 weeks, each resident performed a porcine laparoscopic nephrectomy. Each surgical procedure was intraoperatively evaluated by two experienced laparoscopic urologists who were blinded to the previous randomization status of the subjects. Also at baseline and 2 weeks later, the residents were tested on an inanimate simulator. At this opportunity, the cumulative time needed to complete five tasks was recorded. After baseline evaluation, the residents assigned to a training group practised the same tasks alone on the bench trainer for 30 min a day for 10 days while the control group did not receive this kind of training. Although at baseline no statistical differences were noted in laparoscopic experience, inanimate training or overall operative assessment between the two groups, after training, the cumulative time to perform the tasks decreased significantly in the group assigned to daily training. Nevertheless and despite operative assessment improving significantly in both study groups, training did little to improve the performance of the laparoscopic nephrectomy. Essentially the most important factor for improving the operative performance was the baseline "in-vivo laparoscopic nephrectomy" [28]. This paradoxical result can be explained by the fact that only dissection skills are needed for a nephrectomy while more advanced laparoscopic skills are needed in the current urological laparoscopy [27]. It is nevertheless a universal consensus that hands-on training on a bench model is an essential part of the laparoscopic skills acquisition [8, 27, 29].

Laparoscopic Urological Simulation in the Model-Based Simulator

Most of the models used in the Pelvic Trainer are made of rubber, foam or other inorganic material. Simple drills can be designed to improve dexterity using pins, rubber bands and small balls [30].

For developing dissecting and suturing skills, organic tissue is used; the bladder of a pig and chicken skin have been used to simulate human tissue and cut in different shapes and sizes to reproduce the surfaces to suture during pyeloplasty and radical prostatectomy [31].

A model reproducing the suture between the bladder neck and the urethra has been described using an entire chicken whose stomach and oesophagus are left

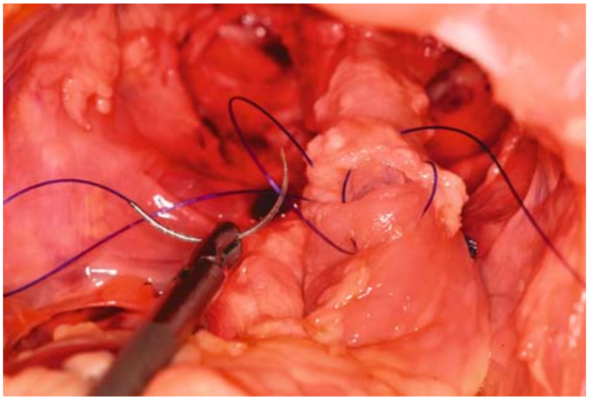

Fig. 2. A simulation of the anastomosis between bladder and urethra after laparoscopic radical prostatectomy using a chicken model

in. A cut is performed between the two organs and the resultant edges mimic the bladder neck and the urethra after laparoscopic radical prostatectomy (LRP) [32] (Fig. 2). Different types of suture can be practised. The greatest advantage of this model is the reduced cavity, even smaller than the male pelvis cavity, where the trainee has to practise what makes the exercise realistic. The model possesses construct validity [33] (Fig. 3).

Only task simulation is possible in a dry lab.

Computer-Based Simulators

Advances in mimetic technology as well as the development of the three-dimensional integration system and virtual reality computer-based systems have led to the development of the virtual reality simulators (VR simulators). Virtual reality is a computer-generated environment that reproduces detail to mimic reality. Early concepts in VR have refined and widely applied in space administration and in aeronautics. Virtual reality combines a convincing representation of an organ system or body region with the means to work with this image as if it really existed [34]. The production of an analytical virtual environment is complex and requires a mathematical approach. In VR medicine, the physical properties of a biological system – three-dimensional, often not linear, with different structural characteristics and inconsistent behaviour – have to be recreated with the aid of computer software. In VR the anatomical objects are created using two-dimensional structures named polygons. Multiples of these polygons join together to form a smooth three-dimensional object. Stereopsis or the viewer's perception of the 3D is accomplished using a head-mounted display unit or by a 3D video monitor combined with special glasses. After creation of the mathematical model, different and varying conditions can be applied to the virtual model, modifying the interaction of the system.

Incorporating tissue properties and tactile and force feedback mechanisms that make the models more realistic, virtual simulation has emerged in the

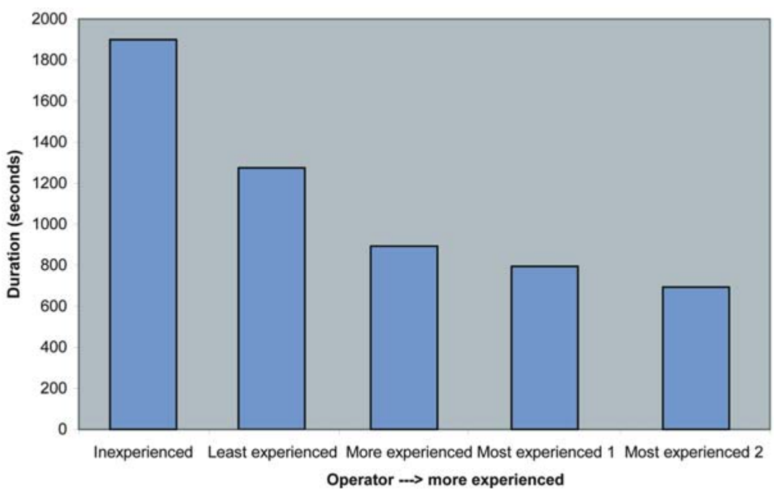

Fig. 3. Different times of task completion according to the operator's experience

last decade as a promising tool for helping in the acquisition of technical skills [8, 35, 36]. Current VR simulation is able to recreate fluid and blood movements.

Hybrid Simulators

From the pure VR simulators consisting in a computer screen, technology has evolved to the hybrid simulators where physical models are combined with computers, often using a realistic interface such as real instruments or real diagnostic tools. The incorporation of real instruments generates a more realistic sensation of pressure and force. Particularly inherent difficulties associated with the reproduction of the instruments and human tissue are solved in the latest generation of VR simulators [8].

Virtual reality simulators can be skills-oriented, task-oriented and procedure-oriented, but most of them combine the three (Fig. 4). The taxonomy includes precision placement tasks, simple manipulation and complex manipulation, composing tasks of increasing difficulty to an integrated procedure.

The more complex the simulated manipulation is, the lower the realism and the higher the range of limitations are, due to the extremely high demands for computer power.

Several hybrid simulators have been developed for minimally invasive procedures. MIST-VR and LAP Sim are good examples of these complex hybrid simulators. The current generation of manipulation simulators allow practising a range of generic laparoscopic skills (instruments navigation, tissue grasping, simple dissection, clipping of blood vessels and intracorporeal knotting). Currently some of them also offer an additional haptic component.

Virtual reality simulators seem to be a reliable tool to assess laparoscopic psychomotor skills and they improve the automation of the fulcrum effect.

A major advantage of the computer-based simulators is the ability to objectively measure performance. The virtual reality simulators for laparoscopy have become popular. Extensive tasks, tailoring functions, advanced features for the recording and processing of training results are available in the marketed simulators. To our knowledge, at least the following VR simulators are used with training purposes in laparoscopy in the different training facilities and skills laboratory programmes, although most of them do not yet have a specific task for urological procedures: MIST-VR, Procedicus KSA, VEST, Lap SIM Basic Skills, Lap Mentor, Xitac LS 500 and CompuSkills LTS 2000 (Fig. 5).

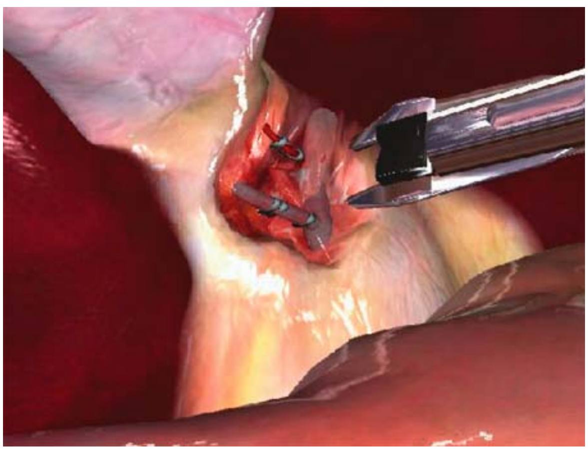

Fig. 4. Example of task oriented virtual reality simulation

Fig. 5. Virtual reality simulator for laparoscopy (Lap Mentor, Simbionix, Tel Aviv, Israel)

New models with better interfaces and more realistic haptic feedback are currently being developed.

Potential benefits of virtual simulation are divided into two categories: skills acquisition and skills assessment. The educational value of the simulation will require assessment and comparison to currently available methods of training in any given procedure. It is also necessary to determine by repeated trials, whether a given simulation actually measures the performance parameters it purports to measure [37].

Animal Models

As seen above, animal practice seems to be of capital importance [28]. Nevertheless, it requires sophisticated facilities and it is subject to legal restrictions in some countries), for example, the United Kingdom. Furthermore, it requires specialized personal and is expensive to maintain.

In spite of these limitations, when possible wet labs can be included as an intermediate step between the bench models and real practice (Fig. 5).

Cadaver Simulation

Cadavers may offer an ideal surgical environment, as well as a better understanding of dissection and surgical performance. They are an interesting step in the framework of laparoscopic training courses. However, the use of cadaver models raises several problems and cannot be widely used as a laparoscopic training model.

Both bench and cadaver training have been proven superior to text learning [38].

A comparison on trainee perspectives between data from two consecutive seminars performed at the same institution, one with a porcine model and the other with fresh cadavers, showed high general satisfaction in both groups and desire for another similar session. Yet trainees ranked the training in cadavers higher because of a better understanding of surgical anatomy, a more realistic laparoscopic technique and more appropriate understanding of the use of instruments [39].

Nevertheless training in this manner is limited to a few institutions due to the limited availability of fresh cadavers. Some methods have even been developed to improve the laparoscopic view in nonfresh cadavers. To obviate the problem of rigor mortis, section of lateral muscles of the abdomen (oblique muscles) with a previous cutaneous-subcutaneous flap construction seems to be helpful [40].

Laboratory animals or cadavers are currently unavailable in some countries such as the UK, and expensive in the rest of the world.

Validation of Current Simulation

Surgical simulation is increasingly being considered for training, testing, and possibly credentialing in medicine and surgery. Even though 97% of the US medical schools use mannequins as standardized patients for instruction and 85% use them for assessment, it is furthermore intended that standardized patients be used for the US Medical Licensing Examination in 2003 [41].

The important issue of validation needs to be addressed before inanimate or virtual reality simulators become widely accepted or used for training and accreditation purposes. Simulators, specially the sophisticated VR ones, are expensive tools that need to prove their effectiveness and reliability [42]. Their usefulness depends on the extent to which they possess a number of features: credibility, comprehensiveness, reliability and feasibility [43]. In fact, performance measurement has been severely neglected and ignored in many applications of simulators [44].

A valid simulation must provide an environment close to the one in which the task will eventually be performed. It must be able to mimic visual-spatial and real-time characteristics of the procedure and to provide realistic haptic feedback [45]. Additionally it should be able to measure performance in an objective way. It is obvious that some of the bench models describe above do not have all these requirements. For example, it is impossible to objectively measure some aspects of performance in a model-based simulator due to its inert character. On the other hand, the computer-based simulators have developed objective metrics.

Different aspects must be considered in evaluating the validity of a simulation. Basically the concept addresses the question "Do we measure what we intended to measure?" Five levels of validity are important in simulation testing: face, content, construct, concurrent and predictive value [45, 46].

Face and content reflect the appropriateness for a given use and are obtained by the feedback of experts on the realism of the simulator. Face and content validity are of extreme importance and must be considered before designing the simulation: they are obtained by subjective expert opinions and a literature search [45, 46].

Construct validity is the ability of mimicking what one intends to mimic or the ability to discriminate between surgically naïve and experienced subjects; thus operative performance in the simulator should improve with increasing operative experience. In other words, seniors should score better, more efficiently and with fewer errors than juniors, and individual trainees should improve with practice [21].

Concurrent validity is the ability of simulation to correlate with actual performance in the OR.

Predictive validity tests individual performance first in the simulator and then during the real task.

But besides evaluating the characteristics of a simulation, the paramount goal of any validation process is to answer the crucial question: can the use of the simulator ultimately improve the performance in a real patient and in the true-life environment? Thus in the most strict sense, validation means the presence of an effective transfer of the lab skills to the real situation, improvement of performance in the operating room being the end point. Confusion has been noted in many publications between the terms validity and validation. In fact, what has been compared is the effect of training on repeating performance in the same simulator, rather than comparing the features of the simulator to the real procedure. In endourology, the effect of training on a simulator, the transfer rate, has never been measured in the real procedure. And although the design of some of the above-mentioned reports as well as the measurement tools used make it possible to conclude that the studied device per se is valid to be used as a simulation tool, to date the transfer from the simulator to the patient has never been validated or measured in urology.

The optimal level of fidelity to the actual surgical procedure for transfer of training (TOT) may be variable according to the level of expertise of the trainee and the type of exercise [47]. Very little TOT from open surgical procedures to laparoscopy seems to occur [48, 49]. TOT from inanimate VR bench models has been proven in porcine lab and human cadavers [50]. Nevertheless, TOT to the operating room has only been investigated in selected studies. Intense training in simulators seems to improve video-hand-eye skills, allowing for a better performance at least in junior residents [51]. Others have proven an effective transfer of training in the MIST-VR simulator for a cholecystectomy [52–54]. Surgical trainees who received training performed significantly faster than the "nontrained" control group and showed more economy of movements. They conclude that virtual surgical simulation is a valid tool for training in laparoscopic psychomotor skills and could be incorporated into surgical programs [49].

A determined task (diathermy task) of the MIST VR has been validated in a prospective and double-blind manner, proving that subjects trained in this simulation perform better and with fewer errors during cholecystectomy [52]. Nevertheless, using the same simulator, other group has obtained controversial results. Ahlberg et al. [55] did not find significant differences in the performance of a laparoscopy appendectomy in a pig between the group of students trained in the MIST VR or the group without training. The simulator nonetheless seems to be useful in predicting surgical outcome, confirming its value in assessing psychomotor skills [55]. A possible explanation for these controversial results can be the different study populations of surgical residents in one study [52] or medical students in the other [55] emphasizing the importance of the global learning process, already initiated in the case of the residents. Subjects with lower spatial abilities demonstrated significant positive transfer from a simulator-based training task to a similar real-world robotic operation task. Subjects with higher spatial skills did not respond as positively from training in a simulated environment [56].

To date no transfer effectiveness ratio (TER) is available for surgical simulation.

In general, little evidence exists that simulator performance correlates with actual technical ability. In spite of the abundant literature on the use of simulators, little has been done in the field of validation of the surgical simulators and tension often exists between the design and the evaluation of surgical simulators [9]. A lack of high-quality published data is compounded by the difficulties of conducting longitudinal studies in such a fast-moving field [9]. To our knowledge no transfer of training has been studied for the current urological simulations.

Concurrent validity studies are rare. Faulkner et al. [57] demonstrated a significant positive correlation between scores achieved by senior but not by junior trainees in a six-station OSATS and faculty rankings of operative ability. McMillan and Cuschieri showed that overall performance and number or error-free runs, but not time scores, correlated with consultant assessment of clinical competence on the ADEPT [16].

Paisley et al. [21] evaluate the construct validity of six simulations, including a performance in a closed box (Pelvic Trainer) and another in a MIST-VR. The cohort was composed of surgical trainees, naïve first-year medical students and general surgical consultants (experienced group). A weak correlation was found between surgical trainee laparoscopic performance and the consultant technical skills score and the box trainer error. A significant, although weak, negative correlation between experience and time taken to complete a small intestinal anastomosis in the MIST-VR was found. Moreover, there was no significant correlation between duration of experience and box trainer performance or MIST-VR error or economy scores. Surgical trainees were significantly faster in laparoscopic tasks and more efficient in MIST-VR after 6 months of surgical training but also medical students showed significant improvement in a second try 6 months later, suggesting this improvement may be attributable to a practice effect. None of the simulations tested by Paisley correlated strongly with the duration of training or experience. The explanation for this lack of correlation between experience and simulation performance may be that simple natural abilities such as handling a needle holder or a forceps correctly are more important than complex abilities.

To date the ability of simulators to discriminate between subjects at different stages of training is still equivocal.

Sometimes construct validity is found for determinate tasks and not for the simulators per se [58] or for some parts of the evaluation system and not for others [18].

A crucial process in surgical education is to evaluate the level of surgical skills. For laparoscopic surgery, skill evaluation is performed subjectively by experts grading a video or procedure performed by the trainee. A hidden Markov model based on a force-torque by means of an instrumented laparoscopic grasper has been developed to distinguish between novel and experienced surgeons [59].

In evaluating surgical skills, the need to develop structured check lists and objective score ratings must be emphasized. This has already been done in endourology [60–62]. The check list is intended to itemise important and generic manoeuvres or steps during the surgical procedure, while the global rating score captures the overall process, taking advantage of examiner expertise [61]. As an example, the University of Kentucky's model can be mentioned [63]. In this model the performance is videotaped and assessed by trained faculty on a global scale grading of five items:

1. Clinical judgment or respect for the tissue
2. Dexterity
3. Serial/simultaneous complexity (or flow of the operation)
4. Spatial orientation
5. Overall competence in each simulation

In addition they use a pass rating (would you be confident in allowing this trainee to perform the procedure in the operating room?) that intends to respond to the ultimate goal of the training process.

We can conclude that a great deal of work is needed to establish the reliability and validity of currently available simulation models before introducing them for high-stakes assessment.

The Role of Robotics in Learning Laparoscopy

It has been suggested that robot-assisted laparoscopy may decrease operative times and shorten the learning curve [64]. Although robots can provide a three-dimensional view and a range of instrumentation equal to the human hand, there is still a lack of tactile feedback. The da Vinci Robotic Surgical System (Intuitive Surgical, Mountain View, CA, USA) allows surgeons to complete drills faster than traditional laparoscopy, thus level or equalize, at least in the dry lab, the playing field between surgeons of different skills levels [65].

When comparing the pelvic trainer with the Da Vinci, positive results, although not statistically significant, favouring the robotic training have been shown in dexterity and suturing tasks. In fact while the same results can be achieved by repetitive manual training, a theoretical level of proficiency is more rapidly achieved when using a robot-assisted system [66].

A similar study has been performed comparing not only the training in a pelvic trainer or by means of the Da Vinci system, but also the time to completion for those urologists trained before and after 1990. For all the pelvic trainer tasks, surgeons who completed training after 1990 had faster times. More advanced tasks were more rapidly done with the Da Vinci, the robotic system virtually equalizing the two groups' time to completion. This suggests that the robotic system may have a greater impact on surgeons trained before 1990 because of their minimal previous exposure to laparoscopy [67].

However, in spite of some favourable reports, most of the them investigating the real clinical scenario, robot-assisted systems have not been fully integrated into current urological laparoscopy and at present it seems uncertain that they will be included in the residency laparoscopic training programs.

Laparoscopic Training Program: A Must

The American College of Surgeons states that before undertaking laparoscopic procedures "the surgeon must be qualified, experienced, and knowledgeable in the management of the disease for which the technology is applied" [68].

In the current urological scenario, a laparoscopic training program is necessary for many reasons: because laparoscopy is slightly more difficult to learn than open surgery [22], because urologists trained prior to 1990 had minimal exposure to laparoscopic techniques and they still make up a large component of the work force in current urological practice and because in urology there is no straightforward, frequently performed procedure that facilitates the development and maintenance of the skills required for laparoscopic urological surgery.

A recent survey conducted in British Columbia states that 88% of the urologists perceive training as useful and of a high utility in the incorporation of a training laparoscopic program during residency [69]. A recent survey conducted by the ESUT (European Society of Uro-Technology) in Europe shows that 45% of the professionals consider training in laparoscopy insufficient [70]. Furthermore, surgeons emphasize the importance of using a variety of training methods for surgical residents during the residency, including laparoscopy virtual reality simulators [9].

Basic surgical skills can be attained outside the operating room in a dry lab setting where individualized instruction and feedback are available [47].

The Society of American Gastrointestinal Endoscopic Surgeons proposes the following measures to integrate the laparoscopic training into general surgical training:

Step One: Train faculty members by means of attendance at courses, mentoring and fellowship in specialized units

Table 4. Objectives to be covered in a residency training program in laparoscopy

Objectives of learning in laparoscopy
Handing instruments and equipment
Adaptation to the two-dimensional image
Learning laparoscopic sutures
Study of the anatomical protocols
Study of the surgical protocols
Protocols in experimentation animals

Step Two: Train residents

Step Three: Provide guidelines for post-residency training for prospective faculty

Because of the late incorporation of laparoscopic techniques in urology, only few centres worldwide have reached the second step. While there is an increasing trend in training faculty members and reluctance has given way to general recognition, most of the residency programs do not yet include laparoscopic techniques, creating a general atmosphere of dissatisfaction among the young generations. An effort has to be made to modify the objectives of residency and incorporate new disciplines.

Training schemas can be competence-based or time-based. Because competence depends on the type and complexity of surgery, aptitude, manual dexterity, and the quality of training received, and it is extremely difficult to assess, most of the training programs are time-based. The objectives of a residency training program are specified in Table 4.

Key points to be covered in every training program are how to acquire skills, the establishment of a certification (how and who) and to determine a clinically safe threshold.

Because the training within this concept requires time (and money), investment, and subsequent maintenance of the practice, the question arises of whether we will be able to train all of our residents and even if we need to train all of them.

Basically two types of training are available: the hands-on training courses proposed by different urological societies and centres and the fellowship programs of variable duration. An additional advantage of most of the fellowships is the possibility to extend the programme with a mentor.

Hands-on Training Courses

Based on the recognized need for laparoscopic training and the availability of bench models, fellowship models for training urologists in laparoscopic surgery are currently being developed [46] in specialized centres: short hands-on training (HOT) courses have become increasingly popular and are easy to attend. Duration varies from centre to centre but consists basically in a 2- to 5-day course. Observational studies have confirmed that skills such as intracorporeal knot-tying are improved significantly by attending hands-on training courses [68, 71].

The different modules are theoretical, including knowledge of the material, basic technical rules and general knowledge of laparoscopy, and practical modules starting with practising simple dexterity exercises in a Pelvic Trainer, then stepping up a more complex exercise in the animal or in cadavers. There are specific centres dedicated to this type of training worldwide, although they are not numerous. In Europe the IRCAD (Strasbourg, France) should be mentioned.

In those specialized centres, hands-on training courses of increasing difficulty and for specific procedures are available and are complemented by live surgery performed by recognized experts in the field.

As already pointed out in this chapter, the use of animate training laboratories have been identified as an important part of a surgical resident's training, mostly with accompanying videotaping of procedures and reviewing and critiquing with the aid of a trainer. A number of nonrandomized studies have confirmed the valuable help of this mentored videotaping, reviewing and critiquing process, with special emphasis on safety of trocar insertion [72]. The value of this exercise is furthermore stressed in a case of previous laparoscopic experience and in the frame of a hands-on course [73].

The value of such courses or seminars has been recognised. Three months after a 2-day course including didactic lectures, live video cases, bench and animal simulation, 40% of the participants had engaged in some form of additional training and 45% of the participants had performed a first laparoscopic operation while 32% had performed more than one. Veress needle placement was perceived as the most difficult aspect of the technique [74].

Fellowships

Fellowship models have been developed with the aim of training residents and postgraduates in laparoscopic urology.

These fellowships include an intensive training program with a swift progression from the bench model to safe clinical practice. They begin by a period of observing and assisting a clinical mentor treating a minimal number of cases of major renal laparoscopic procedures and a progressive initiation and integration of the laparoscopic technique under the mentor's direct guidance in the trainee's hospital.

A reasonable number of cases seems to be essential to maintain the optimal practice and skills.

The programs provide the urologist with clinically applicable experience and allow effective learning in a safe environment under the direct supervision of a mentor, even in the last phases of the program.

The fellowship programs are conceptually equal, and some warrant description here.

In the UK, a fellowship in nine phases has been proposed under the auspices of the BAUS and the SAC, which includes [75]:

- Completing a basic and advanced training course
- Practising in the office setting in a pelvic trainer
- Proceeding to an animal lab course (Fig. 6)
- Visiting centres with an international reputation and a high volume laparoscopic surgery
- Observing the mentor performing a number of procedures (major cases)
- Performing a hand-assisted laparoscopic nephrectomy with the mentor's guidance at the mentor's hospital
- Performing pure laparoscopic procedures under the mentor's guidance at the mentor's hospital
- Starting laparoscopic procedures at his or her own hospital with a mentor
- Proceeding to performing laparoscopic procedures independently.

The impact of a fellowship program should be greater the steadier the learning curve is. In this sense, a laparoscopic fellowship has shown to be advantageous (less surgical time, fewer complications and fewer deaths) for an intervention with a 75-procedure learning curve as in gastric bypass [76]. Recently it has been shown that a fellowship in laparoscopic urology increases the demand and the practice of laparoscopy (B.R. Lee, personal communication).

Fig. 6. Animal lab

At the end of the fellowship, mentoring plays an important role in developing the trainee's own practice [77]. Mentoring provides a useful adjunct to postgraduate urological training and in the integration of the laparoscopy into the community-based practice. Ensuring enough mentors can be a problem in some countries.

Currently most of the recognized urological centres worldwide have some sort of fellowship of variable duration, ranging from a period of 1 year to 2 weeks. An example of a mini-fellowship is the Indiana University School of Medicine (urology, Methodist Hospital). This short fellowship consists in three phases: (1) completing a 2- to 3-day hands-on course in laparoscopy including pelvic trainers and an animal model, (2) observing a clinical mentor perform six or more major renal laparoscopic cases, and (3) performing six or more major renal procedures with a mentor's direct guidance in patients at the mentor's or trainee's hospital after obtaining appropriate temporary privileges [78].

However, there is a general consensus that the duration of a fellowship should last between 3 and 12 months and its value has to be recognized by the urological community in the form of a final certification. Conversely, skills assessment using the adequate skills assessment devices should be an integral part of any training or fellowship program. Formal accreditation of those completing a recognized programme is the First step in establishing the practice of laparoscopy. This has to be followed by prospective audit to ensure the adequacy of training and the safe application of the technique.

Among the different fellowships available in laparoscopy, it is worth to mention the recognised programs of the Society of Endourology in the United States, Europe, Asia and South America.

In Europe, the European Society of Uro-Technology (ESUT) has developed a fellowship programme including training in centres of excellence meeting specific requirements. Theory is imparted in standardized modules and skills labs are acquired in the centre's facilities and in the animal model in the model centre IRCAD-EITS (Strasbourg).

The qualification required to participate in the ESUT fellowship is a postgraduate degree and the duration of the fellowship between 3 and 12 months that can be split between several centres. At the end of the fellowship, a published scientific work has to be demonstrated. After successful completion, the trainee obtains certification.

Beside the fellowships, other programs include placement of a fully trained team on site for a short period of time to execute a full laparoscopic programme training the host team at the same time. This is nevertheless a very demanding form of mentoring and probably more expensive that the classical fellowship [80].

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12 Laparoscopic Instrumentation

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Contents

Introduction

Laparoscopic surgery, reconstructive and ablative, is being increasingly applied in the treatment of a variety of benign and malignant conditions affecting the urinary tract. Improvements in instrumentation and technology have played a pivotal role in the expanding applications of laparoscopic and minimally invasive surgery. This chapter will highlight the fundamental and practical aspects of laparoscopic instrumentation common to most laparoscopic urological procedures.

Laparoscopic Instrumentation

Instruments for Laparoscopic Access

Transperitoneal Access

Closed Access Using the Veress Needle. In the closed approach, a Veress needle (Fig. 1) is initially placed percutaneously into the peritoneal cavity, usually through one of the port sites [1]. The standard Veress needle is a metallic needle with a retractable protective blunt tip. The blunt tip retracts when the tip of the Veress needle is pressed against a tough structure such as fascia, thus exposing the sharp edge of the needle. Once the needle passes through the layers of the abdominal wall and enters the peritoneal cavity, the blunt tip is deployed, thereby protecting the abdominal viscera from injury from the sharp tip. The cannula is hollow, allowing for initial peritoneal insufflation.

The Veress needle is available as a disposable or a reusable instrument. Certain modified Veress needle-type devices are available. One such device is the 2-mm Minisite (USSC, Norwalk, CT) port, which is the author's instrument of preference for obtaining closed peritoneal access. The Minisite has a retractable tip similar to the Veress needle, and can also be used as a 2-mm cannula by removing the inner trocar needle. In cases where the correct position of the needle is questionable, a 1.9/2.0-mm telescope can be passed through the Minisite cannula to assess its position.

For pelvic laparoscopic procedures, the patient is usually supine and the Veress needle is placed through a subumbilical incision. The bladder is emptied and the patient is placed in a Trendelenburg tilt. The needle is directed towards the pelvis in order to avoid injury to the great vessels. For upper tract laparoscopic procedures on the kidney and adrenal, the patient is generally in the flank position, and the Veress needle

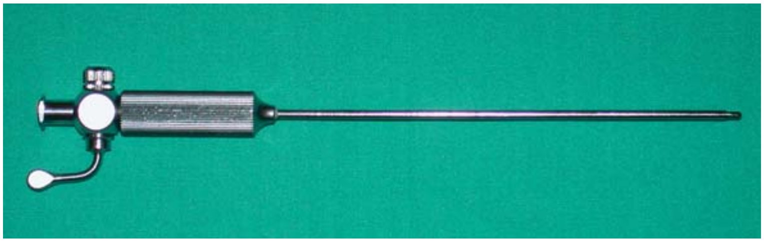


Fig. 1. Photograph of a Veress needle. We prefer to obtain transperitoneal access using a Veress needle in most uncomplicated laparoscopic procedures

is placed through the iliac fossa in order to avoid inadvertent injury to the bowel, which typically gravitates medially. In all instances, it is preferable to avoid a Veress needle puncture in the vicinity of a previous abdominal scar. The tactile sensation of the Veress needle passing through the various layers of the abdominal wall is extremely important. Typically one has two distinct sensations of giving way at the level of the external oblique/rectus fascia, and at the level of the transversalis fascia/peritoneum. The Veress needle is aspirated to rule out presence of blood or bowel content. The correct placement of the needle is confirmed by injecting a few drops of saline and demonstrating the rapid drop of meniscus. Final confirmation is obtained by documenting a low intra-abdominal pressure after initiating insufflation at a low flow (1 l/min). Once the correct intra-abdominal pressure has been confirmed, the insufflation flow rate can be maximally increased. Once the abdomen has been insufflated adequately (intra-abdominal pressure 15–20 mmHg), the primary trocar is placed. The authors prefer to initially insufflate the abdomen up to 20 mmHg prior to inserting the first port. This keeps the abdomen tense and reduces the chances of visceral injury during the initial blind trocar placement. Another technical caveat is to make a generous skin incision for the initial port site so as to reduce the gripping of the skin on the trocar. Additional trocars are subsequently inserted under laparoscopic visualization, thereby minimizing the risk of inadvertent visceral or vascular injury. The closed approach for obtaining transperitoneal access has been criticized as being blind and having greater risk for inadvertent injury to the intraperitoneal contents. We believe that if proper care is taken, the risk with the closed approach is minimal.

Open Access Using the Hasson Technique. Many surgeons prefer the open Hasson approach to obtain initial transperitoneal laparoscopic access [2]. Here, primary access is obtained through a 2.5-cm incision made at one of the port sites. The incision is carried down through the various abdominal wall layers to reach the peritoneum. The peritoneum is then grasped between hemostats and opened sharply. The finger is introduced through the peritoneal opening to confirm presence within the peritoneal cavity.

With the open access system, obtaining an air-tight seal at the site of entry through the abdominal wall in order to minimize insufflant leakage, is of critical importance. A Hasson cannula may be used for this purpose (Fig. 2). The Hasson blunt-tip cannula is inserted into the peritoneal cavity and secured in place with fascial sutures. The authors prefer to use a blunt-tip balloon cannula in lieu of the Hasson cannula since, in our opinion, the seal provided by the balloon port is better.

Fig. 2. The Hasson cannula has a cone at its proximal end that can be secured to the fascia with sutures to provide an air-tight seal after obtaining open access

Retroperitoneal Access

Retroperitoneal access is typically obtained by an open technique [3]. The primary incision is placed below the tip of the 12th rib. The skin, subcutaneous tissue and external oblique fascia are incised sharply. The fibers of the internal oblique and transverses are separated bluntly with the index finger up to the level of the thoracolumbar fascia, which is divided sharply to gain entry into the retroperitoneal space. The correct position within the retroperitoneum is confirmed by palpating the psoas muscle posteriorly and the lower pole of the kidney superiorly. Initially, the retroperitoneal space is developed with the help of the finger. A variety of devices have been used for further rapid development of the working space during retroperitoneoscopy. Simple contraptions such as rubber catheters attached to a latex glove or condom, though inexpensive, in our opinion are not very efficient. We prefer to balloon dilate the retroperitoneal space using the PDB balloon dilator (USSC), for several reasons (Fig. 3). First, the balloon dilator has a rigid shaft which allows optimal positioning in the retroperitoneum. Second, the balloon dilator has a transparent cannula through which a 10-mm laparoscope can be introduced to confirm proper positioning. Identification of the psoas muscle inferiorly and the perinephric fat superiorly confirms the correct balloon position between the kidney and the posterior abdominal wall. Occasionally, other retroperitoneal structures such as ureter, gonadal vein, inferior vena cava, etc. may be identified through the balloon. Third, since the balloon lies entirely in the retroperitoneum, inflating the balloon does not widen the initial incision made through the skin and abdominal wall. The balloon dilator is incrementally inflated up to 800 cc (each pump delivers approximately 20 cc air). The balloon is deflated and additional upper and/or lower retroperitoneal inflations may be performed as per the individual procedure and pathology.

The balloon dilator is removed and a 10-mm blunt-tip balloon trocar (USSC) is inserted through the incision (Fig. 4). The balloon port provides optimal sealing of the abdominal wall, thereby minimizing leak of

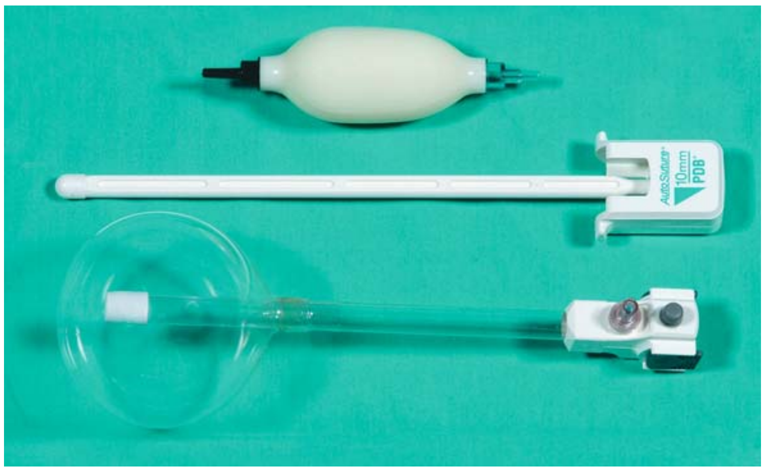


Fig. 3. We prefer the PDB balloon dilator to rapidly and atraumatically create retroperitoneal working space for reasons specified in the text. The balloon used for upper tract retroperitoneal laparoscopy is spherical and one pump delivers approximately 20 cc of air in the balloon. The balloon has a maximal capacity of 1,000 cc

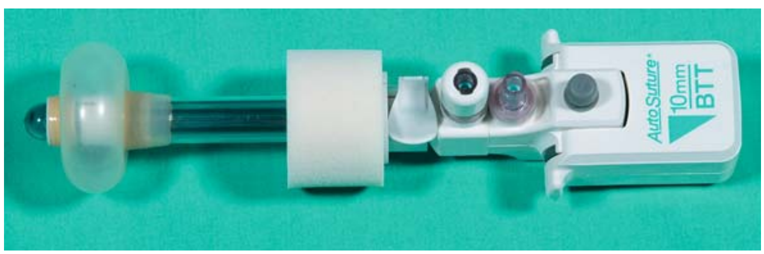


Fig. 4. We prefer the 10-mm blunt-tip balloon trocar for use after open access either transperitoneal or retroperitoneal. This trocar provides an optimal air-tight seal when the abdominal wall is cinched between the external sponge and the inflated balloon

CO_2 and subcutaneous emphysema. This is of critical importance, given the already limited working space in the retroperitoneum [4].

Laparoscopic Trocars

Types of Trocars

The various types of trocars currently used are shown in Fig. 5. Trocars are either disposable or reusable and are available in various sizes (2 mm, 5 mm, 10 mm, 12 mm, and 15 mm). The obturator tip may be bladed or blunt. The blunt-tip trocars may be associated with a lower incidence of injury to abdominal wall vessels and intraperitoneal structures and are the preferred trocars at the author's institute. The larger (10 mm, 12 mm, 15 mm) trocars have a valve or reducer system at the proximal end to allow instruments of various sizes to be passed without causing an air leak. Longer trocars are also available for use in the morbidly obese population.

Sites for Trocar Placement

Individual sites for trocar placement are described in detail with each individual operative procedure. However, there are certain general rules that govern correct trocar placement. The primary camera port should be ideally in line with the structure of interest (for example, renal hilum during laparoscopic nephrectomy), and should be approximately at a 45° angle to the area of interest. The working ports (right and left hand) should be on either side of and at an adequate distance from the primary camera port. Such a trocar arrangement leads to optimal orientation and maximum mobility of the working laparoscopic instruments.

Trocar Insertion Technique

The primary trocar insertion has already been described. All secondary trocars must be inserted under direct laparoscopic visualization to prevent inadvertent visceral injury. The trocar placement site is pressed with a finger and the indentation made on the abdominal wall is viewed internally. We prefer to localize the trocar placement site by puncturing the abdominal wall with a hypodermic needle attached to a syringe. The trocar is firmly grasped against the palm of the hand. The skin incision is made commensurate with the size of trocar to be inserted. The trocar is inserted by a firm constant screwing motion. The trocar should be inserted perpendicular to the abdominal wall. Skewing the trocar through the abdominal wall

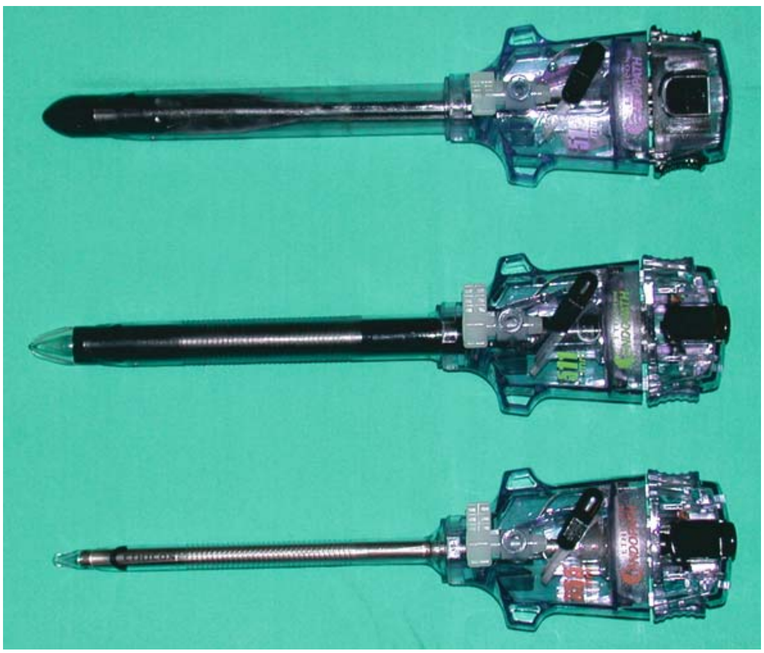


Fig. 5. The figure shows a few of the available blunt and bladed trocars. We prefer to use blunt trocars for all our laparoscopic cases

results in limited mobility and as the procedure goes on the hole tends to enlarge, leading to gas leakage. We prefer to fix all trocars to the skin using an 0-Vicryl suture.

Grasping Instruments

A variety of laparoscopic grasping instruments, disposable and reusable, are currently available. The grasping instruments may be traumatic or atraumatic, locking or nonlocking, have a single or double action jaw, and of various sizes (2–12 mm). The atraumatic graspers generally have serrated tips that are gentle on visceral tissues. The traumatic graspers have toothed tips that offer a firm grasp on rigid fascial or similar nonvital structures. Typically, the reusable instruments are modular wherein different tips can be attached to different handles using varying shaft lengths.

Cutting Instruments

Monopolar electrosurgical instruments are generally used for cutting tissues during laparoscopic surgery. Straight or curved scissors (Fig. 6) and electrosurgical electrodes of various tip configurations (Fig. 7) are available for laparoscopic tissue cutting. Usually a setting of 55 W for coagulation and 35 W for cutting is employed. The shaft of these instruments is insulated to prevent thermal damage to adjacent structures.

Energy Sources for Laparoscopic Surgery

Apart from monopolar and bipolar electrocautery, a variety of different energy sources has been introduced for tissue cutting and/or hemostasis during laparoscopic surgery. These include ultrasonic energy, Ligasure (Valleylab), hydrodissector, and argon beam coagulator.

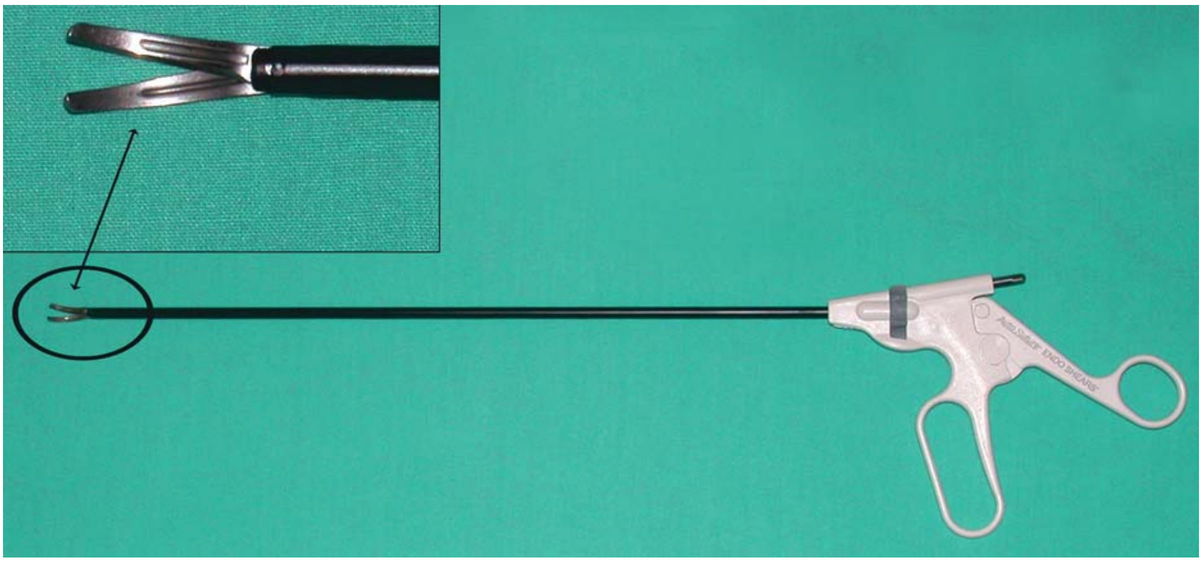


Fig. 6. The curved cutting scissors are used for sharp dissection

Fig. 7. We use the J-hook monopolar electrode (Karl Storz, Culver City, CA) extensively during laparoscopic surgery. The hook electrode is especially useful for dissection around vital structures such as major vessels. The back elbow of the hook is also an efficient blunt dissector

Ultrasonic energy has been successfully used for tissue dissection and hemostasis [5]. The commercially available ultrasonic generators (harmonic scalpel, Ethicon, New Brunswick, NJ; AutoSonix, USSC; SonoSurg, Olympus) provide a wide array of effecter tips (5 and 10 mm) for laparoscopic surgery. With ultrasonic energy, tissue cutting and coagulation is achieved at lower temperatures (50°–100°C) as compared to electrocautery. This reduces the lateral scatter, charring, and smoke production. Disadvantages of the ultrasound dissection include equipment cost and decreased speed of dissection.

The Ligasure system is designed for providing hemostatic sealing of blood vessels up to 7 mm in diameter [6]. Specific to urologic surgery, the Ligasure has been used for securing blood vessels such as the lumbar, gonadal and adrenal vein in select cases in lieu of surgical clips. The Ligasure technology combines compression pressure and thermal energy to cause denaturation of the vessel wall collagen and secure vessel occlusion. A feedback mechanism regulates the amount of energy to be delivered and gives an audible signal to the surgeon when effective vessel occlusion has been achieved. The Ligasure system is thought to produce less charring and tissue sticking compared to conventional bipolar coagulators.

Argon beam coagulation provides excellent superficial hemostasis for superficial bleeding surfaces [7]. It is particularly helpful for controlling mild oozing from parenchymal bleeding surfaces such as liver, spleen, kidney, and muscle. Additionally, the argon beam coagulator does not produce any forward scatter. The use of the argon beam coagulator during laparoscopic surgery may cause a precipitous rise in intra-abdominal pressure and so one of the trocars should be continuously vented during its use.

Clips and Staplers

Surgical clips and staplers form the cornerstone of securing medium- and large-caliber vessels during laparoscopic surgery. Surgical clips are made of either titanium (Fig. 8) or plastic and are available in various sizes. Titanium clips can be applied through manual loading or self-loading clip applicators. The titanium clips do have a tendency to fall off during subsequent dissection and manipulation and hence multiple clips should be used. Importantly, the clips should be evenly spaced and should not cross each other in order to be effective. It is also important to leave a sufficient vessel stump after the last clip to ensure safety of the clip ligature. Recently, locking plastic

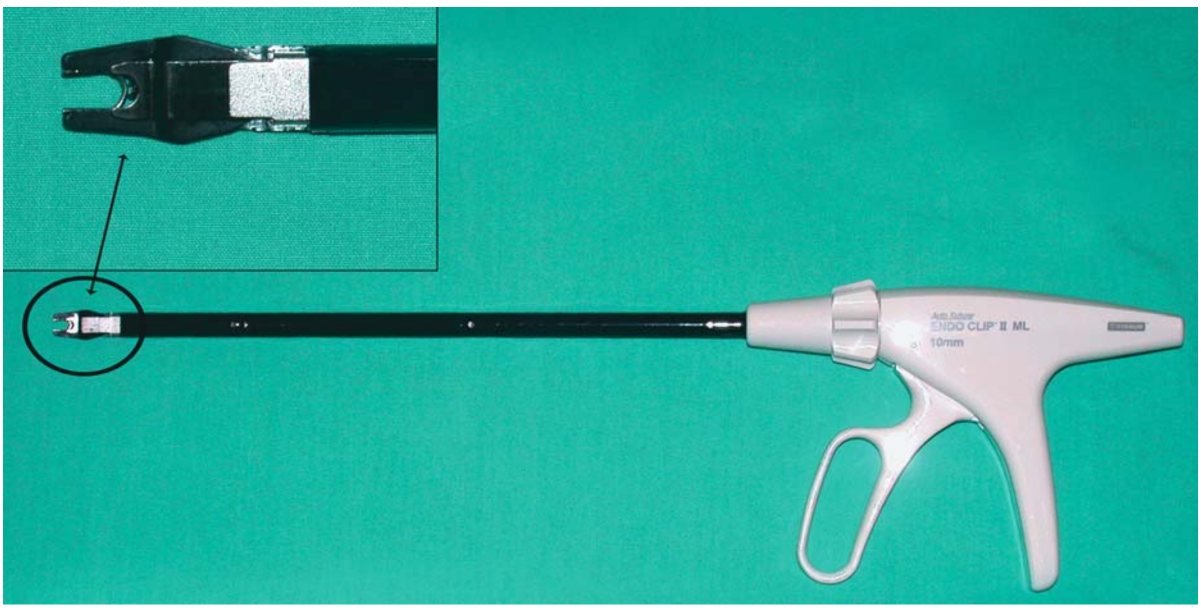


Fig. 8. Multifire titanium clip applicator

clips (Hem-o-Lok Clips, Weck Closure Systems, Research Park, NC) have been introduced to improve the efficacy of surgical clips (Fig. 9). These clips are applied such that the entire clip encircles the vessel and once fired, locks into place. These clips are generally more reliable than titanium clips and are currently our preferred method of securing medium to large vessels such as the renal artery and venous tributaries. Although various reports have supported the use of such clips on the main renal vein, we currently reserve tissue staplers for that purpose. Probably the availability of a 15-mm Hem-o-Lok clip will enable the reliable clipping of the main renal vein.

Endoscopic stapling devices are generally employed for securing hemostasis for large vascular structures such as the renal vein. Typical endoscopic staplers are

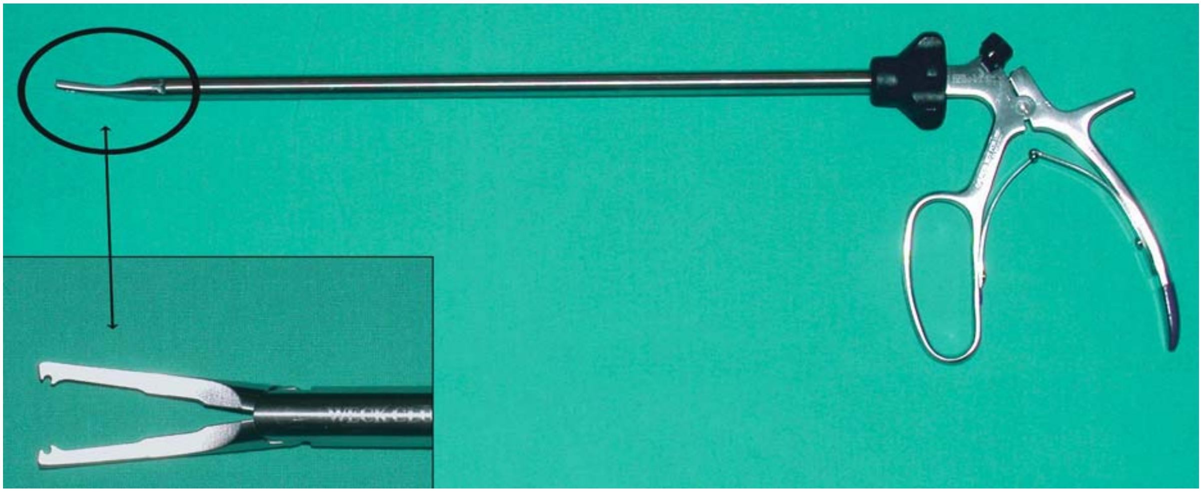


Fig. 9. The Hem-o-Lok plastic locking clip provides reliable and secure closure and is our preferred method of securing the renal artery

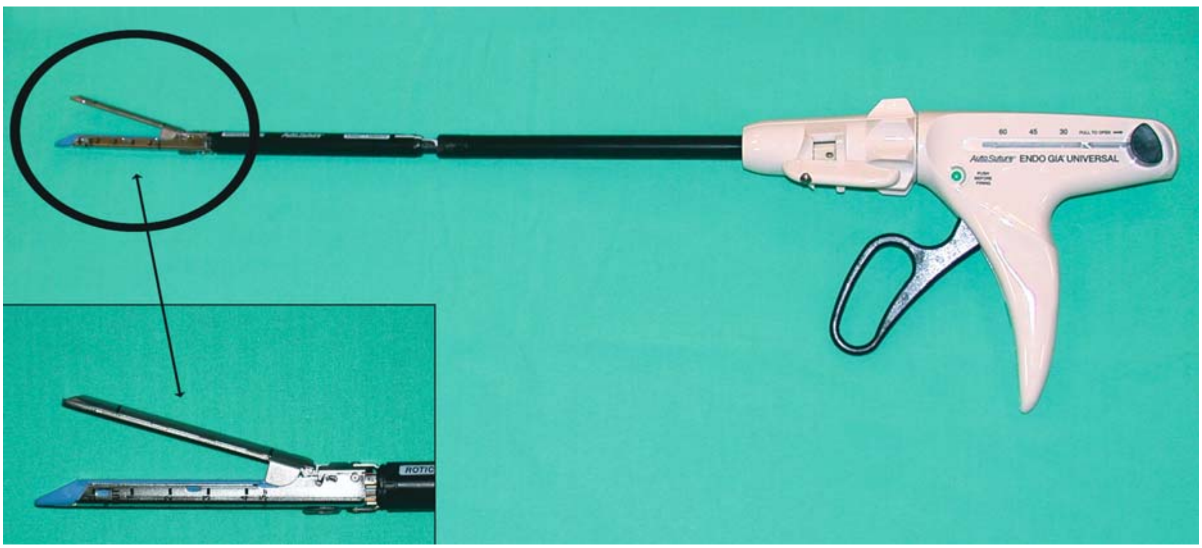


Fig. 10. The articulating and reticulating endoscopic stapling devices are used for major vascular pedicles and tissue approximation. Typically the GIA type staplers lay six staggered rows of staples and cut between rows three and four

of a linear GIA type, lay six staggered rows of staples and cut between rows three and four (Fig. 10). Currently available endoscopic stapling devices can both articulate and reticulate, allowing an increased range of angles for soft tissue and vascular stapling. The stapling cartridges are available in various lengths (30 mm, 45 mm, and 60 mm) and various staple heights (2 mm, 2.5 mm, and 3 mm). The 2-mm stapling loads are typically used for vascular stapling. The 3.5-mm loads are used for soft tissue stapling where vascularity to the stapled edges needs to be preserved (e.g., bowel anastomosis). Certain precautions need to be taken with the use of endoscopic staplers. First, the correct load of staples must be used as per the type and thickness of tissue to be stapled. Second, care must be taken not to fire staplers over clips. However, staples can be safely fired over previous staple lines.

Suturing and Knot Tying

With advances in laparoscopic reconstruction, suturing and knot tying assumes greater significance. The techniques of intracorporeal and extracorporeal suturing along with the application of endoloops are necessary skills for the advanced laparoscopic surgeon [8].

The endoloop consists of a preformed loop of suture with a slipknot at the end of a plastic knot pusher. This device may be used for ligating tubular organs such as the appendix.

Extracorporeal knotting involves formation of the knot by a long suture (about 1 m) outside the cavity and pushing it through the port with the help of a knot pusher. It is a useful technique for approximation of tissues under tension. Intracorporeal suturing is used for approximation of tissues without tension. The needle can be inserted through a laparoscopic port by grasping the suture about 3 cm from the needle. The trocar sleeve valve should be kept in the open position while the suture is being inserted. The size of the needle determines the trocar size required; by and large a 10- to 12-mm port is preferred. The suture is generally cut to a length of 7–8 cm for intracorporeal knot tying. The long end of the suture is looped two or three times around the tip of the needle driver and to complete the first throw of the surgeon's knot. The second and the third throws complete a square knot. Suturing can be performed in interrupted or running fashion. A variety of needle drivers with varying tip and handle configurations and locking mechanisms are currently available. The novice laparoscopist may consider starting out with a self-righting needle driver, although the non-self-righting devices afford the best results and greatest versatility. Our personal preference is for the Ethicon needle driver (E705R) (Fig. 11).

A variety of specialized suturing devices have been introduced to facilitate laparoscopic intracorporeal suturing and knot tying. These include the Endostitch (USSC,) and SewRight (LSI Solutions, Victor, NY). Although these devices may aid the beginner laparoscopist, in our opinion, they lack the finesse of freehand suturing. Additionally, the laparoscopic surgeon

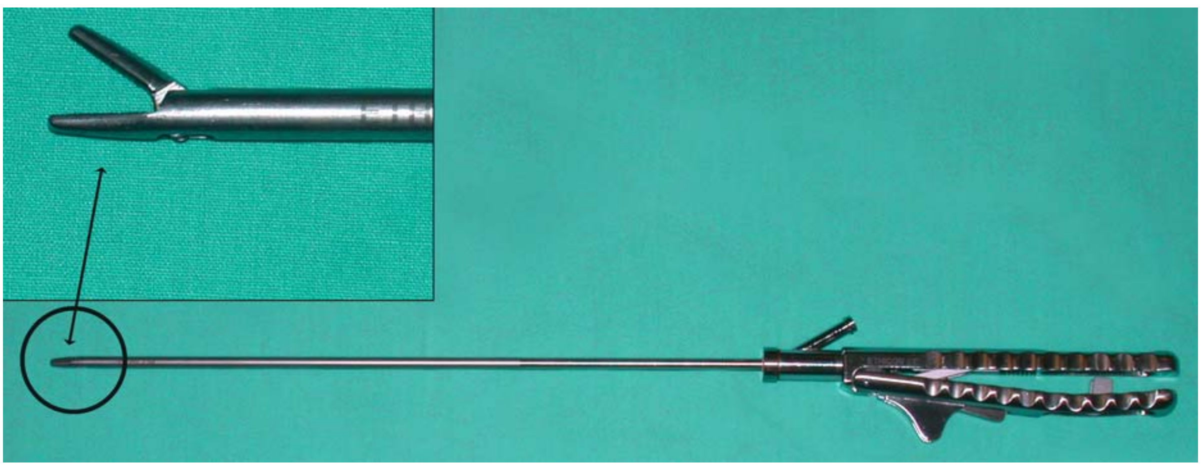


Fig. 11. We prefer the straight tip needle driver for intracorporeal laparoscopic suturing (Ethicon, model E705R)

is limited with the type of suture and needle configurations available.

Glues, Bioadhesives and Hemostatic Agents

Closure of laparoscopic port-site incisions with skin adhesives such as Octylcyanoacrylate (OCA) has been found to be as effective as subcuticular suturing in terms of adverse wound outcomes with the advantage of requiring less operative time [9]. Other adhesives such as N-butyl-2-cyanoacrylate (NBCA) have also been used with similar effect, but OCA is the only one that has FDA approval. OCA carries the disadvantage of having a learning curve for proper use of the product. Moreover, OCA has to be applied to dry, well-approximated incisions and the product must not be allowed to seep inside as a vigorous foreign body reaction resembling an infection often ensues.

A variety of hemostatic agents and tissue sealants have been recently used in laparoscopic surgery. These agents have been specifically utilized in laparoscopic partial nephrectomy, where hemostasis of the renal remnant and urine leak are specific concerns. Gelatin matrix thrombin tissue sealant (Floseal, Baxter Inc., Deerfield, IL) is a two-component tissue sealant, consisting of a gelatin matrix granular component and a thrombin component. Preliminary data reveals that Floseal has been shown to provide immediate and durable hemostasis in laparoscopic partial nephrectomy. In a select patient population, use of this agent may reduce the hemorrhagic and overall complication rate after laparoscopic partial nephrectomy [10]. Tisseel (Baxter Inc.) is a tissue sealant and hemostatic agent. Initial data with Tisseel as regards hemostasis and urine leak after laparoscopic partial nephrectomy are encouraging [11].

Suture repair of the renal parenchymal defect over surgical bolsters [12] and the combined use of fibrin glue and Gelfoam are also effective means to obtain hemostasis during laparoscopic surgery [13].

Aspiration and Irrigation Instruments

A variety of suction-irrigation systems are currently available (Fig. 12). The aspirator, which is connected to a suction system, consists of a 5- or 10-mm metal

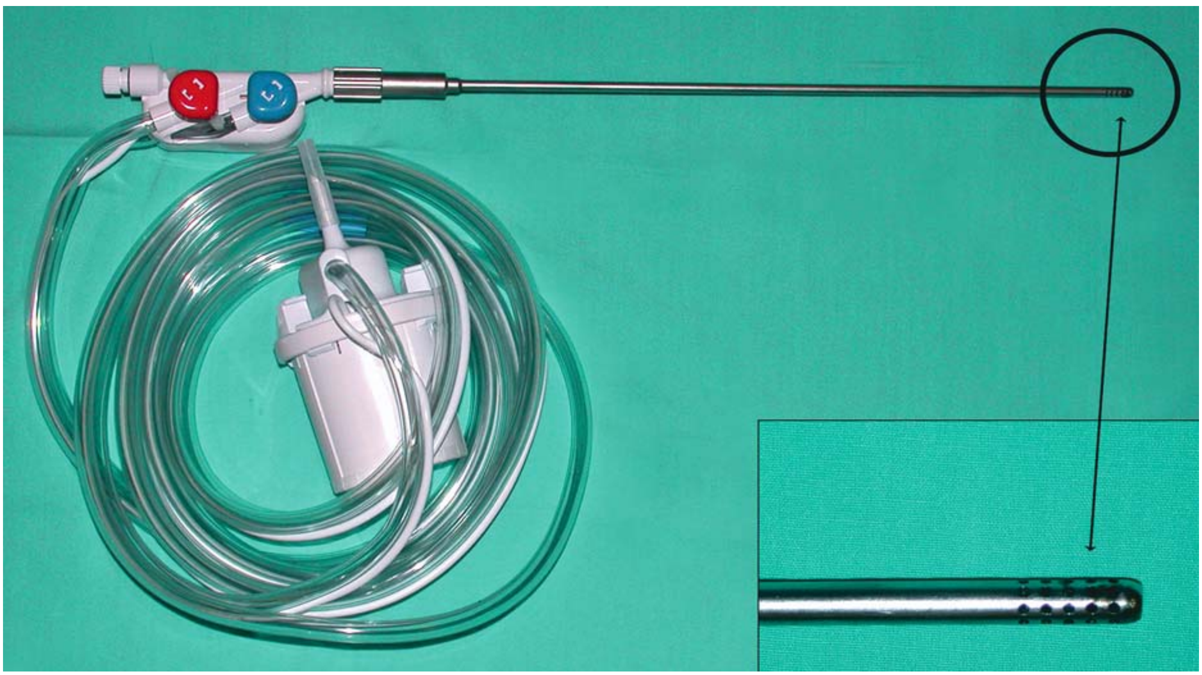


Fig. 12. The Stryker suction and irrigation system has a reusable cannula and disposable tubing that incorporates a battery driven pump. The 5-mm blunt-tip sump suction cannula is invaluable for suction, irrigation and blunt dissection and is the author's instrument of choice for this purpose

tube, with suction controlled by either a one-way stop cock or a spring-controlled trumpet valve. The irrigation channel is also operated by the same mechanism. The irrigation may be pressurized to adequately clear blood clots for optimal visualization. Usually saline or lactated Ringer solution is used as the irrigation fluid. Heparin (5000 U/l) may be added to prevent clots from forming in the surgical field. Furthermore, a broad-spectrum antibiotic may be added to the irrigant in cases where infection is a concern.

Instrumentation for Port Site Closure

The simplest method is retracting the skin with retractors, grasping the fascia with Kocher's clamps, and suturing it with sutures. However, external suture of 1-cm port site incisions may be extremely difficult, especially in the obese population.

Several specialized devices for secure port site closure have been introduced [15–18]. The Carter-Thomason needlepoint suture passer (Inlet Medical, Eden Prairie, MN) consists of a 10-mm metal cone that has two cylindrical passages located diagonally opposite each other. The Carter-Thomason needle grasper is used to insert one end of the suture loop through one of the cylinders within the cone, thereby traversing muscle, fascia, and peritoneal layers. The end of the suture within the peritoneal cavity is grasped with a 5-mm grasper via one of the other ports by the assistant. The Carter-Thomason needle grasper is reintroduced through the other cylinder of the metal cone. The intraperitoneal end of the suture is fed to the needlepoint grasper and pulled out of the abdomen. The metal cone is slid off both ends of the suture. Subsequently, the suture is tied after desufflating the abdomen to provide adequate fascial closure.

The eXit disposable puncture closure device (Progressive Medical, St. Louis, MO) is another such device that is inserted through a laparoscopic port larger than 10 mm. Herein, the special right-angle needles are passed in a retrograde manner from the inside of the abdomen to the outside. Using animal models, the eXit disposable puncture closure and the Carter-Thomason needlepoint suture passer were found to have some advantages over other devices [15]. The Carter-Thomason needlepoint device not only is helpful for wound closure but also can be used to obtain hemostasis in the event of injury to an abdominal wall vessel during trocar insertion.

Insufflant System

The insufflant system (i.e., insufflator, tubing, and insufflant gas) is essential for establishing a pneumoperitoneum, or pneumoretroperitoneum, as the case may be. This is brought into use once the closed (i.e., Veress needle) or open (i.e., Hasson cannula) access to the desired cavity is established.

Most commonly, CO_2 is used as the insufflant because it does not support combustion and is highly soluble in blood [19]. However, in patients with chronic respiratory disease, CO_2 may accumulate in the blood stream to dangerous levels. Accordingly, in these patients, helium may be substituted once the initial pneumoperitoneum has been established with CO_2 [20]. However, helium is significantly less soluble in blood than CO_2. Other gases that were once used for insufflation (room air, oxygen, nitrous oxide) are no longer routinely used owing to their potential side effects (e.g., air embolus, intra-abdominal explosion, potential to support combustion). Noble gases such as xenon, argon, and krypton are inert and nonflammable but are not routinely used for insufflation owing to their high cost and poor solubility in blood.

Initially, insufflator pressure is set at 15 mmHg with a rate of gas flow of 1 l/min. Once safe entry into the peritoneal cavity has been achieved, the flow can be increased. The 14-gauge Veress needle cannot deliver flow rates greater than 2 l/min.

The insufflated CO_2 is cold (21 °C) and is unhumidified [21]. This results in minimal cooling of the patient and likely contributes to problems of fogging of the endoscope during the procedure. Accessory devices for insufflators that warm and humidify laparoscopic gas to physiologic conditions are available. However, the benefit of humidification is largely unproven.

Visualization System

To create a laparoscopic image, four components are required: laparoscope, light source with cable, camera, and monitor. Laparoscopes that are most commonly used have 0° or 30° lenses (range, 0°–70°) and a size of 10 mm (range, 2.7–12 mm). Image transmission uses an objective lens, a rod-lens system with or without an eyepiece, and a fiberoptic cable. The advantage of the larger laparoscopes is that they are able to provide a wider field of view, better optical resolution, and a brighter image. From the eyepiece, the optical image is magnified and transferred to the camera and onto the monitor. Light is transmitted from the light source through the fiberoptic cable onto the light post of the laparoscope. A special variant is the offset working laparoscope, which includes a working channel for passage of basic laparoscopic instrumentation; use of this type of laparoscope enables the surgeon to work in direct line with the image and may allow a reduction in the number of trocars needed to accomplish a particular procedure. However, the working channel occupies space that would otherwise be used for the optical system; hence, the resulting image is usually of lesser quality compared with that of laparoscopes without this feature.

The camera system consists of a camera and a video monitor. Earlier cameras could not be sterilized; hence, a sterile plastic camera wrap had to be passed over the camera and the eyepiece of the laparoscope. The camera wrap was then affixed to the shaft of the laparoscope with wire ties. Most currently available cameras can be chemically sterilized, thereby making them more user-friendly and minimizing a possible source of contamination. The camera is attached directly to the end of the laparoscope and transfers the view of the surgical field through a cable to the camera box unit. After reconstruction of the optical information, the image is displayed on one or two video monitors.

A wide variety of cameras are currently available: single-chip, single-chip/digitized, three-chip, three-chip/digitized, interchangeable fixed-focus lenses, zoom lenses, beam splitter, and direct coupler. Direct couplers are superior to beam splitters, in which light and image are shared between monitor and eyepiece and in which the surgeon may view the area of interest directly through the laparoscope. Three-chip cameras are superior to single-chip cameras in that they provide a higher-quality image with superior color resolution.

To obtain a true upright image of the surgical field on the monitor, the camera's orientation mark must be placed at the 12-o'clock position. With 0° laparoscopes, the camera is locked to the eyepiece in the true position. In contrast, with the 30° laparoscope, the camera is loosely attached to the eyepiece of the laparoscope so the laparoscope can be rotated. Accordingly, the assistant must hold the camera in the true upright position with one hand while rotating the laparoscope through a 360° arc to peer over and around vascular and other intra-abdominal structures; the 30° lens thus provides the surgeon with a more complete view of the surgical field than does a 0° lens.

A vexing problem with the laparoscope is fogging of the lens. To minimize fogging of the laparoscope after insertion into the warm intraperitoneal cavity, it is advisable to initially warm the laparoscope in a container holding warm saline before it is passed into the abdomen. In addition, wiping the tip with a commercial defogging fluid or with povidone-iodine solution is also recommended. Should moisture buildup occur between the eyepiece and camera, both components must be disconnected and carefully cleansed with a dry gauze pad.

Video monitors are available in 13- or 19-in. sizes. A larger monitor does not produce a better picture; indeed, given the same number of lines on both monitors, a higher-resolution image is obtained with the smaller screen. To obtain a better image, more lines of resolution are needed. High-resolution monitors with 1,125 lines of resolution must be matched with a camera system of similar capability.

Light sources use high-intensity halogen, mercury, or xenon vapor bulbs with an output of 250–300 W. Xenon, 300-W lamps are currently preferred. In addition to manual control of brightness, some units have automatic adjustment capabilities to prevent too much illumination, which may result in a washed out image. Any breakage of fibers in the fiberoptic cable, which may occur during sterilization and/or improper handling, results in decreased light transfer from the light source to the laparoscope, and hence to the operating field.

Operating Room Setup

The operating room has to provide enough space to accommodate all necessary personnel and the technologic equipment required by both the laparoscopist and the anesthesiologist. Positioning of equipment, surgeon, assistants, nurses, anesthesiologist, and other support staff should be clearly defined and established for each standard laparoscopic case. All equipment must be fully functional and in operating condition before any laparoscopic procedure is started. A separate tray with open laparotomy instruments must be ready for immediate use in the event of complications or problems necessitating open incisional surgery.

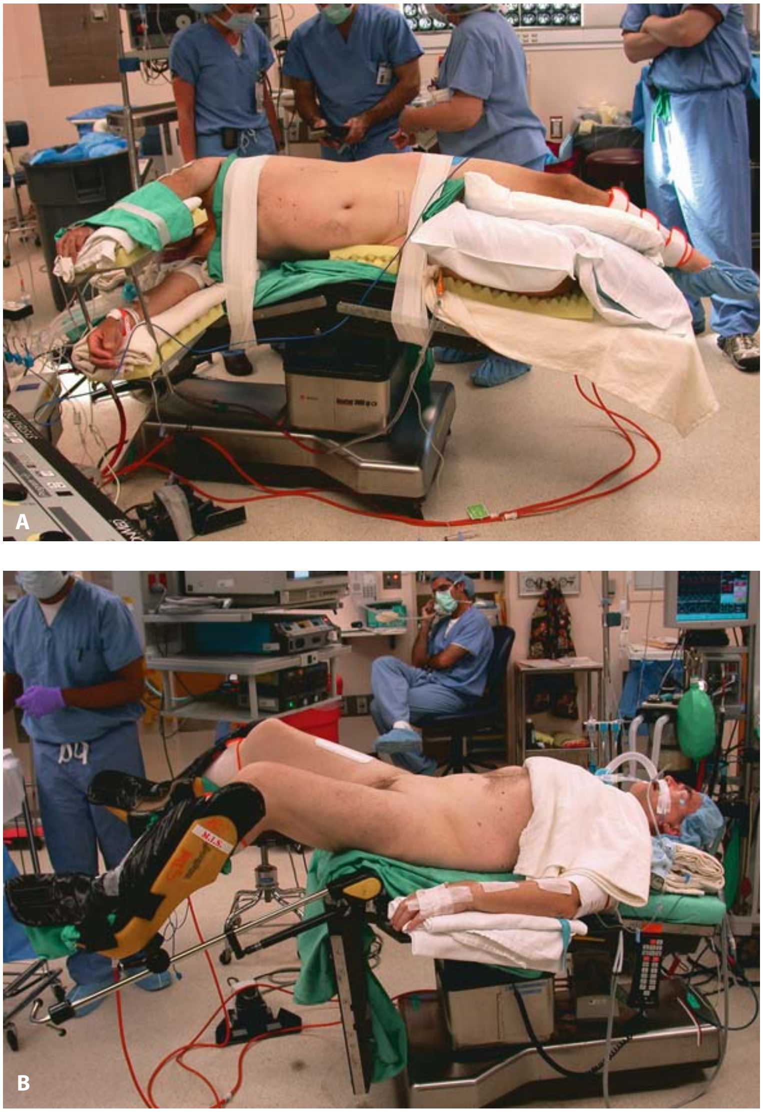


Fig. 13. A Patient positioning for upper tract laparoscopy. The patient is in a full or modified flank position. The bony prominences are adequately padded and extremities are in a neutral position.
B Patient positioning for pelvic laparoscopy. The patient is in a modified low-lithotomy position with a Trendelenburg tilt. The arms are tucked to the side and adequately padded

Patient Positioning and Draping

Positioning of the patient depends primarily on the laparoscopic procedure to be performed (Fig. 13 A, B). Most laparoscopic procedures start with the patient in a supine position with the arms secured at the sides of the body. In the Trendelenburg or lateral position, tape and security belts applied across the chest and thighs provide safe and stable positioning of the patient. In the lateral position, all bony prominences must be carefully padded; likewise, the point of contact between any of the positioning straps and the hip or shoulder should be padded. In the lateral position, the bottom leg is flexed approximately 45° while the upper leg is kept straight; a pillow is placed between the legs as a cushion and also to elevate the upper leg so that it lies level with the flank, thereby obviating any undue stretch on the sciatic nerve. Application of active warming systems may prevent hypothermia should a lengthy laparoscopic procedure be anticipated.

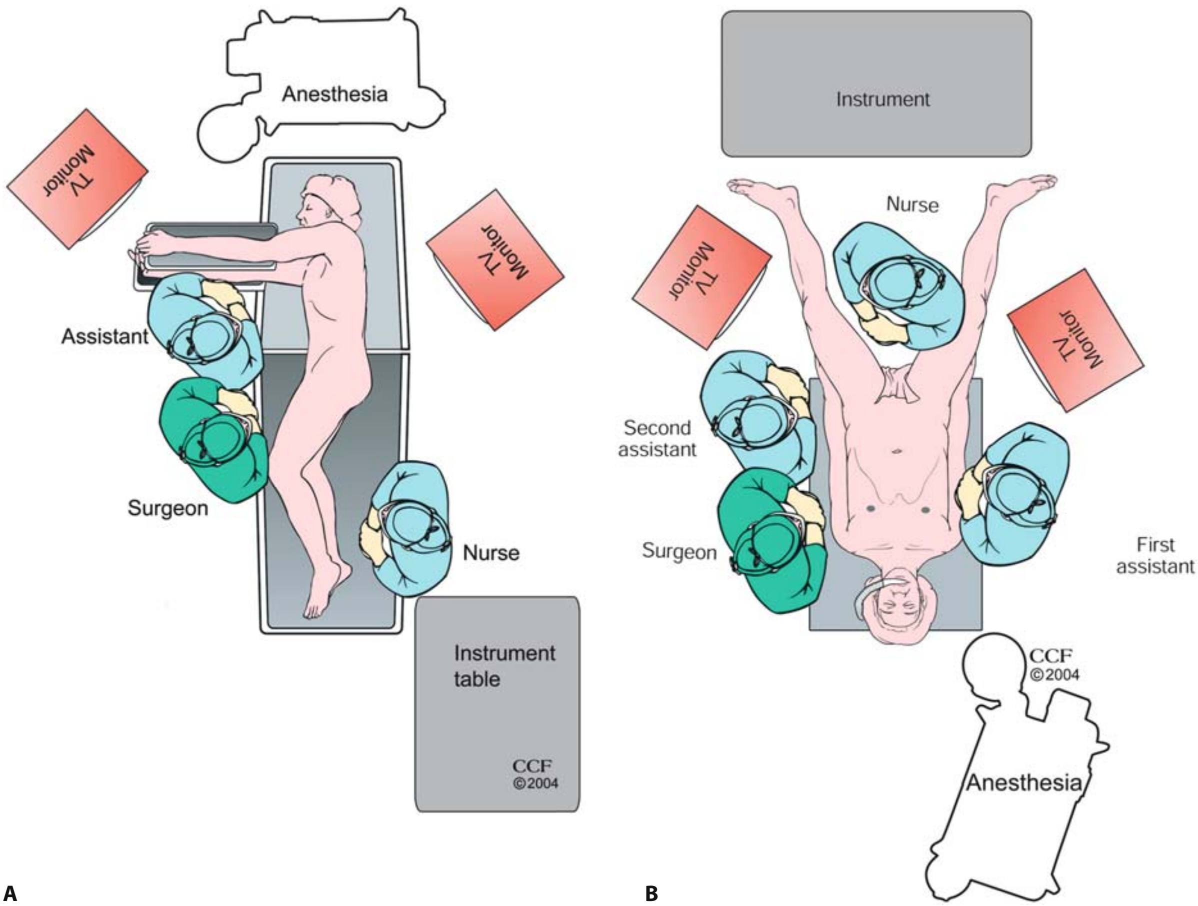
The full extent of the abdominal wall should be prepared and draped from nipples to pubis. In some procedures, it is advantageous to extend the preparation to the knees and to drape the external genitalia into the surgical field. For example, gently pulling on the testicle may help identify the intrapelvic location of the vas deferens and spermatic vessels, insertion of the surgeon's index finger into the vagina certainly facilitates laparoscopic bladder neck suspension, and free access to the urethral meatus enables the performance of auxiliary procedures such as flexible cystoscopy or manipulation of ureteral catheters during a laparoscopic nephroureterectomy or for stent placement at the end of a laparoscopic pyeloplasty.

Before major laparoscopic procedures, placement of a nasogastric tube and a Foley catheter is usually performed to decompress stomach and bladder, respectively, thereby decreasing the chance of injury of abdominal contents during insertion of the Veress needle and the initial trocar. Pneumatic compression stockings are applied as antiembolic prophylaxis.

Placement of Operative Team and Equipment

If only one monitor is used (as in intrapelvic procedures), it is typically placed at the foot of the table. If two monitors are used, they are positioned on either side of the table opposite the primary surgeon and the assisting surgeon, respectively, to allow an unobstructed view (Fig. 14 A, B).

The cart with the monitor for the primary surgeon should also contain the insufflator, placed at the surgeon's eye level, to allow continuous monitoring of the



A B

Fig. 14 A, B. Operating room layouts for (**A**) upper tract and (**B**) pelvic laparoscopic surgery. The illustration highlights the relative positions of the surgeon, assistants, scrub nurse and equipment during laparoscopic renal and adrenal surgery

CO_2 pressure. The light source, camera controls, and any recording device are also on this cart.

The surgeon usually stands opposite the area of surgical interest and the assistant stands on the ipsilateral side of the table. The second assistant stands on the contralateral side of the table. With two monitors in use, the instrument table and the scrub nurse are on the side of the surgeon toward the end of the table. Incoming lines from insufflator, suction/irrigation, and electrosurgical devices enter from the contralateral side of the table. Optional technology (e.g., harmonic scalpel, argon beam coagulator) must be arranged in an orderly fashion using either preexisting or improvised pockets of the surgical drape. Again, these lines ideally should enter the field from the contralateral side of the table or from the ipsilateral head of the table. Robotic devices for electronically controlled or voice-controlled camera manipulation should be brought into the operative area from the contralateral side of the table to prevent any limitation of the surgeon's maneuverability during the procedure. Additional technology (e.g., high-speed electrical tissue morcellator, laparoscopic ultrasound probe) may be moved to the operating table depending on the surgeon's needs as well as on the availability of space [22].

To provide more comfortable positioning of the surgeon's arms, a 15-cm foot-stool can be used, because most operating tables cannot be lowered sufficiently to allow the surgeon to hold the laparoscopic instruments with his or her arm comfortably extended. Using this type of lift is especially helpful during laparoscopic suturing.

A checklist ensuring that all essential equipment is present and operational should be completed just before initiating the pneumoperitoneum. Specifically, this list should include:

1. Light cable on the table, connected to the light source and operational
2. Laparoscope connected to the light cable and to the camera, with an image that is white balanced and focused on a gauze sponge
3. Operational suction and irrigation functions of the irrigator/aspirator
4. Insufflator tubing connected to the insufflator, which is turned on to allow the surgeon to see that there is proper flow of CO_2, through the tubing; kinking of the tubing should result in an immediate increase in the pressure recorded by the insufflator, with concomitant cessation of CO_2 flow
5. An extra tank of CO_2 in the room
6. A Veress needle, checked to ensure that its tip retracts properly and that, when it is connected to the insufflator tubing, the pressure recorded with 2-l/min CO_2 flow through the needle is less than 2 mmHg

Conclusion

In recent years, urologic laparoscopy has breached new frontiers and has evolved into a specialized discipline in itself. Procedures, which until recently were considered beyond the scope of laparoscopic surgery, are now being increasingly performed safely and effectively by laparoscopic surgeons all over the world. The foundation of successful laparoscopic surgery lies in the strict adherence to age-old, established surgical principles, proper training of personnel in laparoscopic skills, and good equipment. In this chapter we have covered the practical fundamentals of laparoscopic urology, which go a long way in ensuring a successful outcome for the patient and surgeon alike.

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13 Anaesthesia for Laparoscopic Urologic Surgery in Malignancies

Christian P. Henny, Jan Hofland

Contents

Introduction

Although endoscopy of the abdominal cavity was already performed in 1911, it was not until the last few decades that laparoscopic surgery became common clinical practice [1]. Initially, the use of laparoscopic procedures was confined to small and rapid gynaecological interventions such as sterilization and short diagnostic procedures. It was generally carried out in young and healthy women and often performed in a day care setting. Recovery from anaesthesia had to be rapid and with a minimum of residual effects. Therefore, laparoscopic procedures became a challenge to anaesthesiologists.

New intra-abdominal laparoscopic surgical techniques have since been developed, performed and are advocated for older patients also. In contrast to the young and healthy female, these older patients may often suffer coexisting cardiac and/or pulmonary disease. Therefore, a careful preoperative evaluation and optimisation of these patients should take place in order to decrease perioperative morbidity and mortality. Because these new procedures may involve extreme changes in patient position, extensive periods of intra-abdominal carbon dioxide (CO_2) insufflation, unexpected visceral injury and difficulty in evaluating the amount of blood loss, anaesthesia for laparoscopy can be considered a potentially high-risk procedure.

Since the early 1990s, elaborate and timely laparoscopic procedures have been performed for the resection of urologic malignancies. The first pelvic lymph node dissection and nephrectomy procedures were soon followed by laparoscopic radical resection of the prostate for treatment of prostate cancer and today even laparoscopic radical cystoprostatectomy with ileal conduit urinary diversion has been reported [2].

These laparoscopic procedures may induce major pathophysiological disturbances. Therefore, the anaesthesiologist must choose an appropriate anaesthetic management technique, apply adequate monitoring and be aware of possible complications. In addition, special attention must be given to the position of the patient lying on the operating table and to perioperative fluid management. Early detection and reduction of possible intraoperative problems can then be achieved.

Finally, during the early postoperative period, special attention must be paid to cardiovascular and pulmonary problems, postoperative nausea and vomiting and pain management.

Preoperative Evaluation

The main goal of preoperative medical assessment of patients is the assessment of risk and a possible reduction of morbidity and mortality of surgery and anaesthesia. Further aims are to increase the quality of perioperative care, to restore the patient to the desired level of function, and to obtain the patients' informed consent for the anaesthetic procedure [3].

Therefore, preoperative assessment should include

1. Risk/benefit analysis of the operation for the particular patient
2. Anticipation of potential perioperative problems

Table 1. ASA Classification of physical status and the associated mortality rates

ASA rating	Description of patient	Morbidity rate (%)	Mortality rate (%)
Class I	A normally healthy individual	4	0.1
Class II	A patient with mild systemic disease	8	0.2
Class III	A patient with severe systemic disease that is not incapacitating	14	1.8
Class IV	A patient with incapacitating systemic disease that is a constant threat to life	34	7.8
Class V	A moribund patient who is not expected to survive 24 h with or without operation	ND	9.4
Class VI	A declared brain-dead patient whose organs are being removed for donor purposes	NA	NA
Class E	Added as a suffix for emergency operation		

ND No data, *NA* Not appropriate

3. Improving any existing factors that may increase the risk of an adverse outcome
4. Giving appropriate information to the patient and obtaining consent for the planned anaesthetic technique
5. Prescription of premedication and/or other specific prophylactic measures if required [4].

Thus, the presence of coexisting medical disease must be identified, together with its extent and association of limiting normal daily activity in the patient. The American Society of Anesthesiologists' (ASA) classification score (Table 1) provides a simple description of the physical state and is one of the few prospective descriptions of the patient that correlates with the risks of anaesthesia and surgery. The formal report of an ASA Task Force on "Practice Advisory for Preanesthesia Evaluation" recommends preoperative evaluation to include:

1. Readily accessible medical records
2. Patient interview
3. A directed preanaesthesia examination
4. Preoperative tests when indicated
5. Other consultations when appropriate.

A directed preanaesthetic physical examination should at least include an assessment of the airway, lungs and heart [5].

Although all conventional complications and concerns of laparoscopy are also applicable to the urologic procedures, two unique extra problems must be kept in mind [6]. First, the large retroperitoneal space with its communications with the thorax and the subcutaneous tissue are exposed to insufflated carbon dioxide. Thus, subcutaneous emphysema occurs frequently and may extend all the way up to the head and neck, with a possible compromising effect on the upper airway. Second, the procedures tend to be lengthy, thus allowing for sufficient absorption of CO_2 to result in acidosis. In general, pneumoperitoneum (PP) and laparoscopy are contraindicated in patients with increased cranial pressure, ventriculoperitoneal shunt, peritoneojugular shunt, hypovolaemia and congestive heart failure [7].

Many hospitals now use questionnaires filled in by the patient, which are specifically designed to identify key features in the medical history that need further clarification. Nevertheless, the fundamental process of taking a detailed history and performing a systematic clinical examination by the attending physician remains the foundation on which preoperative assessment relies.

Further questions about present condition (the most relevant tend to be related to cardiovascular and respiratory diseases), concurrent medical history, anaesthetic history, especially with regard to postoperative nausea and vomiting, family history, drug history and history of allergy are asked, together with smoking and alcohol-intake habits. Although at present usually a manually written anaesthesia record is filled in (see Fig. 1 for an example of the front-page of such a record), in the near future electronic patient data management systems (PDMS) will be used to ensure availability of the record 24 h a day, consistency in data gathering and to enable automatic registration of the intraoperatively and early postoperatively monitored variables.

Apart from a common physical examination, the anaesthesiologist will pay attention to specialized physical examinations such as airway management items (Table 2). According to the recommendations of the ASA Taskforce [5], *routine* preoperative tests do not make an important contribution to the process of perioperative assessment and management of the patient by the anaesthesiologist. However, *selective* pre-

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Anaesthesia record

Attending physician

Date | acute ☐ yes ☐ no | fasted ☐ yes ☐ no

Diagnosis / Planned operation

Height	Weight	HR	NIBP	Temp.	Blood group	Other	ASA

Allergic to
☐ Iodine ☐ Tape ☐ Latex ☐ Antibiotics ______ ☐ Other ______ ☐ Unknown

Main points of clinical history

Medication

Smoker ☐ Alcohol ☐ Drug-abuse ☐

Main points of physical examination

Abnormalities of dentition
☐ No ☐ yes ☐ mentioning damage risk

Potential intubation problems
☐ No ☐ yes

Blood examination results

		pH	
Na^+		pCO_2	
K^+		pO_2	
creatinine		BE	
Ca^{++}		Hb	
Albumin		thromb	
Glucose		APTT	
		PTT	

ECG

Lung function test results

Chest X-ray and other additional examinations

Main points of interdisciplinary consultations

Conclusions and peri-operative risks

Planned anaesthetic technique

Pre-medication day before operation

Pre-medication day of operation

☐ Patient is informed about anaesthetic technique, alternatives, a

☐ Obtained informed consent

Signature

Fig. 1. Example of a front page of an anaesthesia record

Table 2. Clinical examination relevant to the anaesthesiologist according to Baxendale et al. [4]

System	Features of interest
General	Nutritional state; fluid balance; condition of the skin and mucous membranes (e.g. anaemia, perfusion, jaundice); body temperature
Cardiovascular	Peripheral pulse (i.e. rate, rhythm, volume); jugular venous pressure and pulsation; arterial pressure; heart sounds; carotid bruits; dependent oedema
Respiratory	Central vs peripheral cyanosis; observation of dyspnoea; auscultation of lung fields
Airway	Mouth opening; neck movements; thyromental distance; dentition
Nervous	Any dysfunction of the special senses, other cranial nerves, or peripheral motor and sensory nerves

Table 4. Recommended selected preoperative tests in relation to urologic intervention according to our department protocol

Urologic procedure	Recommended tests
Radical prostatectomy	Hb, creatinine
Radical nephrectomy	Hb, creatinine
Nephrectomy for renal cell carcinoma with invasion of large vessels	Hb, thrombocyte and leucocyte count, Na, K, creatinine, albumin, ECG, spirometry, chest X-ray
Pelvic lymph node dissection	Hb, creatinine
Radical cystectomy	Hb, creatinine
Renal transplantation	Hb, Na, K, creatinine, calcium, albumin, thrombocyte count, ECG

Hb Haemoglobin; *Na* plasma sodium; *K* plasma potassium; *ECG* electrocardiography

Table 3. Patient Characteristics for selected preoperative testing according to ASA Task Force [5]

Preoperative Test	Patient characteristic
ECG	Advanced age; cardiocirculatory disease; respiratory disease
Other cardiac evaluation	Cardiovascular compromise
Chest X-ray	COPD; cardiac disease; recent upper respiratory infection; smoking
Pulmonary function tests	COPD; reactive airway disease; scoliosis
Office spirometry	Reactive airway disease; COPD; scoliosis
Haemoglobin/ haematocrit	Anaemia; bleeding disorders; other haematological disorders; advanced age; very young age
Coagulation studies	Bleeding disorders; anticoagulants; liver dysfunction; renal dysfunction
Serum chemistry (i.e. Na, K, CO_2, Cl, glucose)	Renal dysfunction; endocrine disorders; medications
Pregnancy test	History suggestive of current pregnancy; uncertain pregnancy history

ECG electrocardiography; *COPD* chronic obstructive pulmonary disease; *Na* plasma sodium; *K* plasma potassium; CO_2 arterial partial pressure of carbon dioxide; *Cl* plasma chloride

operative tests, i.e. tests ordered after consideration of specific information obtained from sources such as medical records, patient interview, physical examination, and the type of invasiveness of the planned procedure and anaesthesia may assist the anaesthesiologist in making decisions about the process of perioperative assessment and management. So, additional investigations are only initiated with respect to the condition of a specific patient or to specific demands with respect to the scheduled surgical procedure (Tables 3 and 4).

It is preferred that the preoperative evaluation is performed a considerable time before admission of the patient is scheduled. Unfortunately, it is not uncommon that patients are admitted immediately after their visit, allowing significantly less time for preoperative optimisation. Nevertheless, the responsible anaesthesiologist must verify that the basic standards for preanaesthesia care are properly performed and documented in the patient's record [8]. A recent study reported that ideally, the same anaesthesiologist that will provide the anaesthesia visits the patient preoperatively [9]. However, for logistical reasons common anaesthetic practice is 'one patient, two anaesthesiologists'.

Intraoperative Management

Anaesthetic Technique

Common side effects of laparoscopic procedures are irritation of the diaphragm due to the carbon dioxide insufflation for maintaining PP, significant nausea and vomiting and referred pain in the distribution of the phrenic nerve. Although regional anaesthesia has been applied successfully for laparoscopic cholecystectomy [10], general anaesthesia is thought to be the technique of choice for laparoscopic urologic procedures [11].

The combination of a generally uncomfortable position on the operating table together with a long-lasting urologic procedure makes a state of wakefulness during laparoscopic urologic surgery in malignancies not very acceptable for the patients. When regional anaesthesia is combined with sedation, airway protection cannot be ensured, and respiratory depression with further induction of hypercapnia can be expected. The general anaesthetic technique provides a secure airway, enables controlled mechanical ventilation with proper handling of the CO_2 absorption that is induced by the PP, and facilitates management of muscle relaxation necessary to optimise the surgical view. Although epidural anaesthesia for open radical prostatectomy procedures is associated with decreased postoperative analgesia demand [12], it has been argued that morbidity is similar for patients being anaesthetised with epidural or general anaesthesia [13]. In conclusion, general anaesthesia is preferred over a regional technique when it concerns extensive laparoscopic urologic procedures.

Monitoring of the Patients

Cardiac events are the leading cause of death during and immediately after surgical procedures [14–16]. Perioperative morbidity also is associated with pulmonary complications and moderate hypothermia [17]. However, the rate of complications directly related to anaesthesia is low [18].

Anaesthesia-related complications might be attributable to missed technical errors of the apparatus and deficiencies in monitoring [19, 20]. Nevertheless, other factors such as the experience and training of staff, the introduction of physiological monitoring, and changes in perioperative management such as perioperative beta-blockade, maintenance of normothermia and sympathicolysis have a greater effect on mortality [21–24].

One must realise that the operating room, the recovery room and the intensive care units are all cognitively complex environments where the amount of information required by an operator to make a correct decision often exceed the five that can be held in conscious working memory simultaneously [25]. Therefore, triggering critical incidents in these environments is dominated by human factors errors [25]. Although, instrumental monitoring cannot prevent adverse reactions, the design of the equipment is known for its influence on the incidence of human factors error. Therefore, this equipment must be engineered and designed with an understanding of the causes of human factors errors to optimise and therefore improve the safety of the patient [25].

Although guidelines and recommendations for monitoring standards are usually defined by the national societies of anaesthesia, some *basic* aspects should be monitored in every patient regardless the choice of anaesthetic technique, type of surgery, or condition of the individual patient [26, 27].

Published on the ASA website, in short, are two points: (1) qualified anaesthesia personnel shall be present in the room throughout the conduct of all general and regional anaesthetics and monitored anaesthesia care, and (2) during all anaesthetics, the patient's oxygenation, ventilation, circulation and temperature shall be continually evaluated [27]. Table 5 gives methods for the application of these basic monitoring standards.

Table 5. Methods for basic monitoring standards

Essential	Oxygenation	Ventilation	Circulation	Temperature
	Inspired gas monitoring Pulse oximetry Clinical Observation	Expired gas volume Disconnection detector Expired carbon dioxide	ECG HR Blood pressure Clinical observation	Body temperature
If Applied	Muscle relaxant use Nerve stimulator	Volatile anaesthetic use Inspiratory anaesthetic concentration Expiratory anaesthetic concentration		

ECG electrocardiography, *HR* heart rate

Advanced monitoring consists of the measurement of cardiac filling pressure, cardiac output and mixed venous oxygen saturation. The conventional monitoring of cardiac filling pressures needs central venous cannulation. Although complications of this cannulation are infrequent, they may result in severe morbidity [28]. Because laparoscopic urologic procedures are usually performed in the elderly, often cardiovascular disabled ASA III or IV patient, such advanced monitoring may often be necessary. However, when the cardiac function is impaired the relation between central venous pressure and cardiac preload is altered and the cardiac filling pressure measurements may not be reliable [29]. In such cases, insertion of a pulmonary artery catheter will be considered.

Transoesophageal echocardiography (TOE) is a semi-invasive method of measuring cardiac performance and ventricular filling. It also offers additional information about cardiac morphology and pathology [30]. The use of TOE in laparoscopic procedures is recommended for early detection of gas embolism and examination of a possible patent foramen ovale (PFO) [31]. The estimation of the prevalence of PFO in postmortem studies is 25%–35% [32]. The clinical significance increases from 5%–10% at basal in vivo conditions to 18%–22% after sudden release of intrathoracic pressure, a situation that might be expected during laparoscopy [33]. Although the effect of regular TOE use on outcome is unknown, when used by experienced staff the complication rate of the technique is low [34]. Therefore, its use is recommended in subsets of patients, such as those having a known cause of haemodynamic instability [26].

Fluid Management

Fluid management in laparoscopic surgery can be a dilemma for the anaesthesiologist. Usually, patients enter the operating room after a time of fasting, most often at least 6 h. The patients' circulatory status is therefore relatively hypovolaemic and anaesthesia, whether general or regional, further increases the fluid debt.

Depending on the positioning of the patient in combination with PP on the one hand, a restrictive fluid regime may be advantageous, whereas on the other hand, vital organ perfusion requires intravenous fluid loading.

The Trendelenburg head-down position in itself causes increased venous return [35]. In combination with PP, this venous return may be even further increased due to compression of the splanchnic vasculature. In cardiovascularly compromised patients these sudden haemodynamic changes may lead to congestive heart failure and/or even acute myocardial infarction.

The Trendelenburg position, especially the long-lasting extreme head-down position, can raise the intracranial and intraocular pressures. Cerebral oedema and retinal detachment may occur. Due to venous stagnation, cyanosis and oedema in the face and neck may be expected. On the other hand, hypotension can be induced when high intra-abdominal pressure (IAP) is applied in combination with intermittent positive pressure ventilation (IPPV) due to compression of the inferior vena cava in combination with an elevated intrathoracic pressure. The latter is especially seen in relatively hypovolaemic patients. Furthermore, high IAP pressure may reduce renal perfusion and consequently urine production. The best method for maintaining renal perfusion is the preservation of an adequate intravascular volume.

The reverse Trendelenburg head-up position reduces venous return, which may lead to a fall in cardiac output and arterial pressure. If the patient has an adequate intravascular volume, PP will compensate for this decrease by increasing the venous return.

The lithotomy legs-up position will induce autotransfusion by redistributing blood from the vessels of the lower extremities into the central body compartment, which thus will increase the preload of the heart. Subsequent PP will further increase venous return, the effect of which on the cardiac output (CO) will depend on the patient's circulatory filling status.

The lateral decubitus position used for nephrectomy can cause direct compression of the inferior vena cava, resulting in a decreased venous return and subsequent hypotension.

In conclusion, because of a combination of anaesthesia, positioning and PP, impressive fluid shifts may take place. Therefore, it is recommended that the patients are adequately intravenously fluid loaded to maintain a normal CO. However, as mentioned above, ASA class III and IV patients then may need advanced cardiac monitoring. It should be stressed that due to positioning and intrathoracic pressure, central venous pressure monitoring does not reliably reflect the patient's filling status.

Intraoperative Complications

Apart from the common side effects of laparoscopy and usual reported morbidity and mortality around all surgical procedures, specific complications during laparoscopic surgery may occur. These complications basically result from the carbon dioxide PP and/or patient positioning.

Pneumoperitoneum will induce haemodynamic, pulmonary, renal, splanchnic and endocrine pathophysiological changes. However, most of these changes are clinically insignificant if appropriate anaesthetic care is provided.

Pulmonary Changes

Carbon dioxide is a highly soluble gas that is rapidly absorbed through the peritoneum into the circulation inducing hypercapnia and acidosis. During PP, the end-tidal CO_2 concentrations increase progressively with time, reaching maximum value after 40 min of CO_2 insufflation if ventilation is kept constant [36]. Thereafter, CO_2 begins to accumulate in the body reservoir; up to 120 l CO_2 can be stored. The absorption of CO_2 is especially increased during prolonged surgery in combination with high IAP. The body is not so well adapted to handle an acute elevation in the carbon dioxide tension (pCO_2), because there is virtually no extracellular buffering. Since the renal response takes time to develop, the cell buffers, particularly haemoglobin and proteins, constitute the only protection against acute hypercapnia. A persistent elevation in the pCO_2 stimulates renal H^+ secretion, resulting in the addition of bicarbonate to the extracellular fluid. The net effect is that after 3–5 days, a new steady state is attained [37]. So, during laparoscopic procedures CO_2 is almost only excreted through the lungs, and thus, hypercapnia must be decreased by compensatory hyperventilation. This hyperventilation may best be accomplished by increasing the tidal volume of ventilation in anaesthetized patients. Nevertheless, respiratory acidosis and increased CO_2 output last for at least up to 1 h postoperatively [38]. Carbon dioxide exhaustion is reduced when cardiopulmonary function is compromised [39].

Intra-abdominal pressure plays a major role in the cause of hypercapnia as it increases the absorption and decreases the exhaustion of CO_2. Elevated IAP and abdominal expansion shifts the diaphragm cephalad. This causes an increase in intrathoracic pressure; the abdominal part of the chest wall stiffens, thus restricting expansion of the lungs. During general anaesthesia alone, the functional residual capacity of the lung is reduced by about 20% [40]. During increased IAP, the pulmonary dynamic compliance is significantly decreased up to 50%, whereas peak and plateau pressures are increased [41–43].

Ventilation-perfusion mismatch and intrapulmonary shunting may become increased. In patients with a normal preoperative pulmonary function, this will not lead to hypoxemia. In contrast, patients with compromised cardiopulmonary function such as emphysema or chronic obstructive pulmonary disease (COPD) will be at risk for developing hypoxemia.

To avoid hypercapnia and respiratory acidosis during PP the minute volume of ventilation should be increased perhaps even to approximately 12–15 ml/kg. However, the anaesthesiologist will consider the disadvantages of hypercapnia and acidosis vs the increases in inspiratory peak and plateau pressures that may induce ventilator-induced lung injury (VILI). Although positive end-expiratory pressure (PEEP) improves the pulmonary gas exchange during PP [44], it should be realized that PEEP in combination with increased IAP increases the intrathoracic pressure, thus causing a reduction in CO [45].

Pulmonary Complication

Pulmonary complications that may occur during laparoscopic surgery are hypoxemia, barotrauma, pulmonary oedema, atelectasis, gas embolism, subcutaneous emphysema, pneumothorax, pneumomediastinum and pneumopericardium.

Hypoxaemia may develop in patients with cardiopulmonary co-morbidity such as emphysema and COPD. In most cases, adequate ventilation and oxygenation will reverse hypoxaemia. If not, conversion to open surgery may be required.

The combination of increased mean airway pressure and decreased lung compliance is associated with barotrauma, which may result in acute pneumothorax [46].

Carbon dioxide embolism is a very serious but rare complication of PP; mortality rates of up to 28% have been described [47]. The major cause of CO_2 embolism is known to be misplacement of the Veress needle, either directly into a vessel or into a parenchymal organ. Carbon dioxide bubbles can enter the circulation through an opening in any injured vessel due to the raised IAP. With respect to the occurrence of gas emboli during the initial institution of PP, the Hasson technique seems safer than the Veress needle technique [48].

The intravascular presence of small amounts of CO_2 frequently occurs usually without any clinical consequence. Studies with TOE revealed 68% of asymptomatic patients to have CO_2 bubbles in the right ventricle during laparoscopic cholecystectomy [49]. Since CO_2 is very soluble in blood, a large amount of it must rapidly enter the circulation in order to be clinically relevant. A known risk factor is hypovolaemia. If serious gas embolism is suspected during the course of laparoscopic surgery rigorous measures must be taken.

Gas embolism may present as profound hypotension, cyanosis, arrhythmias and/or asystole. A grinding murmur can be found by auscultation of the heart. End-tidal CO_2 concentration suddenly increases, followed by an acute decrease due to cardiovascular collapse.

Upon suspicion of embolism, the following measures must be taken at once [50, 51].

- Immediate deflation of PP
- Placement of the patient in a left lateral head-down position will enable the gas embolus to move into the right ventricular apex, thereby preventing its entry into the pulmonary artery
- Increase of minute ventilation and administration of 100% in-tidal O_2 will help to eliminate CO_2
- Placement of a central venous catheter to enable aspiration of the gas
- Cardiopulmonary resuscitation must be performed in case of asystole
- Hyperbaric oxygen therapy can be used, if available

Subcutaneous emphysema may be caused by gas passing through a disruption of the peritoneum into the subcutaneous tissue and into the retroperitoneal space. Its occurrence has been estimated at 0.3%–3.0% [49]. From the intra-abdominal and retroperitoneal spaces, the insufflated CO_2 can escape through the soft tissues around the vena cava and aorta into the mediastinum. In addition, CO_2 may escape into the intrapleural space through congenital defects of the diaphragm or through accidental diaphragmatic injuries. The latter has been described during laparoscopic adrenalectomy and fundoplications [52].

Pneumothorax may occur during laparoscopy due to increased mean airway pressures and should be differentiated from capnothorax caused by CO_2 diffusion into the intrapleural space. The presence of subcutaneous emphysema should lead to the suspicion of capnothorax. End-tidal CO_2 concentration increases in both subcutaneous emphysema and capnothorax. Clinically significant capnothorax should be suspected when the mean airway pressure increases and SpO_2 declines. A chest X-ray then is required for diagnostic purposes. In contrast to a pneumothorax, the capnothorax generally does not require insertion of a chest drain because CO_2 is rapidly reabsorbed once PP is released.

Haemodynamic Changes

Cardiovascular changes occur due to a combination of anaesthesia, PP and patient positioning. Many clinical studies of laparoscopic surgical procedures have characterized the influence of the different modalities on patient haemodynamics [46, 53–60]. Most studies report increased systemic (SVR) and pulmonary vascular resistances (PVR) and a reduction of cardiac output when laparoscopy is performed with maximum IAP set at 15 mmHg or more in combination with reversed Trendelenburg position. Significant increases were also noted in mean arterial pressure (MAP), right atrial pressure (RAP) and pulmonary capillary wedge pressure (PCWP). At lower IAP during PP the above parameters change to a lesser extent. Interestingly, all measured variables usually return to preinsufflation values 30 min after the start of PP.

Haemodynamic changes during PP with the accompanying position of the patients are caused by a number of mechanisms. A quick rise in blood pressure, which is often seen at the start of PP, is mainly caused by an increased preload due to an increased venous return from blood compressed out of the splanchnic vasculature. Neurohumoral changes during PP may increase the SVR, which can lead to an increase in MAP. Induction of CO_2 PP also may lead to an increased plasma renin activity and increased antidiuretic hormone (ADH) production, which, in combination with the influence on the sympathetic system, may induce SVR elevation [53].

Hypotension is a rare complication that may occur during laparoscopic interventions. Generally, this is induced by a high IAP in combination with IPPV. High IAP may cause compression of the vena cava with subsequent impairment of the venous return, inducing a reduction in CO. Furthermore, venous return may be reduced by an increased intrathoracic pressure due to IPPV and worsened by adding PEEP. In addition, high intrathoracic pressures may cause compression of the heart, especially when hypovolaemia is present. Since in this context, the RAP reflects intrathoracic pressure rather than venous filling status, intraoperative monitoring of patients with cardiopulmonary co-morbidity should be performed using either a pulmonary artery catheter or TOE. Increasing the intravascular volume prior to induction of PP can prevent hypotension and/or a reduction in CO. A volume loading of 10–12 ml/kg is common practice for prevention of hypotension. Finally, it should be remembered that high IAP in combination with the reversed Trendelenburg position reduces cardiac filling even further.

Insufflating the abdomen can provoke arrhythmias. Differentiation must be made between more innocent arrhythmias due to release of catecholamines such as sinus tachycardia and ventricular extra-systoles and the more dangerous brady-arrhythmias such as bradycardia, nodal rhythm, atrioventricular dissociation and asystole. These latter arrhythmias are generally caused by a vagal nerve-mediated cardiovascular response due to acute stretching of the peritoneum [47]. Carbon dioxide also may induce arrhythmias, as it causes irritability of the heart. Most arrhythmias respond to a reduction in IAP and increase of minute ventilation with FiO_2 set at 1.0. Cardiac arrest associated with laparoscopy is either caused by a vasovagal response to rapid CO_2 insufflation into the intraperitoneal cavity or by gas embolism.

Since some of the pathophysiological mechanisms underlying a number of cardiopulmonary complications are well known, preventive measures can be taken. Preoperative volume loading (10–12 ml/kg) may prevent a decrease in CO that is induced by the IAP in combination with a reversed Trendelenburg position of the patient. Invasive haemodynamic monitoring or TOE may be necessary in ASA III and IV patients. Slow CO_2 insufflation will reduce gas embolism and avoids vasovagal response leading to collapse, cardiac arrest and arrhythmias. Finally, it is recommended to apply the lowest possible IAP for each particular procedure. Extreme positioning should be avoided, as it could influence cardiac function and ventilation and could cause peripheral nerve damage.

Renal physiology is influenced by PP, which may induce renal complications such as oliguria [61]. The following underlying mechanisms are considered:

- Compression of renal vasculature and parenchyma [62]
- Increased release of antidiuretic hormone [63]
- Activation of the renin-angiotensin-aldosterone system (RAAS)
- Decreased CO

An inverse correlation exists between IAP and both renal perfusion and urine production. When IAP is increased from 0 mmHg to 20 mmHg, the renal vascular resistance will increase and the glomerular filtration rate (GFR) will decrease. Postoperatively, the decrease in renal blood flow (RBF) may last for 2 h. A decreased RBF is an activator of the RAAS system. An increased renin concentration activates RAAS, causing renal vasoconstriction mediated by angiotensin II [64]. Blood flow within the kidney is directed from the cortex toward the medulla, thus initiating further impairment of renal perfusion [65]. This is a circulus vitiosus. Esmolol inhibits the release of renin and may therefore protect against renal ischaemia during laparoscopy, especially in patients with a borderline kidney function [66]. PP with cool, room temperature CO_2 has not only been shown to decrease core temperature, but urine output as well [67]. Warm (body temperature) insufflation probably causes a local renal vasodilatation and may be beneficial to patients with borderline renal function [67]. In conclusion, PP, especially with high IAP, may impair renal function. The best method for maintaining renal perfusion is preservation of an adequate intravascular volume load, before as well as during laparoscopy, with concomitant insufflation of warmed CO_2 for maintenance of PP.

The splanchnic circulation also may become compromised when high IAP is applied during laparoscopy. In healthy patients, an increase in IAP from 10 mmHg to 15 mmHg significantly decreases blood flow, to the stomach by 54%, the jejunum by 32%, the colon by 4%, the liver by 39%, the parietal peritoneum by 60%, and the duodenum by 11%. Splanchnic blood flow decreases along with insufflation time [68]. The direct mechanical compression of the superior mesenteric artery and hepatic portal vein is the mechanism suggested in the literature [68]. To prevent this possible complication, IAP should not exceed 8–10 mmHg.

Recovery Period

Postoperative care following laparoscopic urologic surgery is quite important, especially when it concerns the elderly patient with significant coexisting morbidity.

Surgical injury induces a complex and orchestrated stress response characterised by profound endocrine-metabolic changes with hypermetabolism and catabolism, as well as an inflammatory response with activation of humoral cascade systems leading to malaise, hyperthermia, and immunosuppression [69]. Modern anaesthetic and surgical care aims to reduce surgical stress responses, although the best way to modify such a natural evolutionary response is unclear [69]. Various techniques are described for reduction of surgical stress responses, such as prevention of hypothermia, high inspired oxygen fraction postoperatively, application of peripheral nerve blocks, etc. [70].

The process of postoperative recovery can be divided into an early and late period [70]. In the early postoperative period, items such as management of the surgical stress response, pain, nausea, vomiting, ileus, mobilisation, fluid management, nutrition, fatigue and sleep disturbances play a role, while in the late postoperative period pain, fatigue, sleep disturbances and convalescence must be managed [70].

Routine postoperative care should consist of adequate monitoring of vital organ functions. This involves continuous monitoring of peripheral oxygen saturation, respiratory rate, ECG, heart rate and rhythm. Intermittent measurements of blood pressure and urinary output are obligatory.

As noted, advanced haemodynamic monitoring may be required in cardiovascularly debilitated ASA III and IV patients. If appropriate, this may include measurements of right atrial (RAP), pulmonary artery pressures (PAP) and cardiac index (CI) by means of a pulmonary artery catheter [55].

Monitoring of end-tidal CO_2 is important when prolonged laparoscopic procedures are performed, when high IAP is applied or when extensive subcutaneous emphysema is present. Since up to 120 l of CO_2 can be stored in the human body during PP, prolonged postoperative mechanical ventilation may sometimes be needed until all extra CO_2 has been eliminated [71]. When extensive subcutaneous emphysema is present or when either capnothorax or pneumothorax is suspected, a chest X-ray should be taken. Since prolonged PP, especially at higher IAP levels, may cause oliguria, urine output must be followed carefully, the filling status of the patient monitored and variables of kidney function measured. This is specifically important in patients with borderline renal function.

The gut clearly plays a role in postoperative recovery. Laparoscopy has been shown to blunt the response in serum IL-6, with no change in gut mucosal IL-6, as compared with open laparotomy [72]. Laparoscopy causes less trauma to the peritoneal environment by decreasing the inflammatory response of the gut as compared with open laparotomy. This different response of the gut may partially explain the more rapidly restored intestinal function following laparoscopy as compared to laparotomy [72].

Postoperative nausea and vomiting (PONV) is common after laparoscopic surgery. At present, the aetiological mechanism is not quite clear. Amongst the possible causes mentioned in literature are mechanical pressure to gut and stomach and stretching of vagal nerve endings in the peritoneum. Carbon dioxide may induce vasodilatation of the cerebral vessels, consequently raising the intracranial pressure (ICP). A raised ICP is a well-known cause of nausea and vomiting [73]. In many centres, prophylactic administration of antiemetics is routine. Optimal timing of its administration, however, is important. When ondansetron, 4 mg i.v. is given, it is most efficacious if administered just before the end of surgery. Dexamethasone, especially in combination with ondansetron, was shown to extend the duration of antiemesis [74]. Antiemetic interventions are equally effective and act independently. Therefore, the safest or least expensive drug should be used first [75]. Multiple interventions should be reserved for high-risk patients [75].

Pain after laparoscopic surgery is multifactorial and may be quite intense. Many patients require opioid analgesia [76]. A number of measures can be considered for the management of postoperative pain. Amongst them are local anaesthetic infiltration of port sites, avoiding IAP peaks and prolonged PP with high IAP, evacuating residual gas and using pre-emptive analgesia.

Early postoperative complications, which should be recognized rapidly, are intra-abdominal and/or retroperitoneal haemorrhage, capnothorax, capnopericardium and pneumothorax. When extensive subcutaneous emphysema is present and extended to the neck area, respiration must be carefully monitored.

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14 The Future of Laparoscopic Surgery in Urologic Malignancies

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Patients dread pain, and as a result any therapeutic intervention they associate with pain. In general they conceive more extensive surgical access trauma leaving more visible sequelae with more pain, and they will go a long way to avoid or at least reduce this. Any treatment resulting in less access trauma, be it real or only apparent, will therefore be considered favourably, and patients will even be ready to accept some loss of therapeutic efficacy or a higher risk of complications. As treatment discussions are heavily driven by patients' choice, laparoscopic surgery is therefore a clear winner over traditional incisional surgery whenever it can provide comparable results. That this is already the case for a wide spectrum of urological interventions is documented by the contents of this textbook. There can be no doubt that laparoscopic urological surgery has a bright future.

Technology in the field is expanding at a breathtaking pace, with rapid clinical percussions:

- Image transmission is being revolutionized, most importantly by replacing optical with digital transmission. With the ongoing miniaturisation of chip cameras, these can be mounted at the tip of the endoscope, rendering traditional rod lens or fibre-optical systems unnecessary. Digital images not only provide better resolution, they can be modulated automatically to correct for changes in colour, brightness or glare. Better display monitors with higher resolution, better light sources and 3D vision systems are in clinical testing and promise to bring vision to a level unsurpassed by direct vision, even with loupe magnification.
- The range and quality of laparoscopic instruments continues to be expanded. Instruments providing for safer access, more versatile dissection, more effective tissue retraction and simpler and more reliable hemostasis and suturing are rapidly eliminating many of the problems of early laparoscopic surgery in urology. Targeted tissue ablation using microwaves, radiofrequency or cryoablation under laparoscopic control may prove an adjunct or alternative where mechanical removal appears too risky. Improved techniques for intraoperative monitoring of the lesion as it develops with laparoscopic ultrasonography, infrared spectrophotometry, DOC technology or direct thermometry are being developed for more predictable use of these techniques.
- With better instrumentation and growing experience, the laparoscopist will not only expand the spectrum of his/her surgery, but will continue to reduce morbidity by better port placement, by using thinner ports, and by more targeted, faster surgery. The present trend towards a primary extraperitoneal approach to the urinary tract and thus avoiding the problems of the pneumoretroperitoneal approach is providing direction. Better patient selection based on growing experience with laparoscopic surgery and its potential pitfalls, but also more precise preoperative imaging to clarify the individual anatomical situation permit a more targeted and hence less traumatizing approach. Most important, with growing expertise, operating times and complication rates continue to be reduced, making the laparoscopic approach even more attractive.

At present the steep learning curve of laparoscopic surgery appears to be the most important limiting factor for its acceptance, at least for surgeons well experienced in traditional surgical techniques. Patient demand and convincingly lower morbidity will be the decisive arguments, as previous experience with open prostatectomy vs transurethral resection for benign prostatic hyperplasia or open stone surgery vs endourological stone removal has clearly documented. Intermediate solutions, such as attempts to reduce access trauma of incisional surgery with minilap techniques or combining laparoscopic and incisional technique in hand or video-assisted surgery may facilitate the transition for the advanced nonlaparoscopic surgeon, but they will fade out with the coming generation of surgeons trained primarily in laparoscopic techniques. Robot-assisted laparoscopic surgery appears to be a more logical step to reduce the learning curve, with robot systems smoothing out deficits in laparoscopic dexterity. With better training programs, more patients coming to laparoscopic surgery and a younger generation of urologists used to working of a monitor and coming to laparoscopy at an early stage of their training, the learning curve problem will diminish to the typical training challenge of any surgical procedure.

Ultimately, the most important argument for laparoscopic approach in everyday clinical practice may come from financial aspects. Less morbidity reflects faster rehabilitation and return to normal activity. The actual cost saved by faster recovery depends on the socioeconomic environment and the actual cost of laparoscopic surgery. The former varies widely, but the latter can be controlled. Lowering the expenditure by moving from disposable to reusable instruments, better utilisation of facilities and streamlining procedures may turn laparoscopic surgery from an administrator's nightmare to the choice without alternative.

Clearly, laparoscopic surgery will replace a majority of transitional incisional procedures in urology in the near future. Nevertheless, it also remains an invasive procedure, including in the patient's perception. Even less invasive interventions will be more attractive, and if they achieve comparable results, laparoscopic surgery may be the loser. If the therapeutic goal can be achieved through a natural body opening or by using natural pathways without the need of dissecting structures through an external approach, this is less invasive and will become the preferred technique. This is already happening with the expansion of retrograde ureteroscopic surgery to the kidney vs percutaneous surgery, or with coronary transluminal angioplasty vs coronary bypass surgery.

Even more perceivable is a breakthrough of percutaneous tissue ablation techniques. Already modern high-dose external beam radiotherapy and brachytherapy are reducing the number of patients coming to laparoscopic radical prostatectomy. Percutaneous needle ablation of small renal masses using microwave-, radiofrequency- or cryoablation are in advanced clinical testing, and are already competing for patients with laparoscopic partial nephrectomy. Extracorporeal tissue ablation using high-intensity focused ultrasound or radiosurgical methods appear even less invasive. Although at present purely experimental, relatively minor technical improvements could result in the clinical breakthrough. Extracorporeal shock-wave lithotripsy of renal stones has shown the way.

Laparoscopic surgery certainly has a bright future in urology and will play a dominating role in the coming years. Nevertheless, it remains a segment only in a dynamic and ever-changing field, and its role may again rapidly be diminished by other developments. The challenge for the urologists remains staying abreast of these transitions, in an open-minded manner and with the readiness to adapt when this appears favourable for his/her patient.