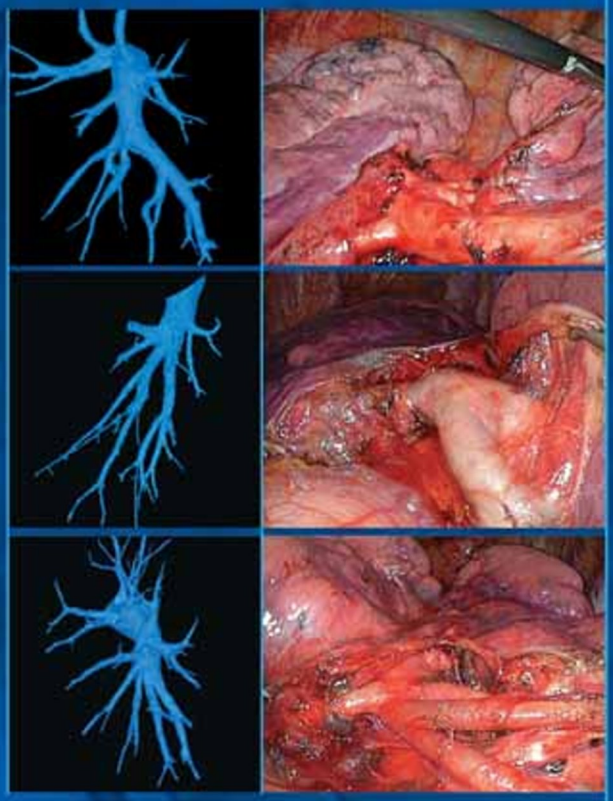
Dominique Gossot



Atlas of Endoscopic Major Pulmonary Resections

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Warning

The techniques of video-assisted or thoracoscopic lobectomy are numerous and vary according to:
- the use or nonuse of an access incision;
- the type of instruments;
- the use or nonuse of a full video display;
- the type of approach, i.e., anterior or posterior.

The techniques described in this atlas are based on the author's experience. They may differ from other reported techniques and do not claim to be superior. The reading of this atlas does not replace direct observation in the operating room and training.

Acknowledgments

This atlas is the result of an experience that was made possible only by the expertise and commitment of the pulmonologists of the Thoracic Department of our institution: **Raffaele Caliandro, Philippe Girard, Christine Raynaud,** and **Jean-Baptiste Stern.**

Many thanks go to the scrub nurses of our operating theater for their patience and professionalism. They have made endoscopic major pulmonary resections an almost routine operation.

I am greatly indebted to **Christiane Strauss** (Imaging Department, IMM) for the hours she spent on CT to produce high-quality three-dimensional reconstructions of the bronchovascular anatomy.

Special thanks go to **Nathalie Huilleret** (Springer-Verlag) for making this project possible and **Claire Viader** for the publishing work.

I also thank **Jacques Marescaux** who made possible the link between this atlas and *Websurg* as well as **Guy Temporal** and **Richard Bastier** for their work on the videos.

Finally, I extend my gratitude to the staff and engineers of Olympus for their cooperation and for providing us with outstanding endoscopes and imaging systems, an essential condition for completing the complex procedures described in this atlas.

Abbreviations and symbols used in this atlas

ML: Middle lobe

LLL: Left lower lobe

LUL: Left upper lobe

RLL: Right lower lobe

RUL: Right upper lobe

a.: artery

v.: vein

: Patient's apex

: Patient's front

: Direction of organ retraction

: Danger

: Trick

: The video can be consulted on WEBSURG

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Foreword

It is my greatest honor to be asked to write this foreword for the first edition of the *Atlas of Endoscopic Major Pulmonary Resections* by Dr Dominique Gossot. I have known Dr Gossot for over 15 years and have worked with him for many workshops and thoracic meetings. He is a pioneer in video-assisted thoracic surgery, and one of the most innovative thoracic surgeons I have known.

Minimally invasive surgery has set a new standard of care for all surgical disciplines. Video-assisted thoracic surgery (VATS) offers a much kinder approach to the management of a wide variety of surgical conditions compared with conventional thoracotomy for these patients.

Anatomical or major lung resections are a complex set of procedures commonly performed by thoracic surgeons. The adoption of the VATS approach for these procedures has received increasing acceptance by the thoracic surgical community, our pulmonologist and oncology colleagues, as well as the patients over the past two decades. There is now a growing body of evidence in the literature showing that the VATS approach is safe, oncologically sound, and associated with much lower morbidity compared with its conventional counterparts in the management of early lung cancers and benign conditions.

Although there have been other books and atlases on VATS, this volume distinguishes itself in two respects. One, it is the first atlas, to my knowledge, dedicated to the study of anatomical lung resections from a single master surgeon's perspective. Apart from the detailed descriptions on the resection of each lobe, this atlas gives a complete and unique illustration of segmentectomies – a set of procedures not well described in a single volume until now. Two, the use of three-dimensional reconstruction images from high-resolution CT scans at the beginning of each chapter to illustrate anatomy is superb. It helps us to clearly appreciate the anatomical relationship of the bronchi, pulmonary arteries, and veins, which is absolutely essential to safe dissection.

I have learnt greatly from this atlas. It is well written and beautifully illustrated. I believe it is an invaluable asset to those thoracic surgeons in training as well as in practice who want to pursue VATS anatomical lung resections. It is also useful to medical students and all operating room personnel who want to gain an in-depth understanding of these advanced procedures.

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General considerations

Introduction

I – Tips and tricks

II – Endoscopic mediastinal lymph node dissection

Introduction

Although video-assisted thoracoscopic major pulmonary resections are not widely used yet, the interest in these techniques has grown after the publication of a large number of studies reporting good results . Increasing evidence suggests that thoracoscopic lobectomies can be performed with reduced morbidity and equivalent oncologic outcomes compared to open lobectomies. A multivariate analysis of 21 series of video-assisted lobectomies for early-stage non-small-cell lung carcinoma has demonstrated that they competed with open lobectomies not only in terms of morbidity but also in terms of survival.

One of the main concern for surgeons wishing to embark on these new approaches is that the term "video-assisted lobectomy" covers a broad spectrum of techniques that may be very different according to the use or nonuse of a utility incision and/or of a rib spreader. Differences are also related to other factors: the type of instrumentation, i.e., conventional versus endoscopic, and the type of imaging, i.e., natural vision through the incision or video display or a combination of both. After having used a video-assisted technique we have switched to a full endoscopic technique, termed « *complete VATS* » or "*closed technique*" in some recent papers. As for some major abdominal surgical procedures (hepatectomies, nephrectomies, colectomies), the operation is carried out using only endoscopic instruments and video display. In this technique, there is no utility incision and the specimen is retrieved through one of the port sites that is enlarged after completion of the resection. In keeping with the terminology used in other reports dealing with complex laparoscopic procedures, we use the term "totally endoscopic technique". As proposed by Shigemura et al. "totally endoscopic technique" or "complete VATS" is defined as: (a) no use of rib expander; (b) if a small access window is made, no work performed through it; (c) performing all operative work under thoracoscopy; and (d) using no other instruments than those specialized for endoscopic surgery (**Fig. 1**).

Fully thoracoscopic lobectomies were reported as early as in 1997. In 2002, experimental work on cadaveric model demonstrated that not only lobectomies but also lymphadenectomies were feasible using this technique. In contrast to the field of digestive surgery where the use of laparoscopy has progressively extended to major and complex procedures such as hepatectomies, it was felt that complex thoracic procedures could be safely performed only if a small incision for direct control was used.

Pure endoscopic lobectomies have been reported only recently. At first sight, performing a totally thoracoscopic dissection for a complex procedure such as a lobectomy or a segmentectomy may seem hazardous, not to say unreasonable. However, the quality and accuracy of an endoscopic dissection may be superior to those of an open or video-assisted approach. As mentioned by Kondo and Adachi, the thoracoscope can be used as during microscopic surgery, thus dramatically enhancing precision. "Why not using a utility incision, since an extraction incision will be needed anyway" is a frequently asked question. Our response is multiple:

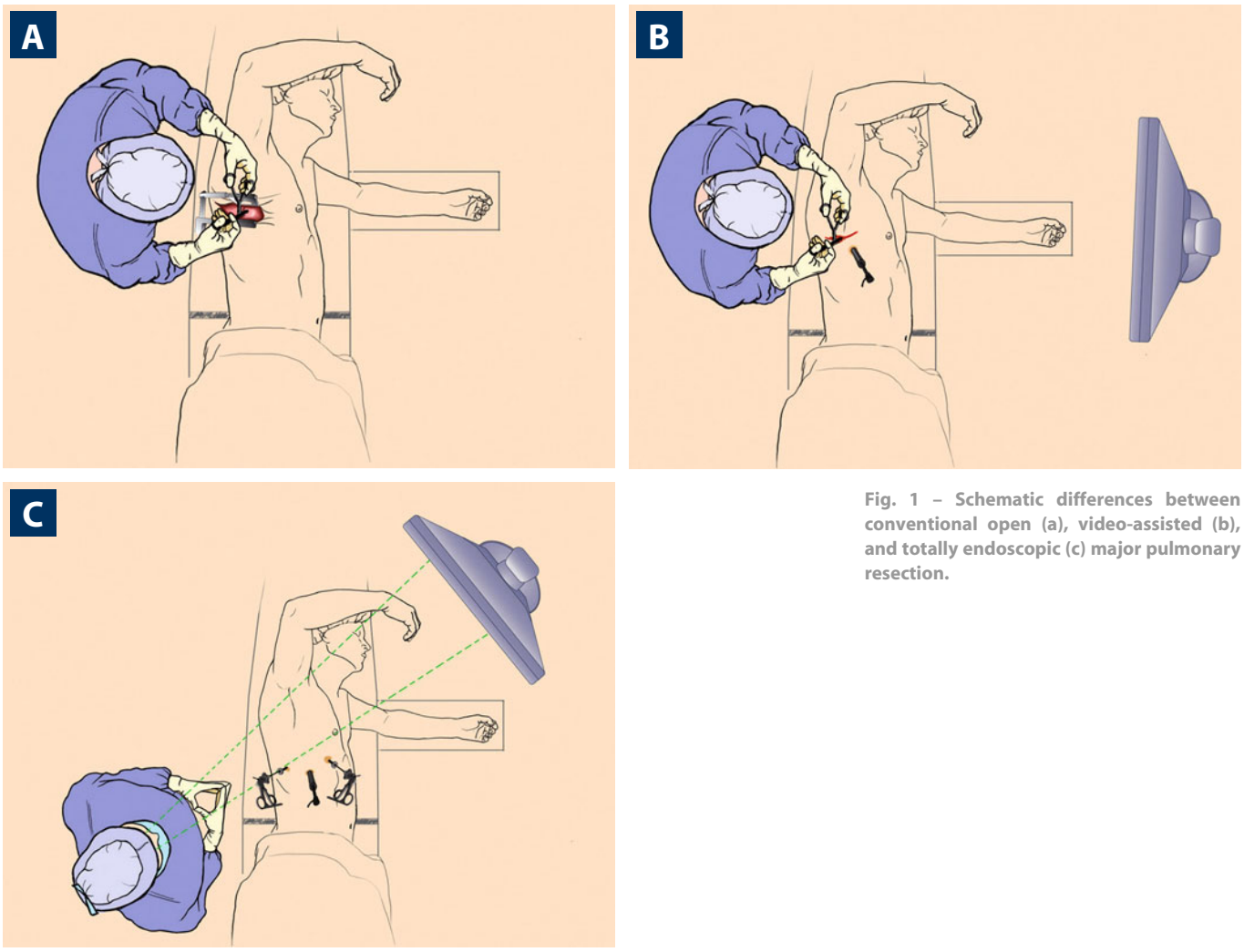

Fig. 1 – Schematic differences between conventional open (a), video-assisted (b), and totally endoscopic (c) major pulmonary resection.

(1) when using only endoscopic instruments, an access incision is useless. (2) We previously used a video-assisted approach and a utility incision and found that it gave a false sense of security. The site of the incision is usually chosen for a dedicated step such as hilar dissection or fissure division, so that there are always some steps of the procedure for which the incision location is not suitable. This is illustrated by the photographs or line drawings in some recent papers that show many different locations for the utility incision. In addition, in case of intraoperative problems, enlarging the incision may be problematic, since it is often not on the line of a posterolateral thoracotomy, which is the most appropriate incision for emergency. As outlined by Nomori et al., using a video-assisted approach for lobectomies means performing a classical operation but with a decreased vision and the feeling of an increased risk. (3) Finally, in digestive surgery, complex procedures with major vascular dissection are carried out laparoscopically without the help of a utility incision, yet these procedures are accepted. The vascular risk in laparoscopic hepatectomies seems comparable to the risk faced during thoracoscopic lobectomies, and in some respects, it may be considered as even more important because of the potential for gas embolism in case of venous injury.
Surgeons who will read this atlas may not choose this technique and may prefer a video-assisted approach because they feel it is less demanding.

Whatever the technique used, the landmarks are changed when compared to open surgery and some steps of the procedures are completely different. It is our hope that surgeons will find helpful information in this illustrated atlas and will better grasp these new anatomical landmarks and unusual vision of major pulmonary resections.

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Chapter I Tips and tricks

Totally endoscopic lobectomies or segmentectomies are considered as challenging. Because of the endoscopic vision with its magnification and unusual viewpoints, the anatomical landmarks are changed. In addition, restricted tissue manipulation and use of endoscopic instruments are disturbing. Eventually, as mentioned by T. L. Demmy, performing endoscopic major pulmonary resection means relearning the procedures.

The aim of this chapter is to stress several technical details that we have found helpful. Most of these tips and tricks can be modified according to the surgeon's preferences and will anyway evolve with upcoming technologies.

The key-points are:

- Taking time. In most series, these procedures are long lasting because one has to proceed meticulously and step by step. It is thus important to cope with ergonomic issues and adequate positioning of trocars.
- Controlling any oozing or bleeding, so that the operative field remains clear and does not deteriorate the quality of vision.
- Achieving a perfect exposure.
- Operating with an outstanding imaging system and preferably with a high-definition camera that gives a sharp image and allows one to operate "as during microscopic surgery".
- Having the right tool for the right task. This means these procedures cannot be performed with just a limited number of instruments. Not only good-quality hand instruments are needed, but also hemostatic devices such as ultrasonic shears or bipolar sealing instrument.

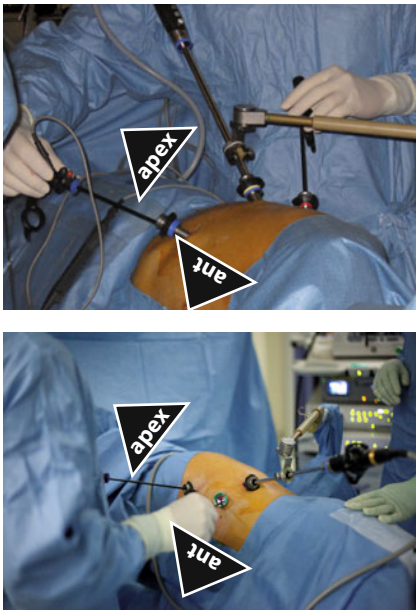


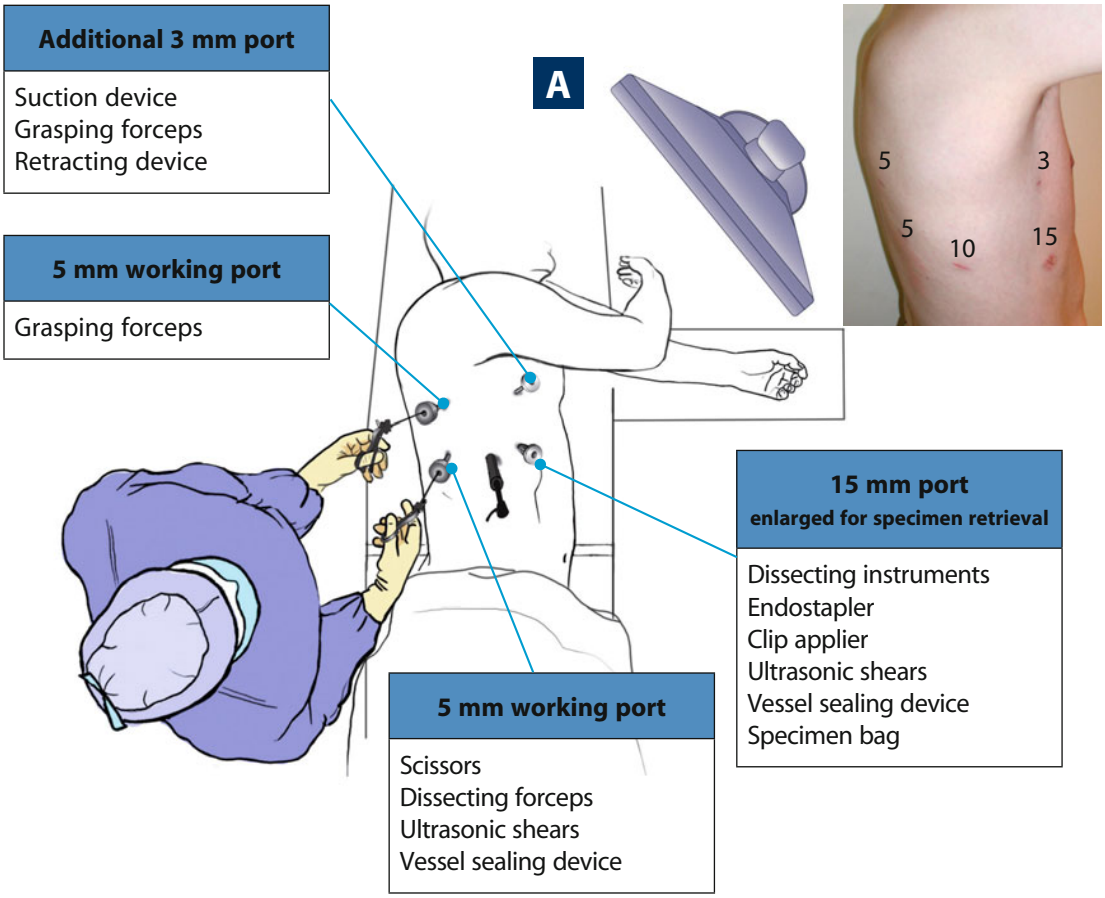
Fig. 1 – Trocar positioning: (a) triangulation with both working instruments opposite one another is uncomfortable; (b) example of a left lower lobectomy carried out with both working instruments coming from the front. This position is more ergonomic and less straining.

Ergonomics and operating room setting

It is usually admitted than video-assisted surgery should be done with triangulation of the endoscope and instruments that are positioned opposite one another (**Fig. 1**). This rule is almost impossible to follow during endoscopic major pulmonary resections for the following reasons:

- These procedures last 2–4 hours. Maintaining an awkward position with both arms spread apart is exhausting and can provoke shoulder pain and stiffness.
- In these complex operations, there is not just one but several targets (pulmonary hilum, mediastinum, diaphragm...), so that there is not a single ideal position of the scope and instruments. Therefore, whenever possible, we have found it more comfortable manipulating the two working instruments from the back or from the front, depending on the resection to be performed. The opposite side is used for insertion of a lung retractor or a suction device.

The scope is held by a robotic or mechanical scope holder, according to the surgeon preference. Its position should be shrewdly chosen so that the endoscope does not conflict with instruments (**Fig. 2**). Endoscopic instruments and trocars are placed on a dedicated rack and the conventional thoracic instruments are prepared on a separate table (**Fig. 3**). The list of instruments is given in Table I.



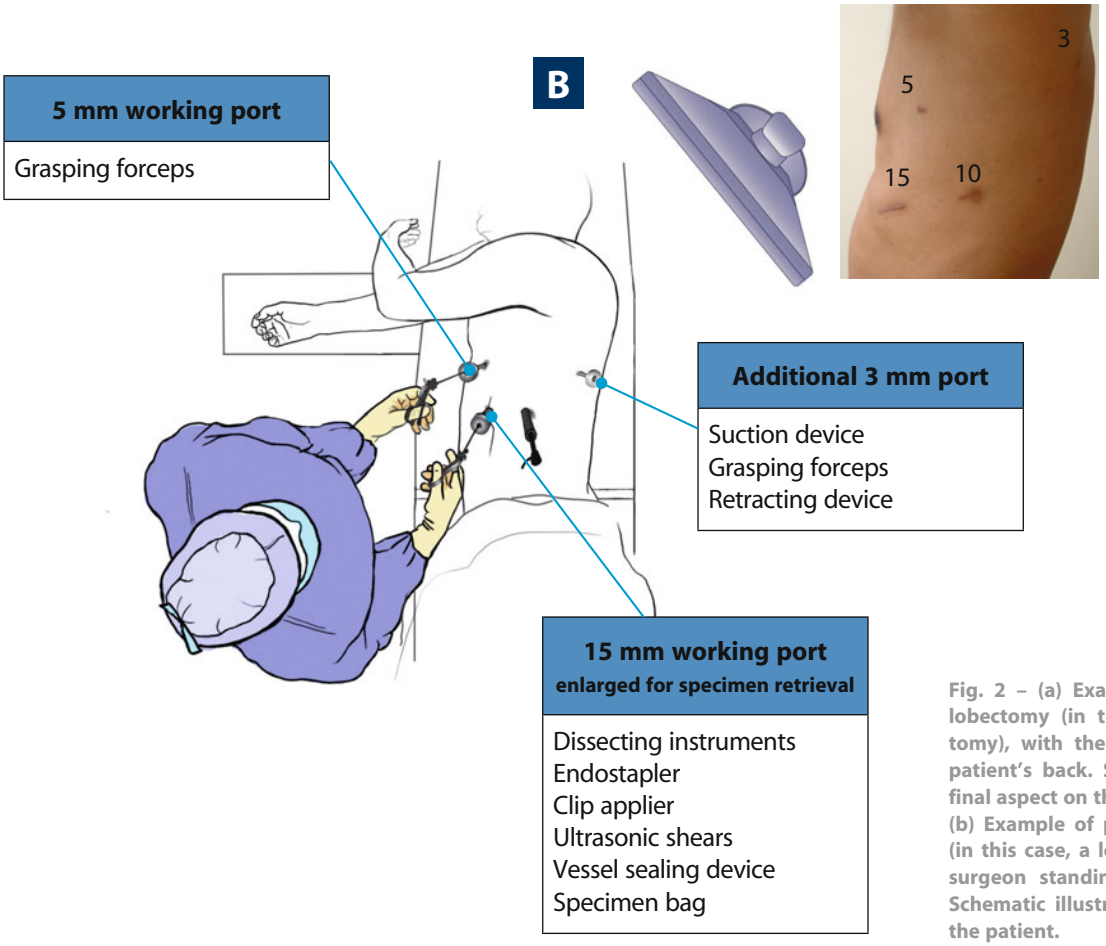


Fig. 2 – (a) Example of ports for a right lobectomy (in this case, a middle lobectomy), with the surgeon standing in the patient's back. Schematic illustration and final aspect on the patient.
(b) Example of ports for a left lobectomy (in this case, a lower lobectomy), with the surgeon standing in the patient's front. Schematic illustration and final aspect on the patient.

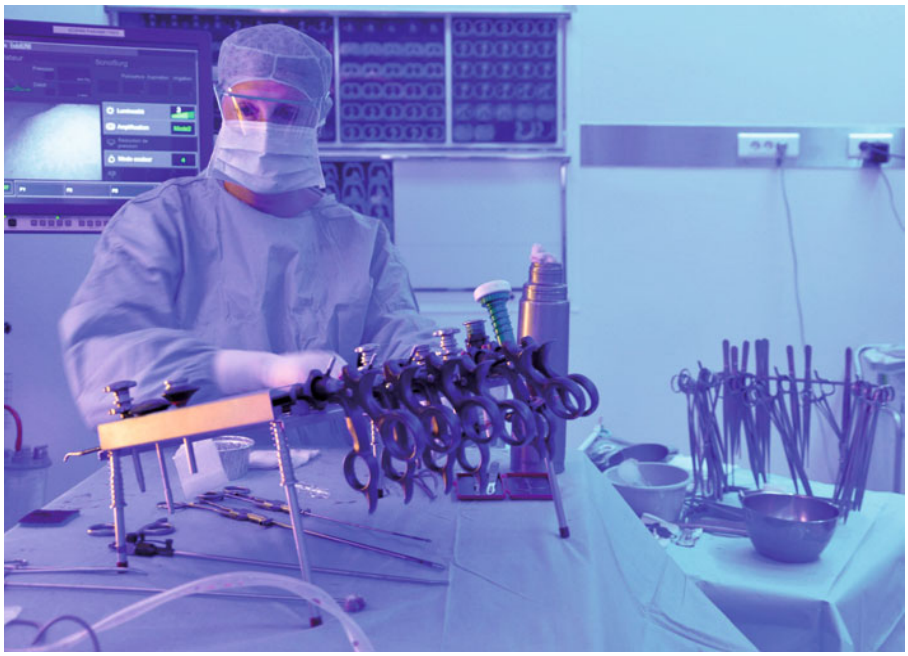


Fig. 3 – Endoscopic instruments and trocars are laid out on a rack while conventional instruments are available on a separate table.

Table I – Standard equipment required for endoscopic major pulmonary resections.

EQUIPMENT	TYPE	REMARKS
Image		
High-definition camera System	Exera II, Olympus	
High-definition monitors (x2)	Olympus	
Deflectable endoscope	LTF, Olympus	
Scope warmer	Applied Medical	
Scope holder	SH-1, Olympus	
Recording	Sony XDCAM HD PDW-70PM	
Hemostatic tools		
Multifunctional bipolar scissors, 5 mm	Aesculap	Disposable
Vessel sealing device, 5 mm	LigaSure™, Valleylab	Disposable
Vascular endostapler, 12 mm	Endo-GIA 30V, Covidien	Disposable
Clip applier	Ligaclip 10, Ethicon	Disposable
Hand instruments		
3-mm Trocars(x2)	Storz	Reusable
5-mm Trocars (x2)	Olympus	Reusable
10-mm Trocar (x1)	Olympus	Reusable
12-mm Trocar (x1)	Olympus	Reusable
15-mm Trocar (x1)	Thoracoport, Covidien	Reusable
Maryland dissecting forceps, 5 mm	Olympus	Reusable
Maryland dissecting forceps, 10 mm	Olympus	Reusable
Metzenbaum scissor 5 mm	Olympus	Reusable

Hook, 5 mm	Olympus	Reusable
Suction device, 5 mm (with coagulating tip)	Olympus	Reusable
Fenestrated grasping forceps, 5 mm	Olympus	Reusable
Atraumatic grasping forceps, 3 mm	Olympus	Reusable
Pulmonary clamp, 5 mm	Storz	Reusable
Vascular clamp, 5 mm	Storz	Reusable
Bulldog clamps (x3)	Aesculap	Reusable
Endostaplers	EndoGia 45 + 60 (staples 3.5 mm + 4.8 mm), Covidien	Disposable
Specimen bag,15 mm	EndoCatch II, Covidien	Disposable
Deflectable retractor, 5 mm	Goldfinger™, Ethicon or Endo Mini-Retract, Covidien	Disposable
Blunt tip dissectors, 5 mm	Endopath®, Ethicon	Disposable
Back-up		
Biopsy needle	Bard® Monopty® 16g	Disposable For biopsy of nodule for frozen section when no preoperative diagnosis is available
Suction catheter as stapler guide	Gentle-flo™, 16F, Kendlall	Disposable For use as a guide for the endostapler tip
Curved instruments, 5 mm	Aesculap	Reusable For freeing of some pleural adhesions that are difficult to reach with straight instruments
Needle holder, 5 mm	Olympus	Reusable Pulmonary tears, bronchial suture
Conventional instruments	Miscellaneous	Ready on a separate table

Trocars

What is the position of trocars is a frequently asked question. Unfortunately, there is no fixed and definite position. It depends not only on the type of resection but also on the patient's morphological type and on the surgeon's habits and preferences. For instance, we prefer performing left resections with the instruments coming from the front (**Fig. 1**), while we do not succeed using this approach for right-sided resections for which we use a combination of dissection from the back and from the front. Other surgeons may feel more comfortable with another approach and different positioning. The only rule we would recommend is inserting the scope in

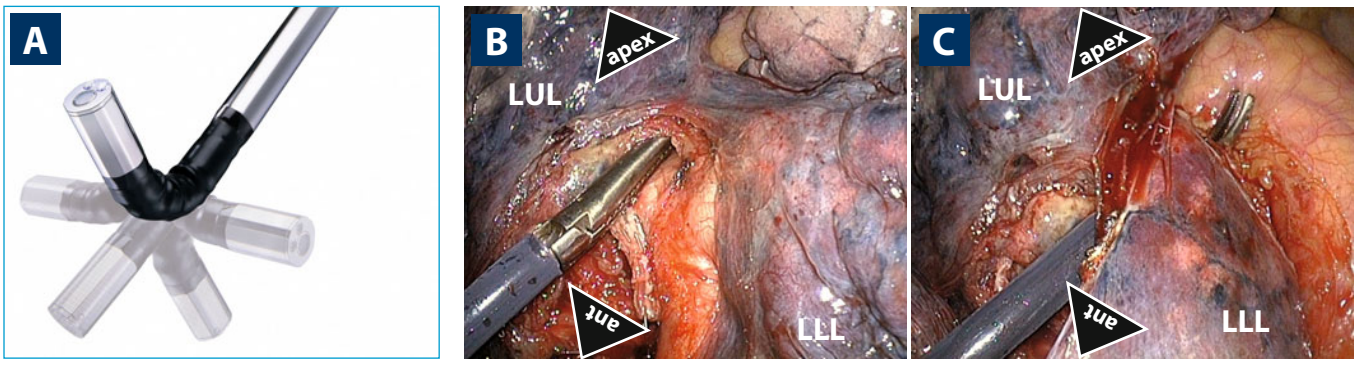
Fig. 4 – Use of a blue backlight enhances image contrast and does not necessitate reducing light of the operating theater.

the mid-axillary line, in the 6th or 7th intercostal space, depending on the patient's morphological type, because of the need to have an overall view on the whole pleural cavity.
Many tasks can be done with micro-instruments. This avoids large ports and, consequently, large scares.

Enhancing vision and video-imaging

During open surgery or VATS, the surgeon usually stands at the patient's back because the anatomical landmarks are more familiar to him/her that way. It is sometimes preferable to stand at the patient's front, or to switch from behind to the front, according to the operation steps. This means that at least two monitors should be used. The light in the operating room should be reduced as much as possible to enhance the monitor's contrast. As working many hours in the dark is tiresome for the staff, the best compromise is to have a blue background lighting which offers a nice contrast and does not oblige working in the dark (**Fig. 4**).
Since the procedure is long lasting, the endoscope tip may be soiled by blood drops sliding down along the trocar sheath. This annoying issue can be partly overcome by using a 12-mm trocar instead of a 10-mm one. The port is cleaned with a cotton-tipped applicator. Smoke aspiration can be achieved via a 3-mm suction device that is left in place throughout the procedure. The EndoClear™ (Virtual Ports) device is very helpful in efficient cleaning of the optic tip without a need for retrieving the scope.
Maintaining optimal vision of the whole operative field with a single 0° optic is almost impossible. One of the main concerns with a direct-viewing scope (0°) is the difficulty in controlling the instrument tip, which may be out of the field of vision. Formerly, to overcome this problem, we switched from a direct- (0°) to an oblique-viewing endoscope (30°) as vision became too tangential. However, these maneuvers were time-consuming and tedious. The rigid scope with a deflectable tip (Olympus LTF™, Tokyo, Japan) has an angle of vision that varies from 0° to 100° (**Fig. 5**). The flexibility is controlled by a lever located on the handle. Once chosen, the angulation can be locked. This allows the surgeon to have a bird's-eye view, making dissection more natural and safer. The endoscope tip houses a distal CCD connected to a high-definition television (HDTV) camera (Exera II™, Olympus), which provides dramatically sharp viewing, thus allowing for close-up vascular dissections.

Fig. 5 – High-definition deflectable tip thoracoscope (Olympus LTF™) allows to perform the whole procedure with a single endoscope and avoids the problems related to tangential vision. Its angle of vision varies from 0° to 100° (a). Example: during the dissection of the posterior part of the left fissure, a 0° vision does not allow to control the instrument tip (b) while it becomes clearly visible with a 90° angle of vision (c).



Obtaining pathological diagnosis

Patients who are selected for a totally endoscopic major pulmonary resection usually present with a clinical stage I tumor. This means the tumor or nodule is often small and not accessible to a preoperative CT-guided biopsy. Thus, many patients are operated on without confirmed pathological diagnosis. When the nodule is small and subpleural, the easiest way is to perform a wedge resection with frozen section. In other cases, we use a biopsy needle (Bard Monopty®, Covington, GA), which provides a pathological diagnosis in most cases (**Fig. 6**).

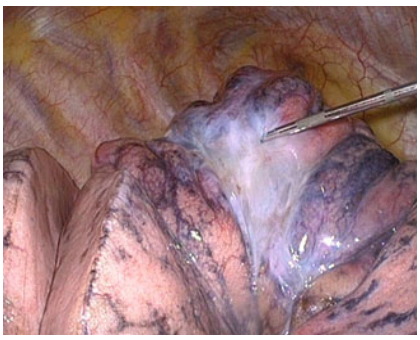


Fig. 6 – Intraoperative view of a needle biopsy.

Exposure and lung retraction

The most efficient and most natural way to retract the lung is by mean of a 5 mm or 10 mm forceps. However, although it is sometimes necessary, the use of a forceps has two drawbacks: (1) it requires an additional port and (2) it frequently tears the parenchyma, causing oozing or even hemorrhage. Although these minor bleedings are seldom serious, these may be very troublesome. Some have proposed to retract the lung with an endoloop. When there is no need to retract the lung with force, pushing it back with a simple endoscopic peanut is as effective while being less traumatic.

For long-lasting steps where the lung needs to remain retracted, we use either a 3-mm grasping forceps (**Fig. 7a**) or a miniaturised lung forceps that can be released inside the chest cavity (Aesculap©)(**Fig. 7b**). It has a triangular tip, like most lung forceps. A 30-cm-long thread is passed and secured at its ring-shaped basis. Once applied on the portion of the lung to be retracted, the thread is loaded through a 2-mm fascial closure device – whose primary use is port site closure during laparoscopy – and simply passed through the skin. Tension is then adapted by pulling the thread more or less. If needed, two retractors can be used.

Fissures

The access to the branches of the pulmonary artery is easy or difficult depending on whether the fissure is separated or fused (**Fig. 8**). Opening a largely fused fissure may be a tedious step of the procedure. The main concern is that opening and dissecting the fissure can cause some minor

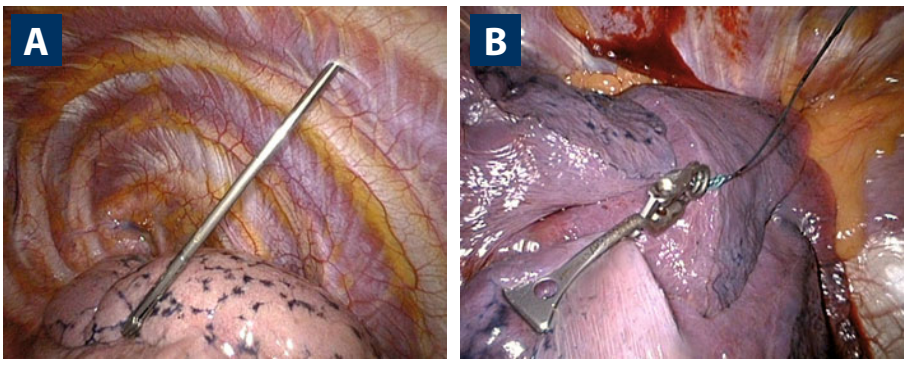


Fig. 7 – Lung retraction. To avoid using large lung retractors, several solutions are available: (a) use of 3-mm grasping forceps; (b) use of mini-retractors that can be released inside the chest cavity and pulled through the chest wall by a thread.

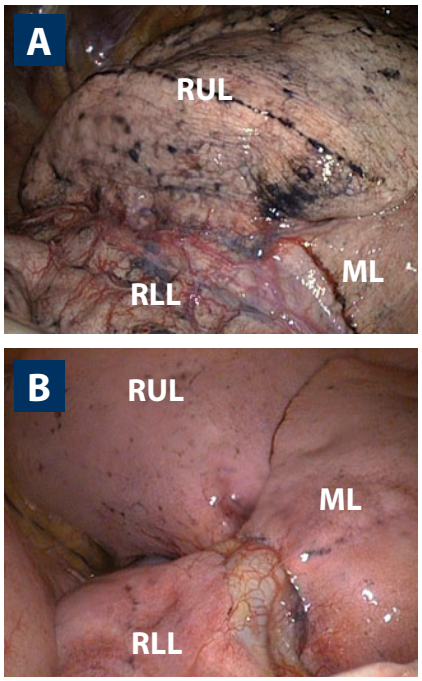


Fig. 8 – Example of fused (a) and separate (b) fissure that gives direct access to the pulmonary artery.

oozing that is troublesome during a thoracoscopic operation where the operative field must remain as dry as possible to maintain optimal vision. One of the keys to a bloodless dissection is to progress step by step, from the periphery to the hilum. We have found thin instruments such as ultrasonic (SonoSurg™, Olympus) or electrothermal bipolar shears (LigaSure™, Valleylab) to be less cumbersome and as effective as stapler for the division of the external part of the fissure. For the inner thick part of the fissure, stapling is however required. A guide is usually necessary to drive the stapler jaws without excessive friction and force on the tissue. We use a small-diameter silicone suction tube whose base is connected to the stapler tip, or we retract the fissure with a tape (**Fig. 9**) .

With a direct-viewing telescope, the division of the fissure can be difficult because its length may make sharp vision on both of its extremities almost impossible. A deflectable tip thoracoscope is of great help during this step because it allows a bird's-eye view of the whole fissure throughout the dissection.

In case of fused fissures, identifying some branches of the pulmonary artery (PA) is tedious. This is usually not an issue for lower lobectomies but can be a real concern for upper lobectomies, since the branching pattern exhibits many variations, especially on the left side. Therefore, preoperative knowledge of vascular anatomy can be helpful. Three-dimensional reconstruction with volume rendering technique provides an accurate vascular mapping of the lobe or segment to be dissected. This preoperative investigation is time-consuming but does not have additional cost or invasiveness, since a preoperative CT with injecting contrast medium is needed anyway.

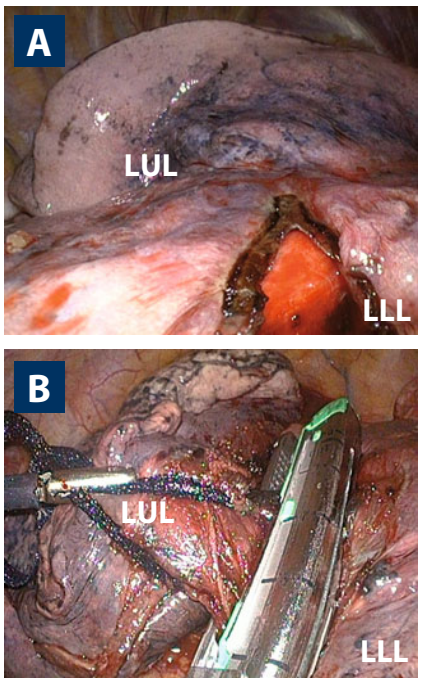


Fig. 9 – Fissure division: (a) division of a thin peripheral part of the left fissure using bipolar sealing; (b) Stapling of a thick central part of the left fissure.

Exposure of bronchial and vascular elements

Exposing and retracting a bronchus or a vessel is frequently necessary when it needs to be loaded within the jaws of a clip applier or an endostapler. The latter must be passed as smoothly as possible. One can use some deflectable devices (Endo-MiniRetract™, Covidien or Goldfinger™, Ethicon whose tip has the advantage of being atraumatic and has a keyhole for a sling) (**Fig. 10**). These instruments can be used both for retraction and for some blunt dissection to create space around the element to be stapled. If this is not sufficient, a guide can be used. We use a chest tube or a 16 Fr suction tube (Gentle-Flow™, Kendall©) (**Fig. 11**). Its base is secured to the anvil by simple pressure. This can be done inside or outside the chest. Its distal end is passed around the structure to be divided and pulled out through the trocar tube. The stapler tip is thus guided around the tissue to be stapled.

Vascular control

Whenever possible, clips should be avoided because they may slip or conflict with staples. However, medium-diameter vessels such as some segmental pulmonary branches are too small for an endostapler and too large to be coagulated with electrocautery or ultrasounds. When clips are used, they are doubled or even tripled. Another solution is to apply a clip at the origin of

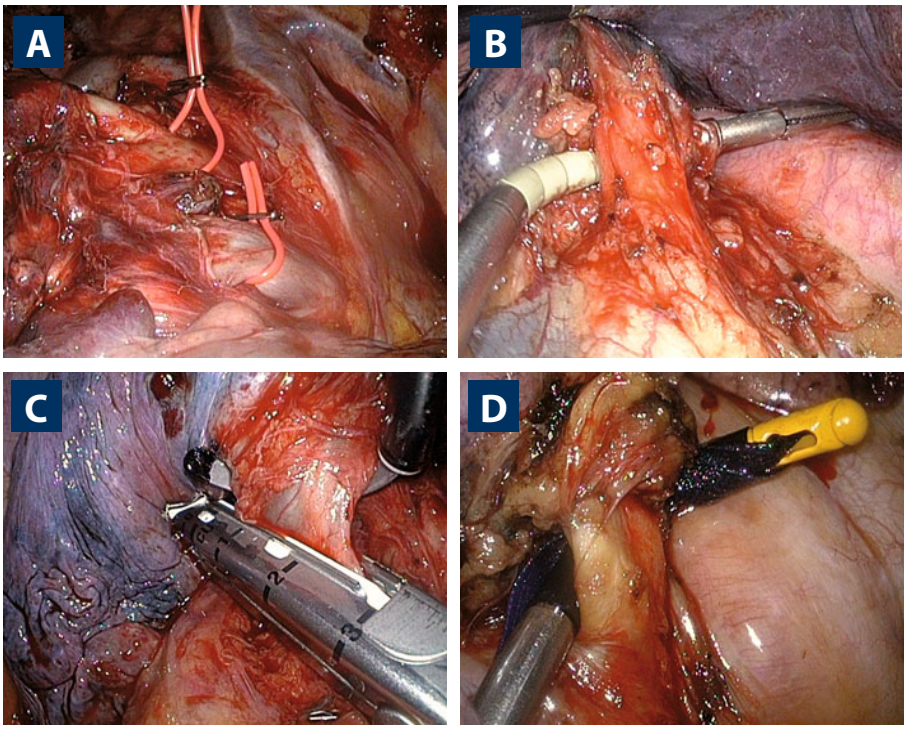


Fig. 10 – Technical tricks to facilitate retraction of vessels and their exposure: (a) use of tapes or slings; (b) use of a 5-mm deflectable forceps; (c) use of a memory-shape 5-mm retractor; (d) use of a 5-mm deflectable retractor whose tip has a keyhole for a sling.

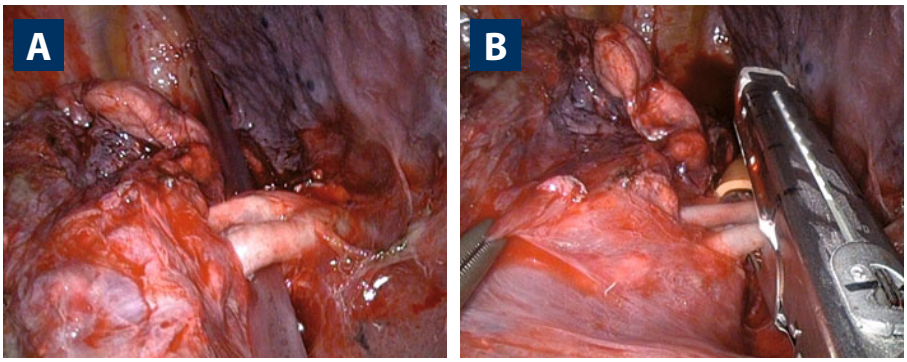


Fig. 11 – Facilitating the passage of the endostapler for arterial division during a thoracoscopic right basilar segmentectomy using a thin suction catheter as a guide. The tip is first passed behind the vessel (a) and then pulled out to attract its basis connected to the stapler jaw (b).

the vessel and complete division with bipolar sealing, so that only one clip is present in the operative field. For all other minor vessels, we use ultrasonic shears (US) (EndoSurg™, Olympus) or a bipolar vessel sealing device (VSD) (Ligasure™, Covidien) (**Fig. 12**). Large vessels are stapled. Complications related to stapling of bronchus or parenchyma are rare but have been reported, while accidents with vascular stapling are extremely rare. However, the stapler must load the vessel without any force or friction, which implies a perfect vascular dissection. Lymphadenectomy is done only with VSD, and clips are almost never used (see page 22). A suction device can be activated all over the dissection time for immediate evacuation of smoke and mist.

Vascular injuries

Avoiding bleeding and massive vascular injury is a constant concern throughout the procedure. Some authors have advocated clamping the main pulmonary artery using a silk suture in order to control any bleeding. This maneuver can be easily achieved during conventional open procedure or even during some VATS procedures through a utility mini-thoracotomy. But

it seems at risk to be done via a totally endoscopic approach because a tear of the main pulmonary artery cannot be controlled. This is one limitation of the endoscopic approach. However, in patients presenting with a regular anatomy, the risk of major vascular injury is minimal due to the close-up dissection and camera magnification. Dissection becomes more risky when neoplastic or inflammatory lymph nodes are present and prevent opening of the vascular sheath that is adherent to the underlying vessel. These situations should lead to abandon and convert to an open procedure.

Massive hemorrhage: Although it has never occurred in our experience, a massive bleeding that is not controllable by thoracoscopy should lead to introduce gauzes through the larger port and temporary control bleeding by pressure, while the surgeon convert to thoracotomy. This outlines the importance of having the conventional thoracic instruments ready on a separate operative table.

Minor hemorrhage: A 5-mm clamp must be available (**Fig. 13a**). An alternate solution is the use of throw-off vascular bulldog clips (Aesculap©) (**Fig. 13b**). They are used for controlling an hemorrhage or during the

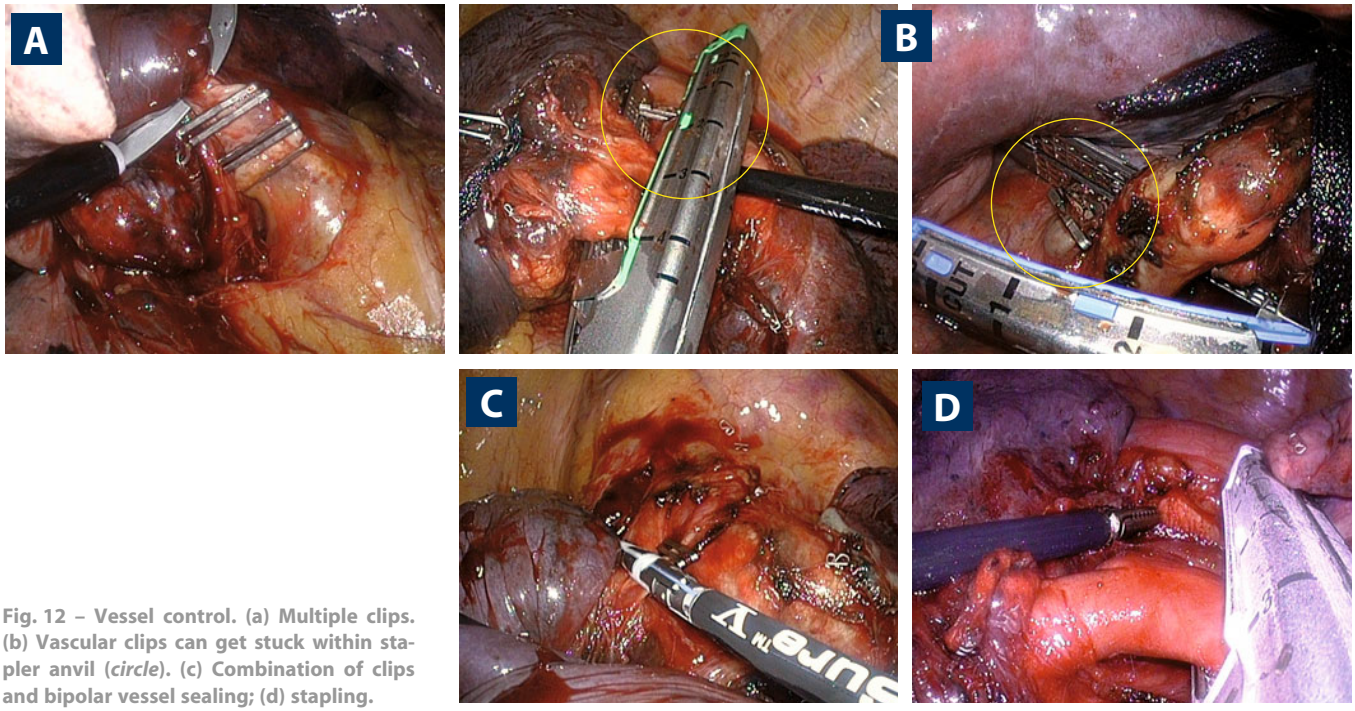


Fig. 12 – Vessel control. (a) Multiple clips. (b) Vascular clips can get stuck within stapler anvil (*circle*). (c) Combination of clips and bipolar vessel sealing; (d) stapling.

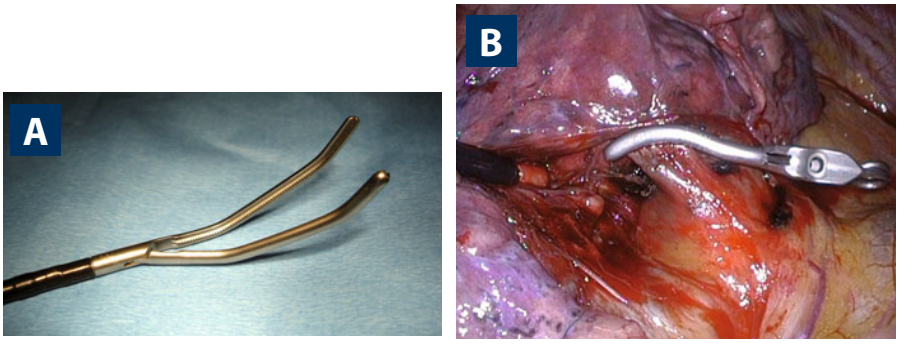


Fig. 13 – Vascular clamps. (a) Conventional thoracoscopic clamp to be inserted trough a flexible trocar; (b) throw-off bulldog clamp.

temporary occlusion of a vessel. They are inserted through a 12-mm trocar using a dedicated applier that is withdrawn after the device has been applied. The same instrument is used for retrieving the device.

Intersegmental plane and division of the parenchyma

Once bronchovascular elements have been controlled and divided, the division of the parenchyma, i.e., intersegmental plane or fused transverse fissure, can actually be one of the most difficult steps. This is a part of the procedure where one does regret not having the assistance of hand in order to feel and compress the parenchyma and precisely place the stapler. The main concern is that the surgeon usually needs reventilation – after bronchial clamping – to detect the limit between the ventilated and the non-ventilated segments. But reventilation reduces the space and hampers vision. Ventilation must be done with low volumes while a long 5-mm clamp compresses the lung (**Fig. 14**). Once the intersegmental plane has been found and if the stapler cannot be immediately applied, it is sometimes helpful to mark the line between the inflated and the deflated lung parenchyma with small dots using diathermy (**Fig. 15**). Another technique is to reventilate only the lobe or the segment to be resected, using jet ventilation. In this technique, the bronchus to be divided is first intubated with a bronchoscope and selectively reventilated, so that the rest of the parenchyma keeps without air (**Fig. 16**).

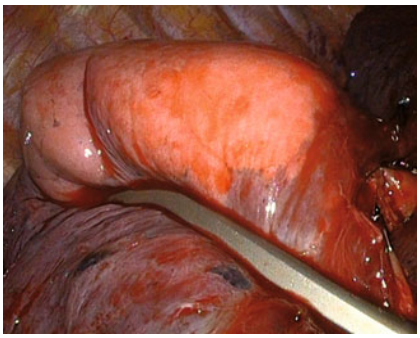


Fig. 14 – Clamping the parenchyma to determine the intersegmental plane (in this case, a right superior segmentectomy) is achieved with a dedicated endoscopic 5-mm clamp.

Fig. 15 – Marking the intersegmental line with dots during a right superior segmentectomy.

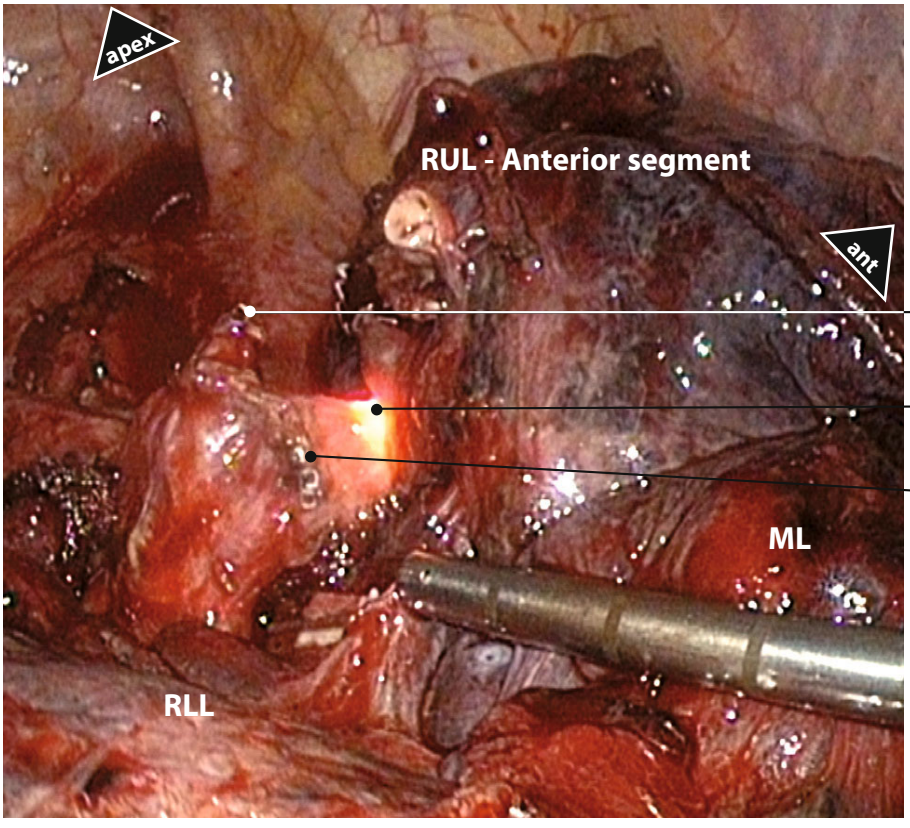


Fig. 16 – Example of selective endoscopy of a segmental bronchus during a right apicoposterior segmentectomy.

Specimen retrieval

It would not be recommended to morcellate the specimen as done in other fields of surgery, since it is of outmost importance to analyze the bronchus and the peribronchial lymph nodes and to check that all margins are free. The lobe or segment must be retrieved en bloc. For a segmentectomy, enlarging a port on a 2–3 cm length is sufficient. For a lobectomy, the port must be enlarged on a 3–5 cm length, depending on the specimen and patient's size. The use of a retractor is never necessary. A solid and large specimen bag must be used (**Fig. 17**). The incision should be done at a site where the intercostal space is soft, preferably in the lower part of the chest on the anterior axillary line or in the axilla (**Fig. 18**).

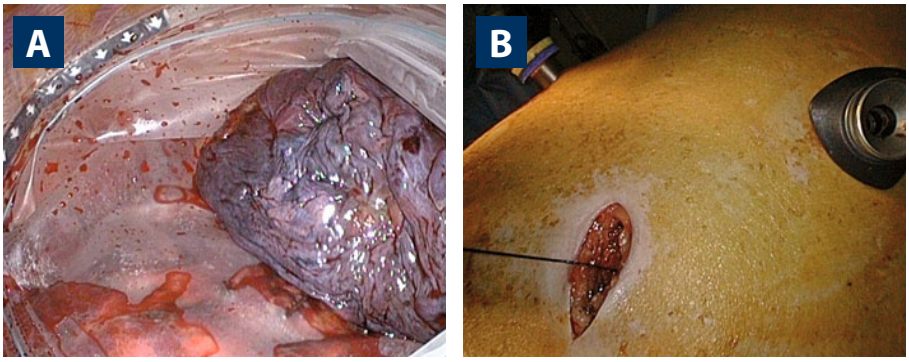


Fig. 17 – Specimen retrieval. (a) Placement of the specimen into a retrieval bag; (b) enlargement of one of the ports on a 3–4 cm length.

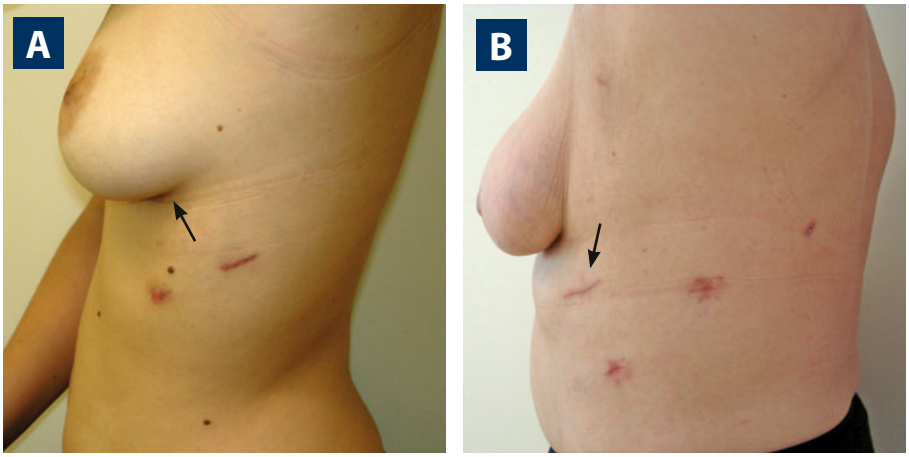


Fig. 18 – Extraction incisions (*arrows*). Results at one month after a segmentectomy (a) and a lobectomy (b).

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Chapter II Endoscopic mediastinal lymph node dissection

Definition

The major pulmonary resections that will be described in the following chapters are mostly done for lung cancer. Surgical treatment of lung carcinoma with curative intent requires complete resection, i.e., microscopically proved free resection margins and systematic nodal dissection. A systematic lymph node dissection means:

- excision of hilar and intrapulmonary lymph nodes;
- excision of the mediastinal fat and enclosed lymph nodes that are dissected and identified.

The extent of lymphadenectomy is still a controversial issue. Many different types of lymph node dissections are found in the literature, ranging from mere sampling to extended lymphadenectomy. In this chapter we will focus on mediastinal lymph node dissection as defined by the American College of Surgeons Oncology Group Z0030 trial, i.e.:

- for right-sided tumors, removal of all lymphatic tissue bounded by the right upper bronchus, the right subclavian artery, the superior vena cava, and the trachea (stations 2R and 4R);
- for left-sided tumors, removal of all lymphatic tissues bounded by the phrenic nerve, the vagus nerve, and the top of the aortic arch (stations 5 and 6); and
- for both sides, removal of lymph nodes from stations 7 to 11.

Specific issues related to the endoscopic approach

Difficulties faced during mediastinal lymph node dissection vary. They are related to the amount of fatty tissue, to the number and nature of lymph nodes, and to the difficulty in reaching and exposing some stations, especially station 7 from the left-side approach.

A perfect vision is necessary during mediastinal lymph node dissection. An oblique-viewing (30°) scope or a deflectable thoracoscope is almost essential to avoid the drawbacks linked to tangential vision, as it frequently occurs with a low-inserted scope. Dedicated instruments are also helpful. The study of textbooks dealing with lymphadenectomy shows that the hand is widely used for retraction of organs, such as the lung or the main bronchi, in order to expose the subcarinal region and/or to ensure sufficient working spaces. Manual assistance cannot be used during endoscopic dissection and must be replaced by the use of atraumatic instruments.

In order to limit the number of ports, we use either 3-mm retracting devices or throw-off retractors for the lung. Even when operating with caution, it is hard avoiding fragmenting lymph nodes. The use of atraumatic, fenestrated grasping forceps minimizes this risk. In case of hemorrhage from a broken node, hemostasis is performed by bipolar cautery. During open or video-assisted

lymphadenectomy, small vessels are usually controlled by a combination of clipping and transection. This is time-consuming during endoscopic dissection and can be replaced by either ultrasonic shears or a vessel sealing device (VSD), which allows both coagulating and transecting with a single tool. Previously, we were using ultrasonic scissors, but we switched to VSD because the cavitation effect created by ultrasonic devices made dissection less accurate. In addition, the active blade and/or its tip, which is not always under vision control during lymph node dissection, can provoke adverse effects.
In summary, the following equipment is needed to achieve a satisfactory endoscopic lymphadenectomy: high-definition imaging, oblique-viewing or deflectable scope, blunt tip retractors, and multifunctional hemostatic instruments, preferably a VSD.

Technique

Stations 11 and 12

Interlobar nodes are encountered during fissure and lobar dissection (**Fig. 1**). Their excision is usually straightforward when they are free and have few adhesions with underlying vessels, which is the case for most patients operated on for clinical stage 1 tumor. The main concern is avoiding tearing and fragmenting the nodes since this provokes troublesome oozing and even hemorrhage for which control can be tedious. Prudent and step-by-step dissection with immediate hemostasis of any bleeding from a node should be done. A helpful tool is the multifunctional bipolar dissector-scissor (Aesculap®), which avoids instrument interchange (**Fig. 2**). Should an important ooze occur, one of the easiest ways to control it is compression by a temporary packing using a swab introduced through the largest port.

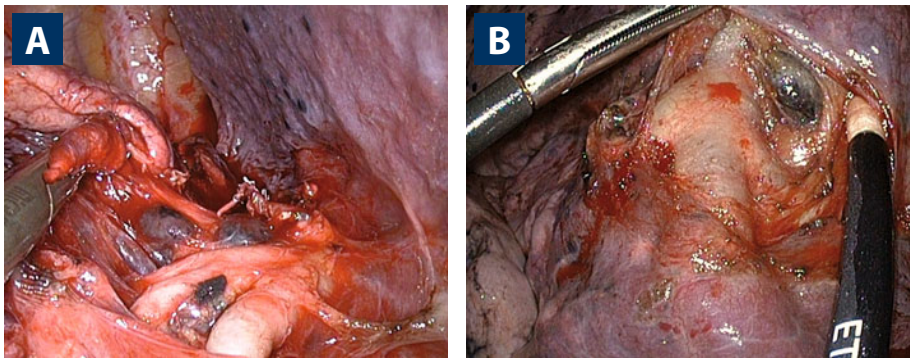

Fig. 1 – Station 11: example of interlobar nodes that must be cleared during dissection.

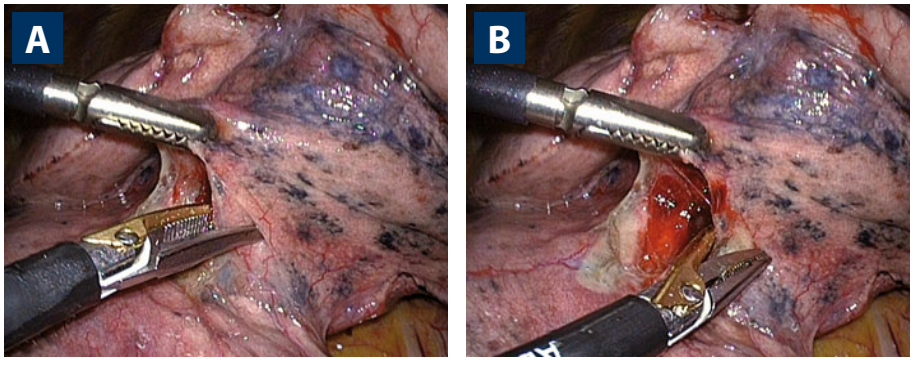

Fig. 2 – Use of multifunctional bipolar «dissecting forceps-scissor» during station 11 node dissection. (a) Coagulation mode. (b) Cutting mode.

When lymph nodes are inflammatory or invaded and are adherent to the underlying artery, their dissection becomes hazardous. Conversion to a thoracotomy is advisable.

Station 10

Nodes in the periphery of the main lobar bronchi can be difficult to excise, especially those located at the origin of the right upper lobe bronchus (**Fig. 3**). These nodes, which are frequently adherent to the bronchial wall, should be progressively excised or swept away toward the specimen side. Care should be taken not to injure the bronchus and not to tear bronchial arteries. These dissections are facilitated by high-definition imaging, close-up viewing, and bipolar technology (**Fig. 3**).

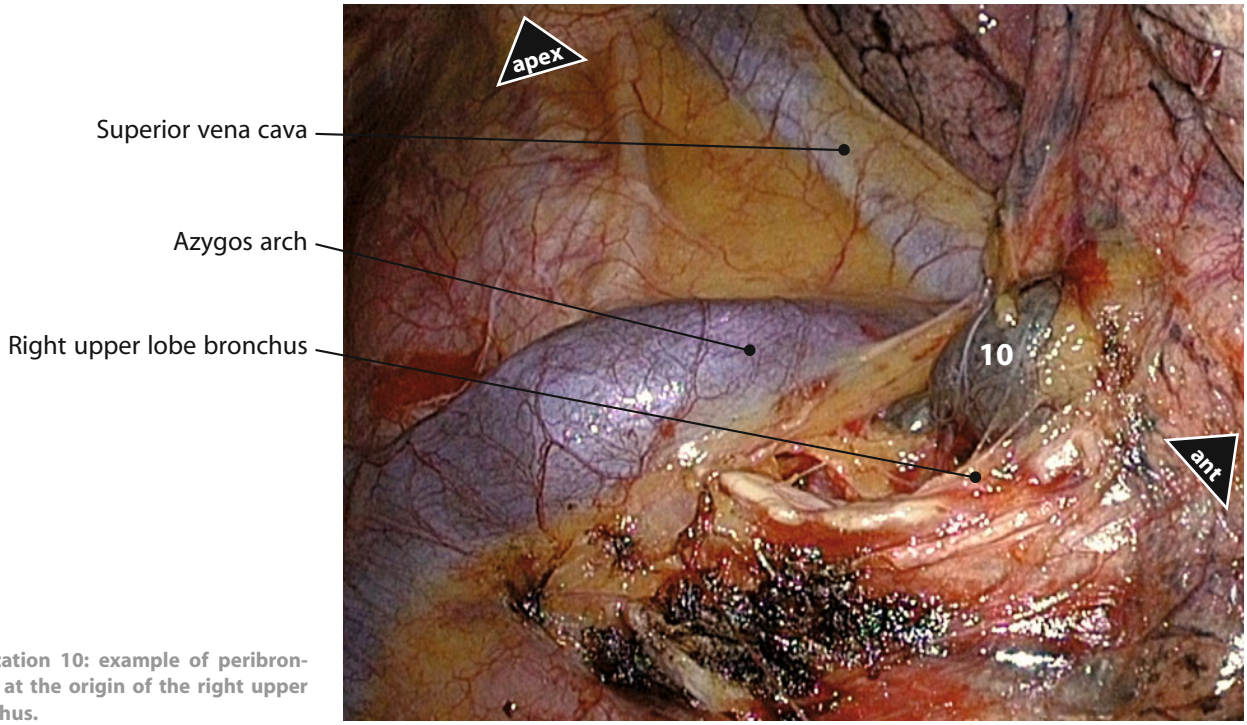

Fig. 3 – Station 10: example of peribronchial node at the origin of the right upper lobe bronchus.

Stations 9 and 8

Dissection of the lymph nodes in the pulmonary ligament (station 9) is usually straightforward. It is started from the diaphragmatic attachment of the pulmonary ligament and continued upward with the dissection of the paraesophageal nodes (station 8) (**Fig. 4**). These nodes are close to fragile organs, i.e., the esophagus and the inferior pulmonary vein. Thus, cautious dissection and the use of bipolar diathermy are recommended.

Station 7 (left-side approach)

As for open surgery, the difficulties faced during the dissection of station 7 from the left side are variable. It can be simple when the tissues are soft or difficult when the nodes are adherent and located in a deep groove between the esophagus and the two main bronchi.

Once stations 8 and 9 have been dissected, the incision of the posterior mediastinal pleura is continued up to the aortic arch. The vagus nerve is located and the esophagus retracted posteriorly with a blunt tip

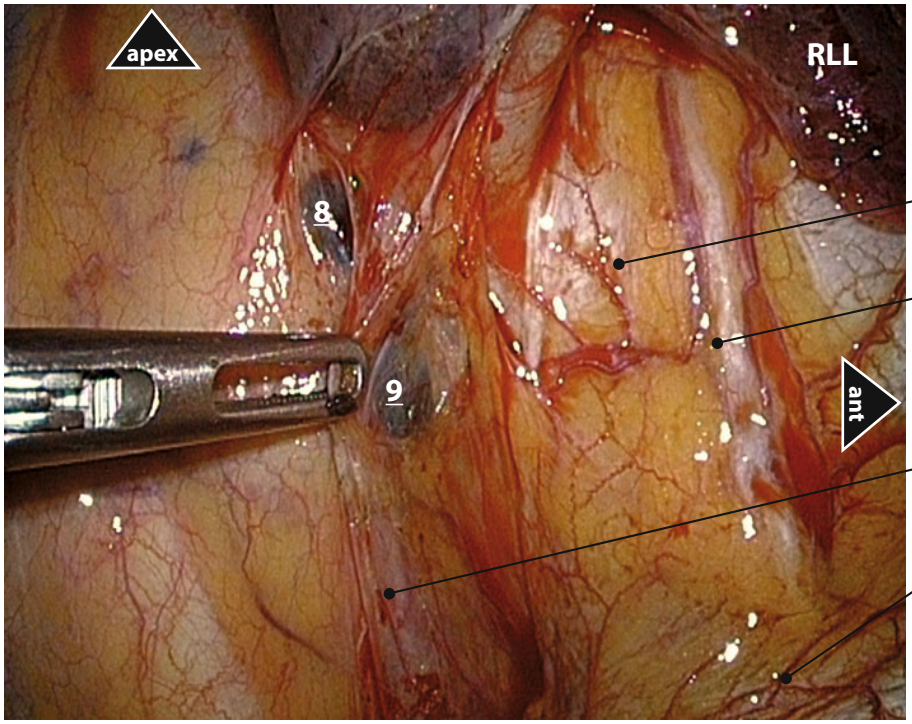

Fig. 4 – Stations 8 and 9. Dissection is achieved by pulling the lower lobe upward and freeing the pulmonary ligament.

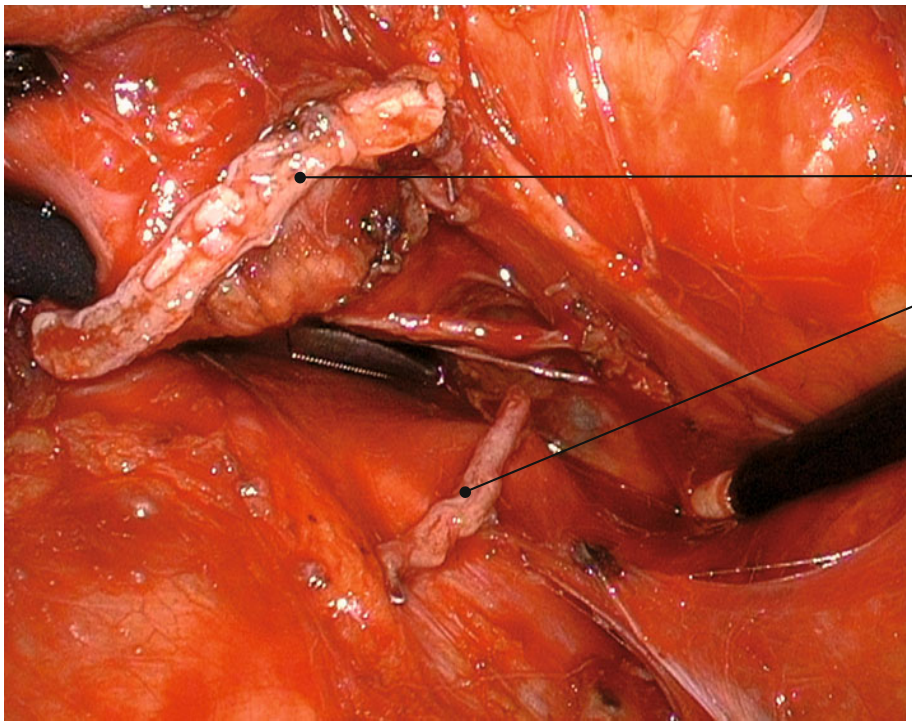

Fig. 5 – After a left inferior lobectomy, the stump of the inferior pulmonary vein can hamper the access to the subcarinal region. It may be advisable to perform lymph node dissection before the pulmonary resection.

Since exposure of the subcarinal region can be difficult, it is advisable to perform this step before the pulmonary resection. Indeed, the vision can be partly obscured by the stump of the left inferior pulmonary vein (in case of a lower lobectomy). In addition, this prevents the risk of tearing a vascular or a bronchial stump during lung retraction (**Fig. 5**).

instrument, thus exposing the subcarinal lymph nodes and/or the right main bronchus (**Fig. 6**). The lymph nodes are dissected with caution to avoid any troublesome oozing, and the carina is progressively cleared. Excessive traction on lymph nodes should be avoided to prevent injury of a bronchial artery for which control can be tedious. Clearance of the internal aspect of the right main bronchus may make it necessary to retract the left lung anteriorly with some force.

Should retraction of the esophagus be necessary, it must be done with a blunt tip device and monitored throughout the procedure to prevent any esophageal injury. This is the same as for the use of suction in this region.

Stations 6 and 5

The left upper lobe is retracted downward. The endoscope is then positioned in such a way that a bird's-eye view on the aortopulmonary window is obtained (**Fig. 7**). The phrenic nerve and the vagus nerve are identified. The mediastinal pleura facing the aortopulmonary window is incised, taking care to preserve the nerves that can be difficult to visualize in some overweight patients. Pleural flaps are gently moved away, and the takeoff of the recurrent laryngeal nerve is identified. This is achieved by prudent opening of the mediastinal fat with a smooth tip dissecting forceps. If necessary, splitting the ligamentum arteriosum can be helpful. All lymph nodes located between the vagus and phrenic nerves (station 6) and all those located adjacent and posterior to the vagus nerve (station 5) are excised (**Fig. 8**).

Station 7 (right-side approach)

The access to station 7 from the right side is much easier than from the left side since the vision on the subcarinal area is direct, and there is no need to retract the bronchi and the surrounding organs.

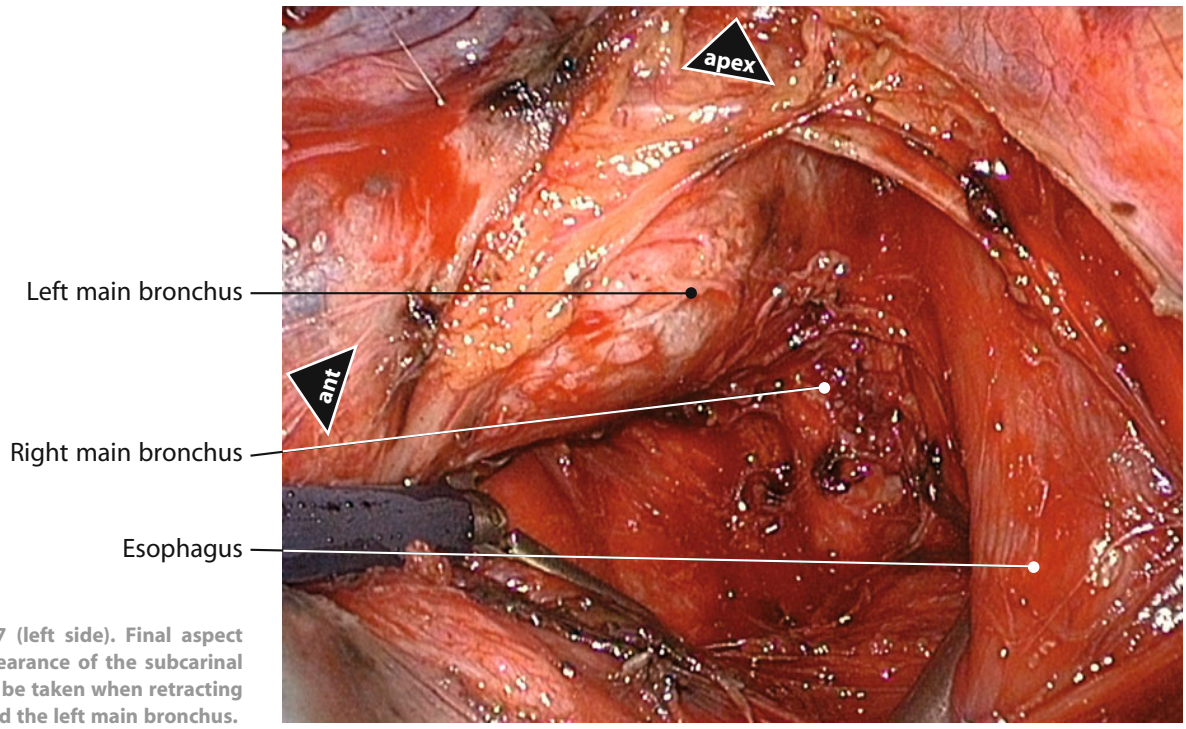

Fig. 6 – Station 7 (left side). Final aspect after complete clearance of the subcarinal area. Care should be taken when retracting the esophagus and the left main bronchus.

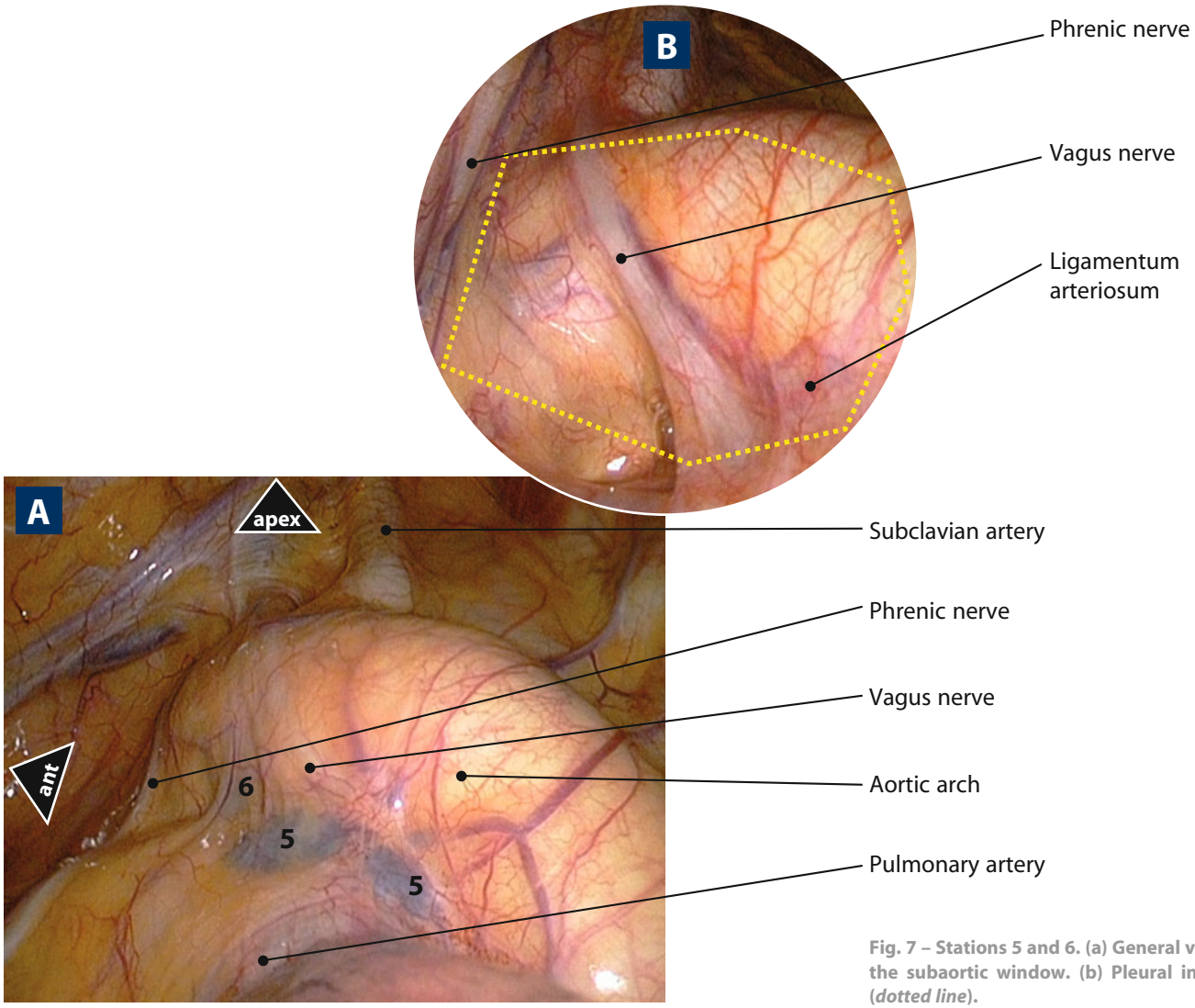

Fig. 7 – Stations 5 and 6. (a) General view of the subaortic window. (b) Pleural incision (*dotted line*).

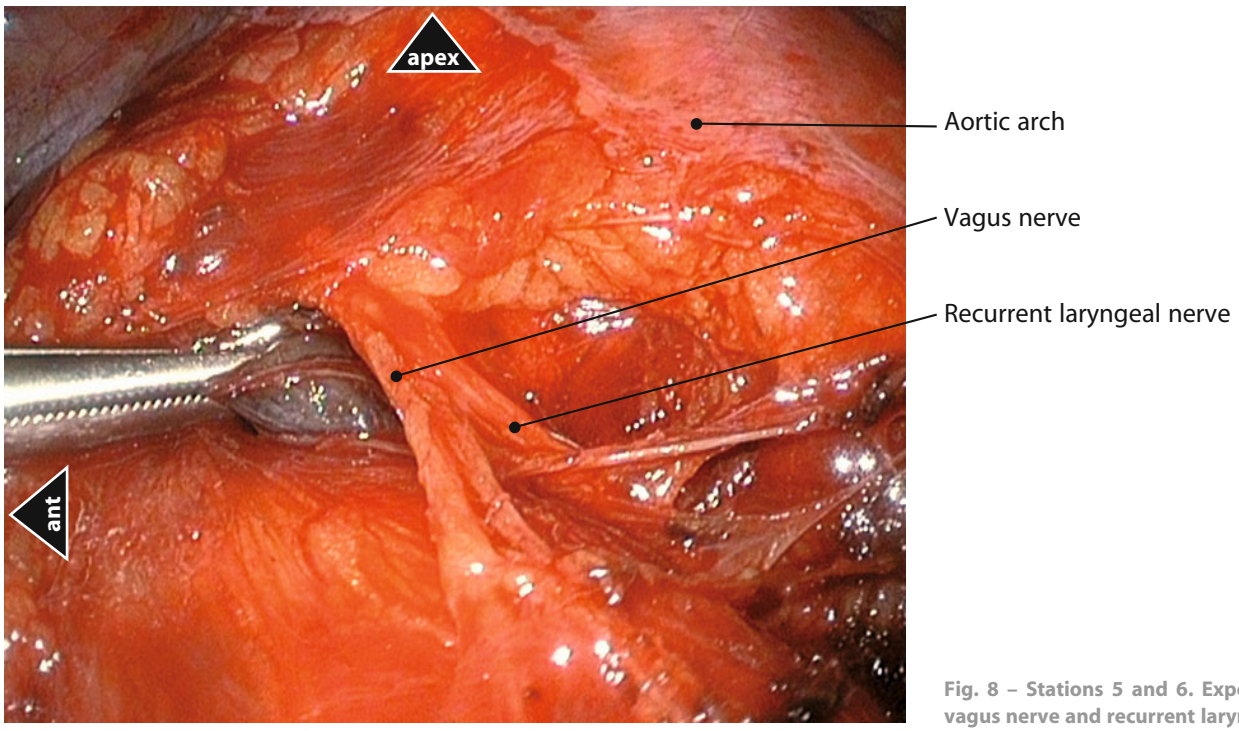

Fig. 8 – Stations 5 and 6. Exposure of the vagus nerve and recurrent laryngeal nerve.

The mediastinal pleura is incised upward, in continuity of the dissection of stations 9 and 8 (**Fig. 9**). The posterior surface of the bronchus intermedius and right main bronchus is clearly visible. Clearance of nodes is performed from the periphery to the carina, taking care to the esophagus, which can be in close contact with some of the nodes (**Fig. 10**). Electrocautery and suction devices must be used with caution.

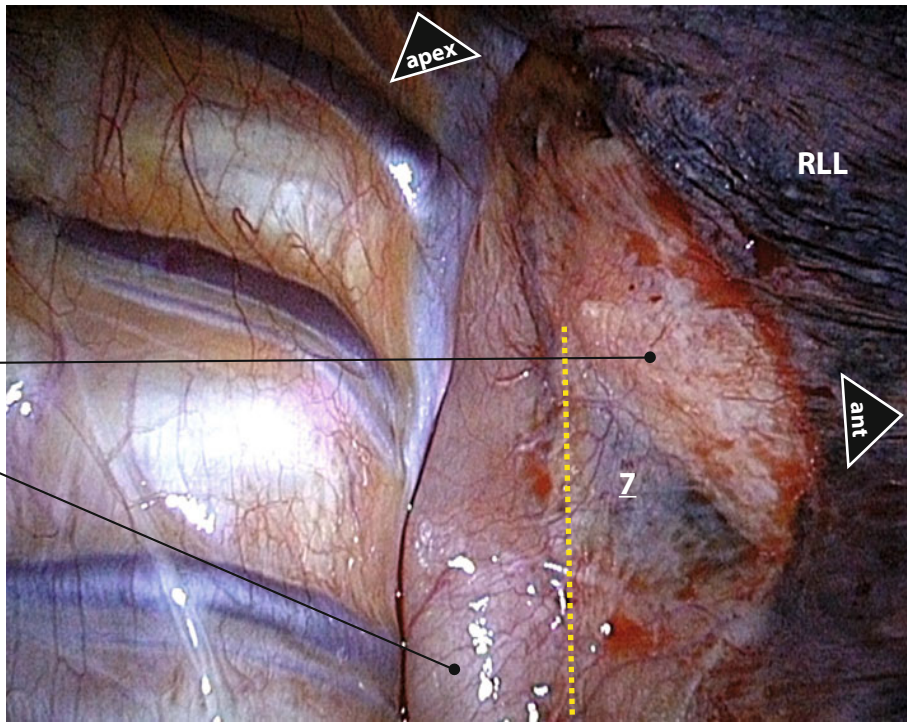

Fig. 9 – Station 7 (right side). Pleural incision (*dotted line*).

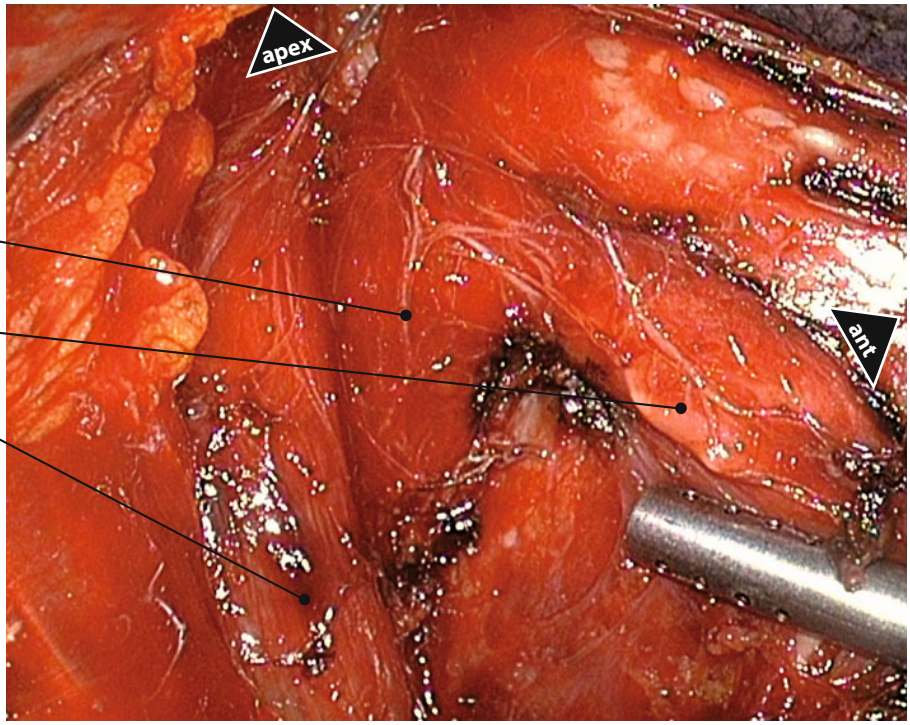

Fig. 10 – Station 7 (right side). Final aspect after complete clearance of the subcarinal area.

Stations 4R and 2R

Even after completion of a right upper lobectomy, the paratracheal region can be obscured by the lung, which must be retracted downward. The endoscope is positioned in such a way that a bird's-eye view on all the area located above the azygos arch is obtained (**Fig. 11**) since a tangential vision can lead to difficult understanding of the anatomy.

The mediastinal pleura is incised horizontally on either side of the azygos arch so that the latter can be lifted up if necessary. Division of the azygos vein is seldom needed in patients operated on for a clinical stage 1 tumor, in whom nodes are usually not enlarged and not invaded. Incision of the mediastinal pleura is then continued so that a square pleural flap is designed. Its limits are:

- inferiorly, the azygos arch;
- superiorly, the lowest visible part of the subclavian artery;
- anteriorly, the posterior aspect of the superior vena cava;
- posteriorly, the posterior aspect of the trachea.

The pleural flap is removed, and the fatty tissues are dissected and removed en bloc with the nodes. Dissection and division of the mediastinal tissue is best achieved by bipolar sealing.

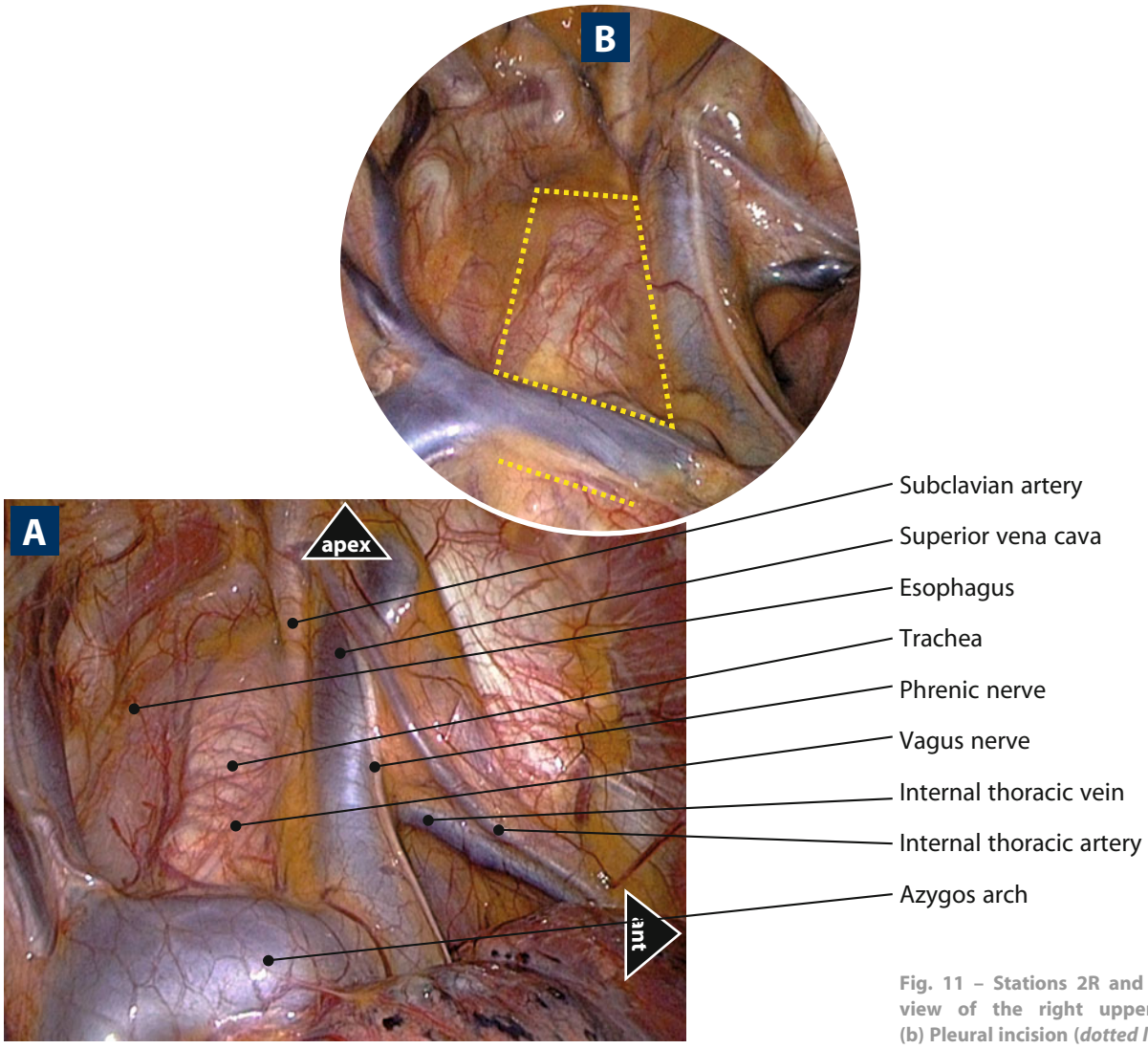

Fig. 11 – Stations 2R and 4R. (a) General view of the right upper mediastinum. (b) Pleural incision (*dotted line*).

All paratracheal nodes located at the level of the middle third of the lateral aspect of the trachea (station 2R) and those located near the angle between the trachea and the main bronchus (station 4R) are removed en bloc. Dissection of 4R nodes may require to lift the azygos vein up, either with an instrument or by taping it (**Fig. 13**).

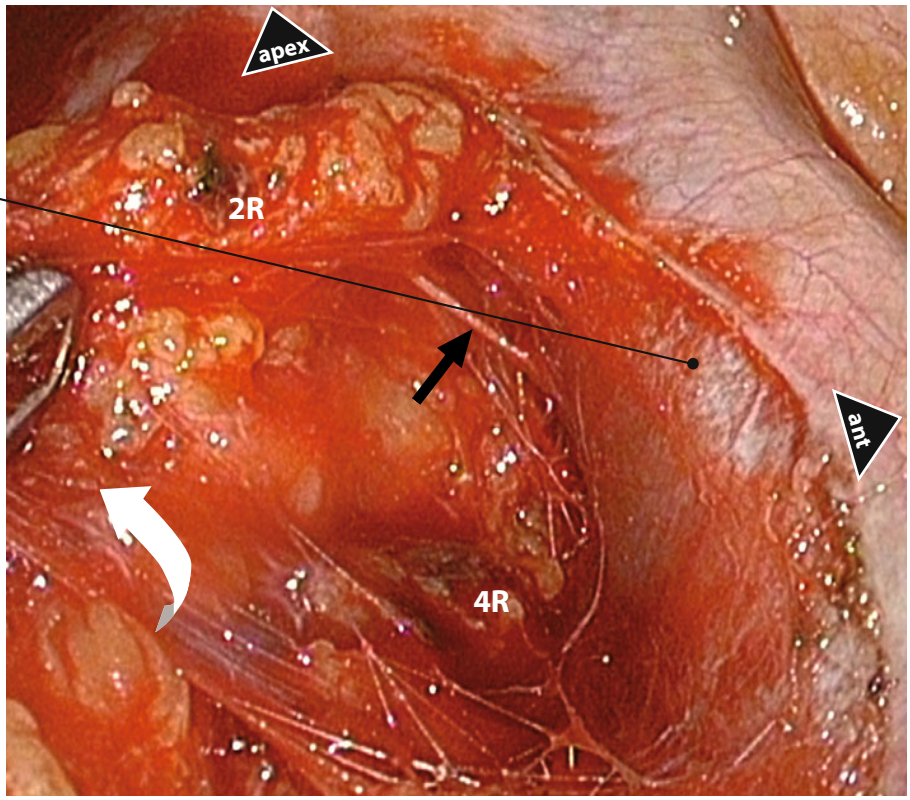

Fig. 12 – Stations 2R and 4R: close-up view of tiny veins arising from the superior vena cava (*black arrow*).

Care should be taken not to tear off the small venous branches arising from the vena cava (**Fig. 12**).

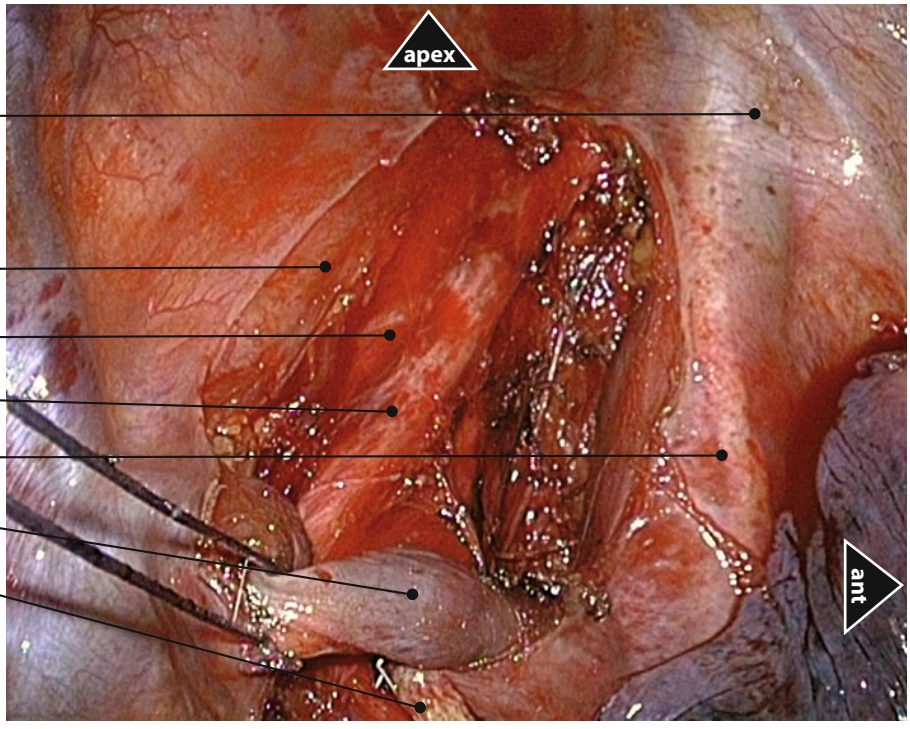

Fig. 13 – Stations 2R and 4R: taping the azygos arch facilitates dissection of station 4R.

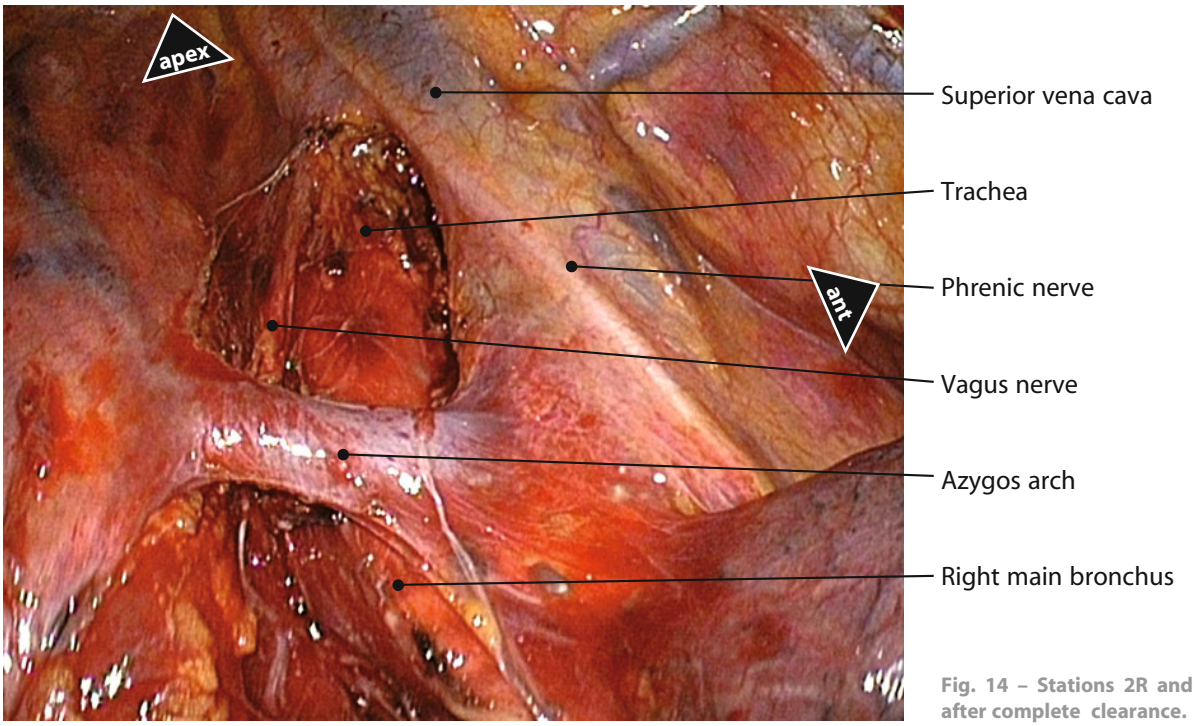

Fig. 14 – Stations 2R and 4R: final aspect after complete clearance.

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General aspects

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: The video of this technique can be consulted on WEBSURG at the following address: http://www.websurg.com/ref/doi-vd01en2922.htm

Lobectomies

III – Right upper lobe

IV – Middle lobe

V – Right lower lobe

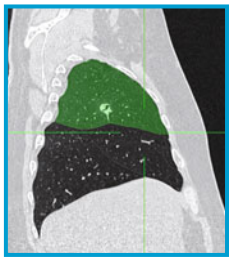
VI – Left upper lobe

VII – Left lower lobe

Chapter III

Right upper lobe

Chapter III Right upper lobe



The right upper lobectomy is a difficult endoscopic procedure. Difficulties are from several orders. The operative field is large, and the scope has to switch from the anterior to the posterior mediastinum and from the apex to the diaphragm. In addition, the following difficulties may be faced:

- The major fissure is frequently fused and sometimes crossed by posterior venous branches from the superior vein.
- Lymph nodes are frequently present at the level of the upper bronchus and can lead to oozing or troublesome hemorrhage during dissection.
- The superior vein and the truncus anterior may be close to each other, so their dissection can be tough. In some cases, it is more advisable to dissect partly from the front and partly from the back. This may require to divide the lobar bronchus first.
- Identifying the interlobar plane between the right upper lobe and the middle lobe can take time.
- Finally, once the upper lobectomy has been completed, securing the middle lobe to the lower lobe is not that simple, because of the lack of global view that makes the proper positioning of the middle lobe sometimes difficult, especially when the latter is fully mobile.

Two different approaches can be used: (1) a classic anterior approach in which the truncus arteriosus and the superior pulmonary vein are controlled first and (2) a posterior approach in which the bronchus is divided first. If necessary, these two approaches can be combined.

Anatomical landmarks (Fig. 1)

- **Bronchus**: In some patients, it may be advisable to divide the bronchus first. The division of the posterior segmental artery gives access to the lobar bronchus. The latter arises from the lateral aspect of the right main bronchus. Lymph nodes are frequent at this level as well as at the bifurcation between the upper lobe bronchus and the bronchus intermedius.

- **Arteries**: The upper lobe arterial supply arises from two main vessels: the truncus anterior, which originates from the hilum, and the ascending artery, which originates within the fissure and usually supplies the posterior segment. The truncus anterior gives the apical and anterior segmental arteries, which can be divided separately or as a stem. In this case, it is of utmost importance to check that one does not mix up this stem with the main pulmonary artery. The posterior segmental branch arises from the posterior aspect of the pulmonary artery, opposite the middle lobe artery, and is controlled within the fissure. In most patients, this artery is single but the number can vary from zero to three branches. The artery is sometimes obscured by the posterior branch(es) of the superior pulmonary vein, which runs in the interlobar plane. One or several lymph nodes are frequently found at this level (so-called sump node).

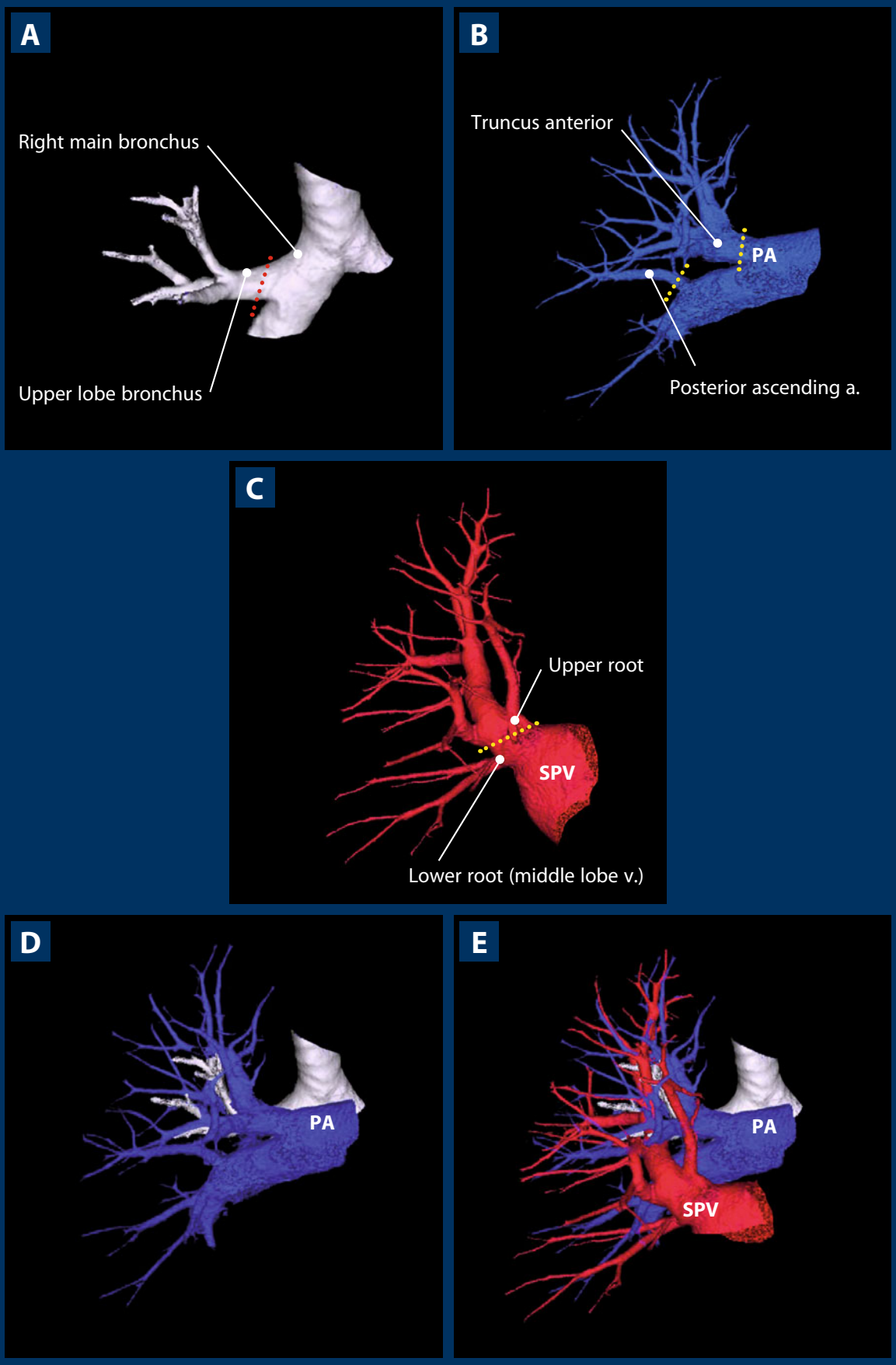


Fig. 1 – Anatomical landmarks. (a) Upper lobe bronchus (anterior view). (b) Arterial supply to the upper lobe (anterior view). (c) Venous drainage (anterior view). The lower root of the SPV is the middle love vein and should be preserved. (d) Relationships between bronchi and arteries of the right upper lobe. (e) Relationships between bronchi, arteries, and veins of the right upper lobe. PA: pulmonary artery, SPV: superior pulmonary vein, dotted lines: level of division, a: artery, v: vein.

- **Veins**: The superior pulmonary vein is the most anterior element. It is sometimes close to the truncus anterior, making its dissection difficult, especially when operating with a direct-viewing scope and instruments coming from low-located ports, which result in a tangential view and dissection. The position of the middle lobe vein must be verified before any division of the three segmental veins, which can be done separately or, more often, as a stem.

Technique 1: anterior approach

1. Hilum

The upper lobe is pulled backward. The mediastinal pleura is incised posterior to the phrenic nerve, down to the superior pulmonary vein. Dissection of the vein is achieved by a combination of bipolar cautery and gentle sweeping motion with an endopeanut (**Fig. 2**).

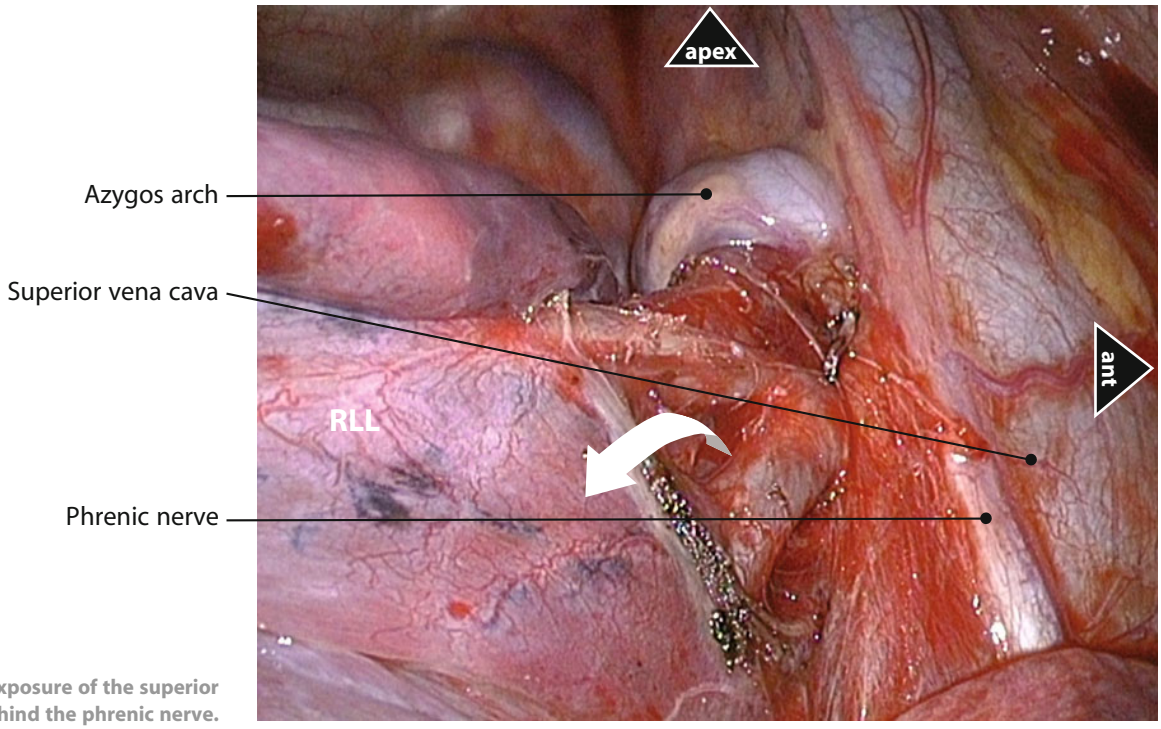


Fig. 2 – Exposure of the superior pulmonary vein behind the phrenic nerve.

The venous branch to the middle lobe (*arrow*) must be clearly identified before encircling the superior pulmonary vein (Fig. 3).

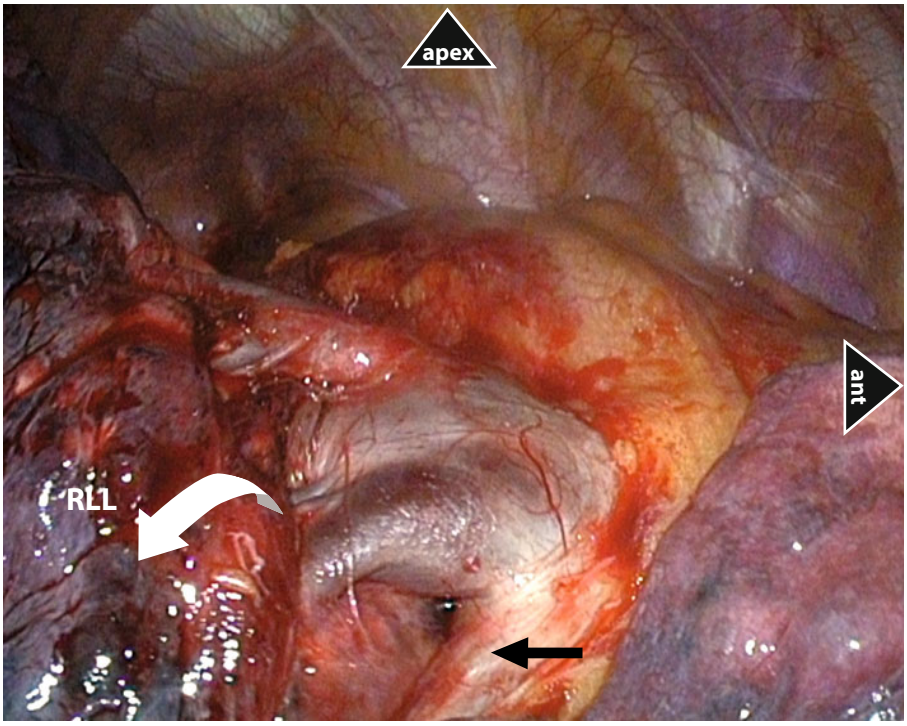


Fig. 3 – Identification of the middle lobe vein (*arrow*), which must be preserved.

It is not recommended to ligate or staple the upper vein first since this may lead to troublesome venous congestion. If possible, this should be done after the arterial control.

Dissection and mobilization of the superior pulmonary vein give access to the two segmental branches (apical and anterior) of the truncus anterior (**Fig. 4**).

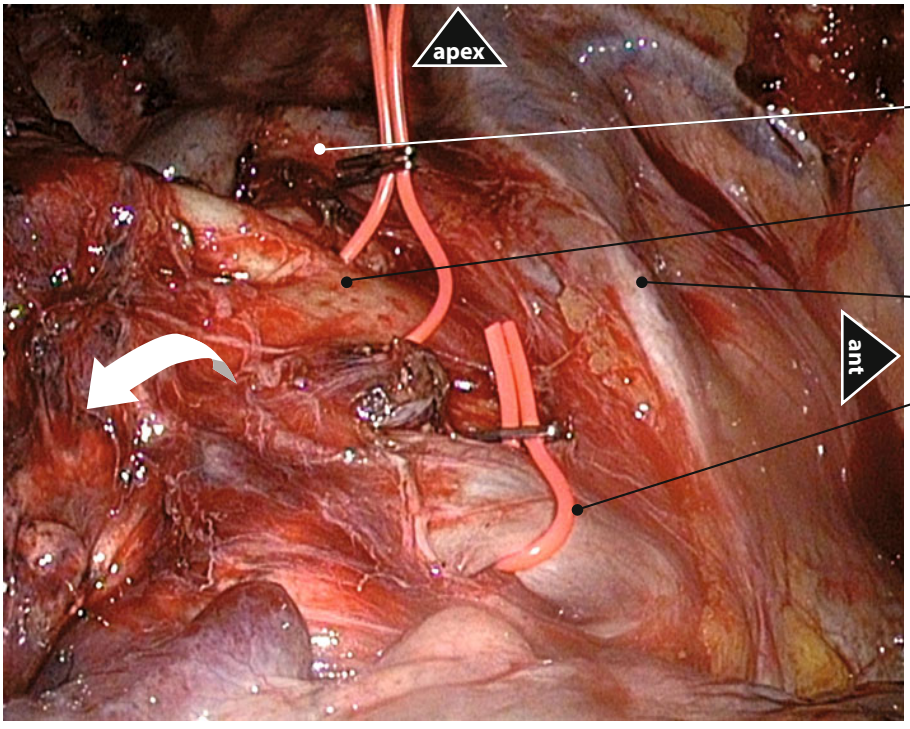


Fig. 4 – Exposure of the superior pulmonary vein and the truncus anterior.

Close-up vision and magnification of the vessels may lead to mistake the truncus anterior for the main arterial trunk. When in doubt, it is advisable to wait for the posterior mobilization of the upper lobe before stapling.

2. Fissure and posterior artery

The second stage is the dissection of the interlobar portion of the pulmonary artery within the major fissure. When the fissure is incomplete or inflammatory, this step can be tedious. Opening the fissure may lead to troublesome minor pulmonary tears and oozing. Thorough progression using a combination of bipolar diathermy and blunt dissection is required until the artery is discovered (**Fig. 5**).

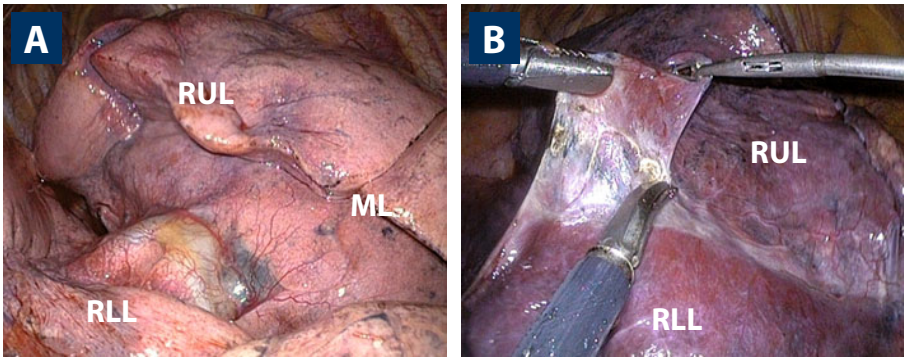


Fig. 5 – Dissection of the pulmonary artery in the fissure.
(a) Easy access to the interlobar pulmonary artery through an open fissure.
(b) Tedious access to the interlobar pulmonary artery through a fused fissure. Note the use of a 3-mm grasping forceps for better exposure.

Once the interlobar artery is identified, the ascending branches to the upper lobe are dissected. In some cases, it may be preferable to first divide the posterior portion of the major fissure since it will facilitate the exposure of the posterior artery. This is achieved by stretching the upper lobe or lower lobe forward, until the posterior mediastinum is fully exposed. The pleura facing the inferior aspect of the upper bronchus is opened using either cautery or blunt dissection or both. A dissecting forceps is then passed from the hilum to the periphery under vision control, thanks to the deflectable scope (**Fig. 6**). Permanent optical control must be kept to avoid injury of the azygos vein or the esophagus by the tip of the dissector.

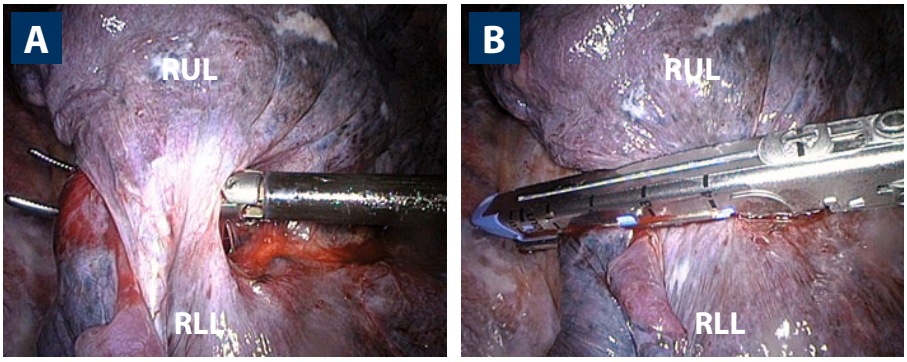


Fig. 6 – Division of the major fissure.
(a) Once the interlobar artery has been identified, a dissecting forceps is passed from its posterior aspect to the posterior edge of the major fissure.
(b) Stapling of the posterior aspect of the major fissure.

Whenever possible, controlling the venous branches by clips should be avoided since these may block the blade of an endostapler.

A 60-mm endostapler can then be applied. This helps exposing the posterior arteries whose number ranges from one to three.
The ascending arteries are clipped and divided. A vessel sealing device or ultrasonic coagulation can also be used if the vessels are small enough (**Fig. 7**).

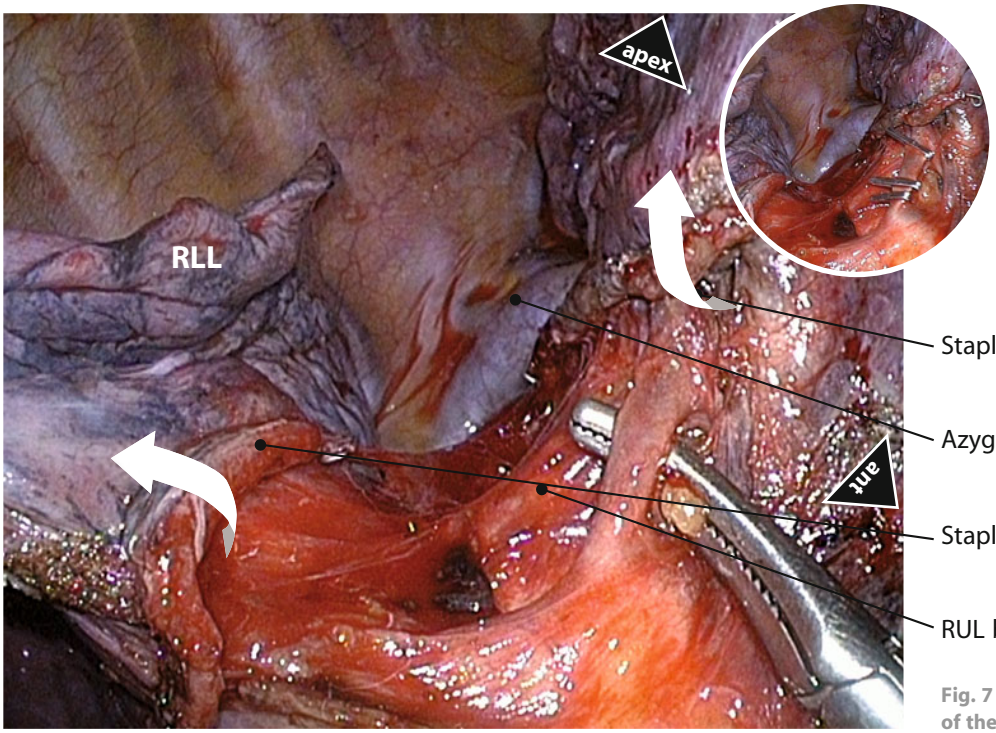


Fig. 7 – Dissection (a) and clipping (b) of the ascending posterior artery.

The presence of large and/or multiple venous branches (*arrow*) within the fissure may increase the difficulty in controlling the arterial branches (Fig. 8).

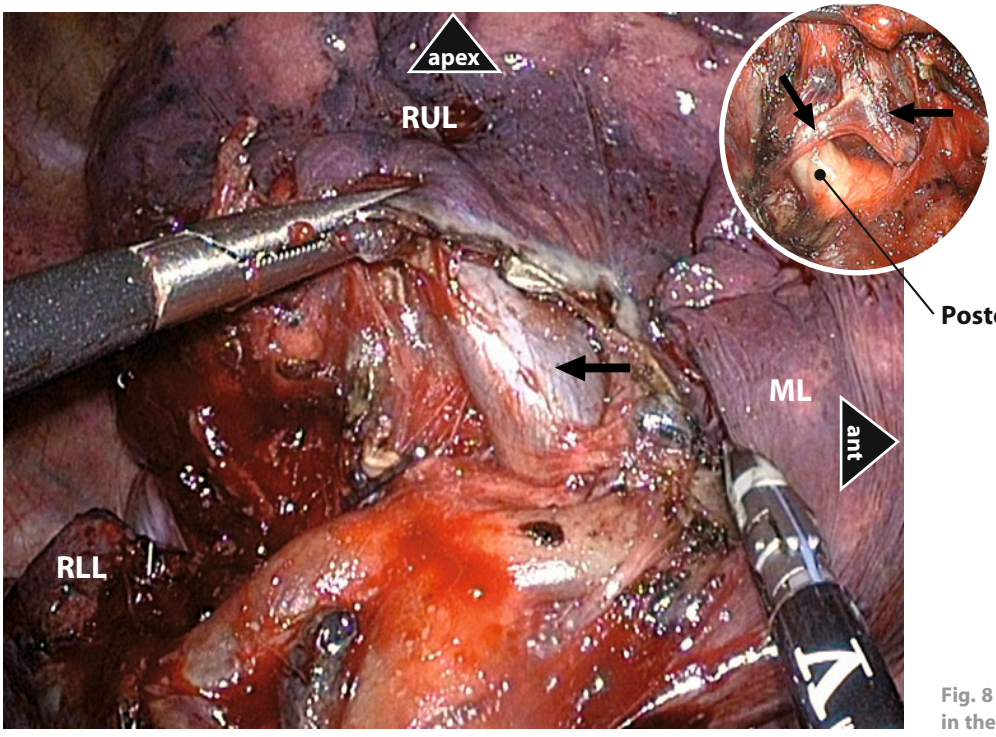


Fig. 8 – Large venous branches (*arrow*) in the fissure.

3. Bronchus

The third stage is the exposure and control of the upper lobe bronchus. The upper lobe is pulled downward and forward so that the posterior and superior aspects of the bronchus are visualized (**Fig. 9**). The tissues and bronchial arteries surrounding the bronchus are freed using a diathermy hook of scissors. Peribronchial lymph nodes are removed during dissection. Traction on the lobe helps exposing the bronchus (**Fig. 10**).

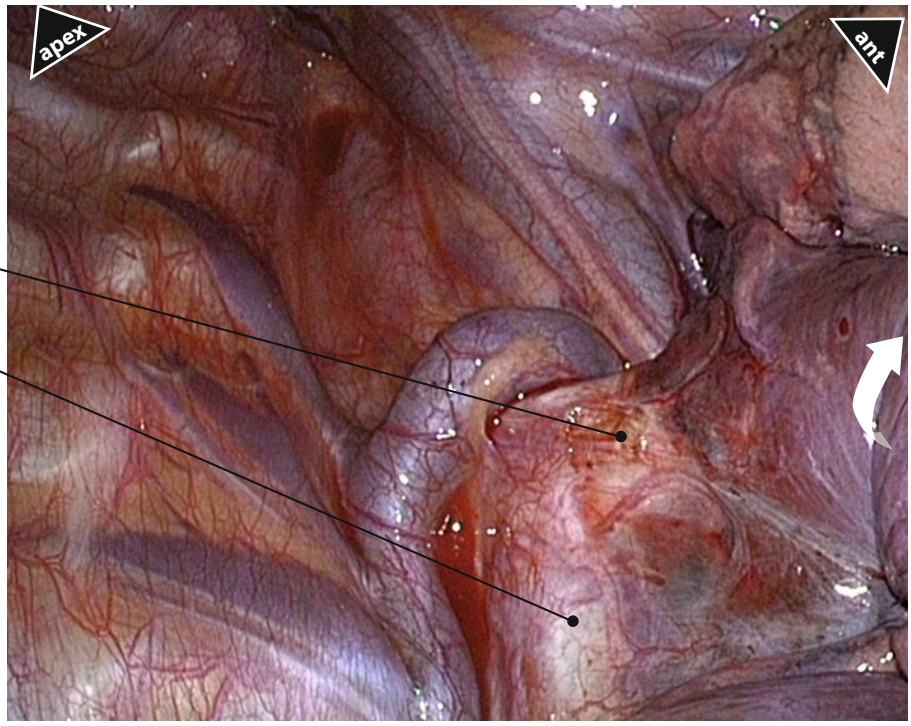
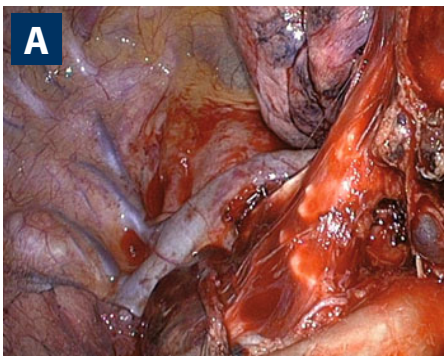
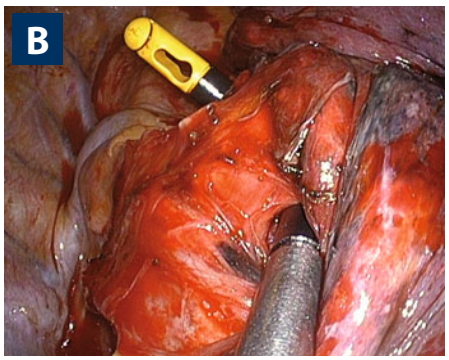


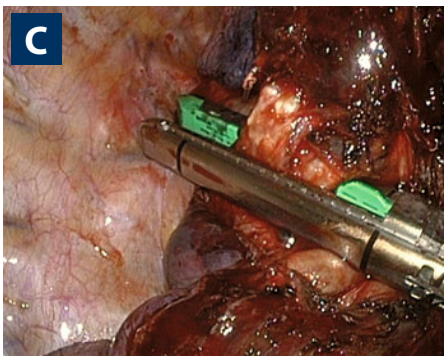
Fig. 9 – The upper lobe bronchus.



Traction on the lobe helps exposing the bronchus.



Encircling the upper lobe bronchus with a blunt tip deflectable retractor.



Stapling the upper lobe bronchus at its origin.

Fig. 10 – Control of the upper lobe bronchus.

Dissection of the anterior aspect of the bronchus must be conducted cautiously and flush against the bronchus wall, especially if the apical and anterior segmental arteries have not yet been stapled.

4. Division of the minor fissure

Once the bronchus has been stapled, the last step is the division of the parenchyma since the transverse fissure is seldom complete.
After having checked once again that the venous branch to the middle lobe keeps remote, a clamp is applied on the parenchyma and its correct position adapted according to the reventilation test. Some pressure is applied on the clamp in order to mark the parenchyma and the stapler is then applied. One to three 4.8-mm cartridges may be necessary to complete the fissure division (**Fig. 11**).
The specimen is retrieved in the usual fashion. After extraction, the pulmonary ligament has to be freed and the middle lobe secured.

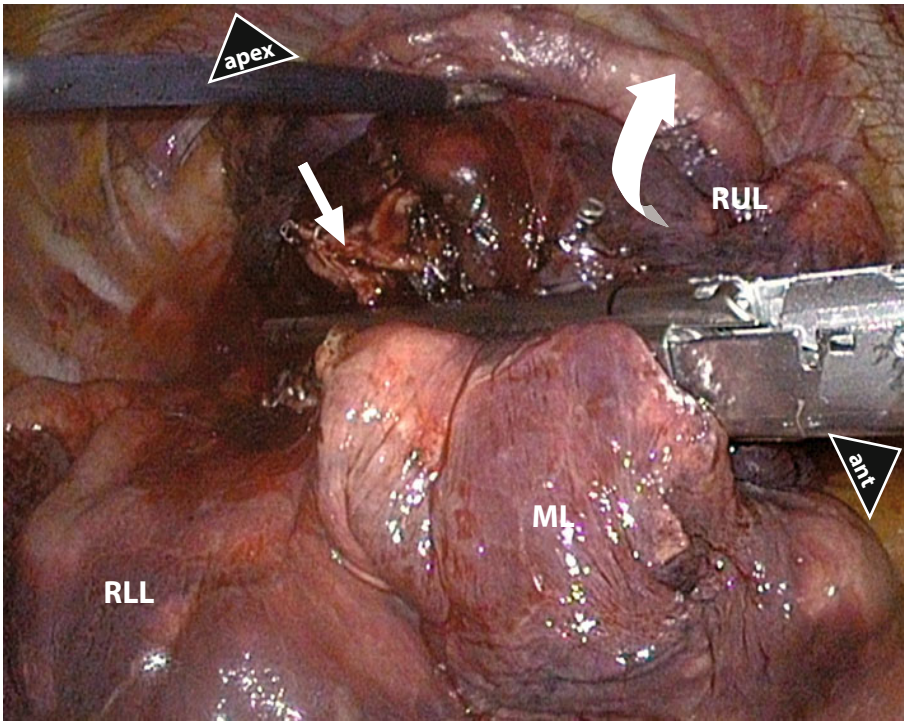


Fig. 11 – Stapling of the transverse fissure. The vascular and bronchial stumps (*arrow*) are kept remote from the stapler jaws.

5. Division of the pulmonary ligament

The pulmonary ligament is divided up to the inferior pulmonary vein using both diathermy and gentle traction on the lower lobe (**Fig. 12**).

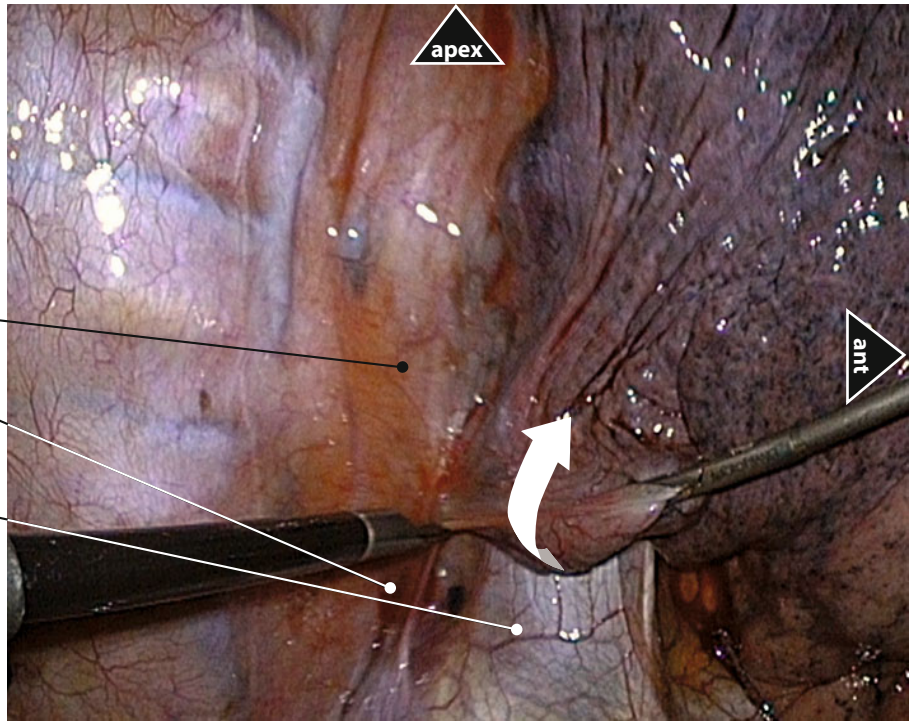


Fig. 12 – Division of the pulmonary ligament.

In some slim patients, the pulmonary ligament can be thin and short so that the inferior pulmonary vein is reached more rapidly than expected. Diathermy must be used with caution.

6. Securing the middle lobe

When the minor fissure is complete, the middle lobe must be repositioned and secured to the lower lobe. Since this is better done under reventilation, there is no room for hand suturing, and it is thus easier to use a stapler without knife (Endo-TA™) (**Fig. 13**).

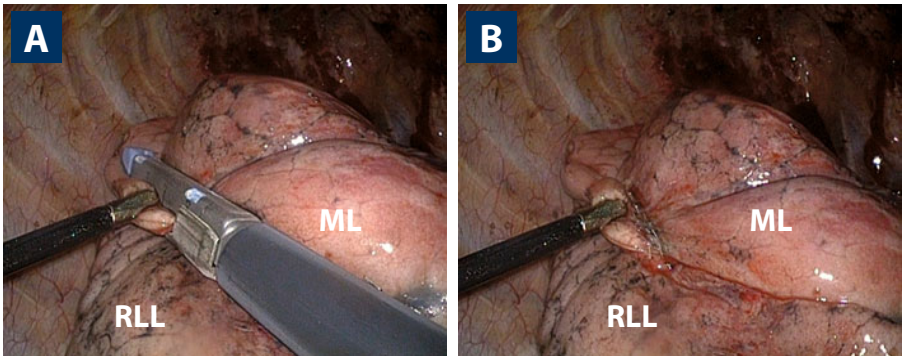


Fig. 13 – Securing the middle lobe to the lower lobe by stapling.

Technique 2: posterior approach

The exposure of the vascular elements in the hilum (truncus anterior and superior pulmonary vein) can be difficult, especially when the truncus anterior is short and close to the superior vein. In these cases, it may be advisable to choose a posterior approach in which the bronchus is divided first, thus exposing the bifurcation of the truncus anterior from behind.

1. Fissure and posterior artery

The posterior portion of the oblique fissure is open as previously described, and the ascending posterior artery is divided (**Fig. 14**).

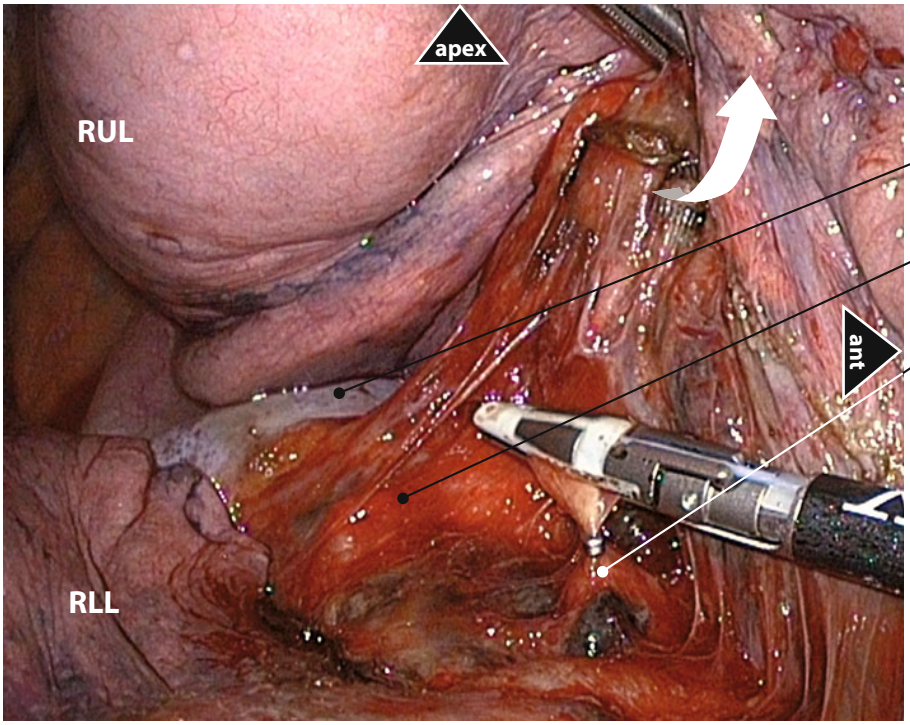


Fig. 14 – The posterior approach to the upper lobe bronchus usually requires to divide the ascending posterior artery (in this case by a combination of clip and bipolar sealing).

2. Bronchus

This gives access to the anterior aspect of the lobar bronchus. All surrounding tissues of the anterior, inferior, and superior surfaces of the bronchus are cleared (**Fig. 15**). A blunt tip device or an endopeanut is then gently passed around its anterior aspect, always keeping flush against the bronchus to avoid injury of the truncus anterior, which lies anteriorly. A sling can then be passed around the bronchus. It helps retracting it backward, allowing the stapler to be passed smoothly (**Fig. 16**).

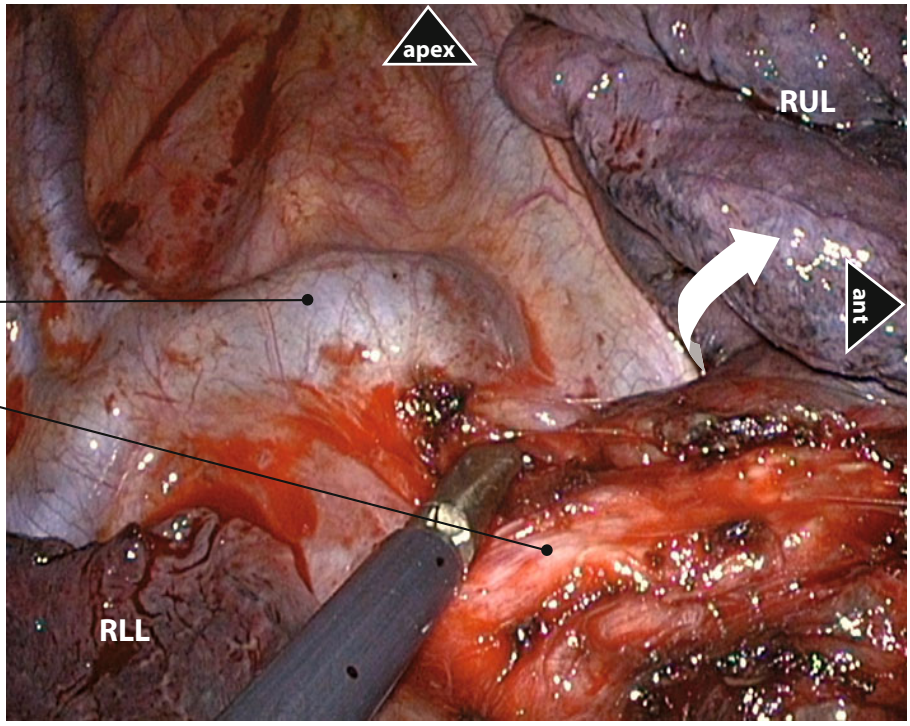


Fig. 15 – Clearing of tissues from the superior aspect of the lobar bronchus is required before stapling.

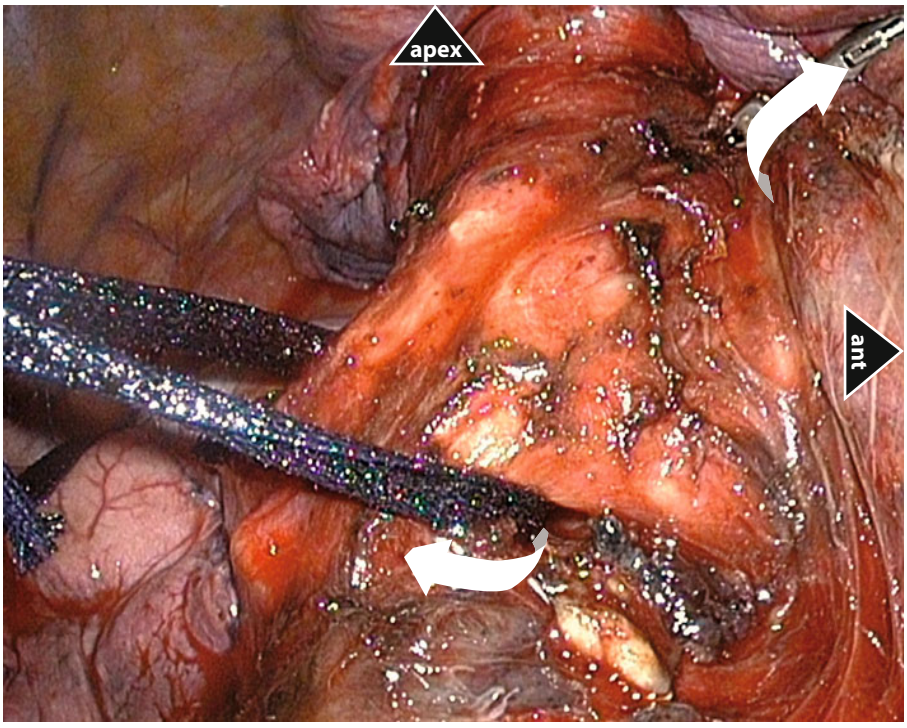


Fig. 16 – Backward retraction of the upper lobe bronchus.

3. Truncus anterior

Severing the lobar bronchus exposes the truncus anterior, which can then be dissected from the back. If the trunk cannot be fully controlled that way, its anterior aspect will be exposed by an anterior approach (**Fig. 17**).

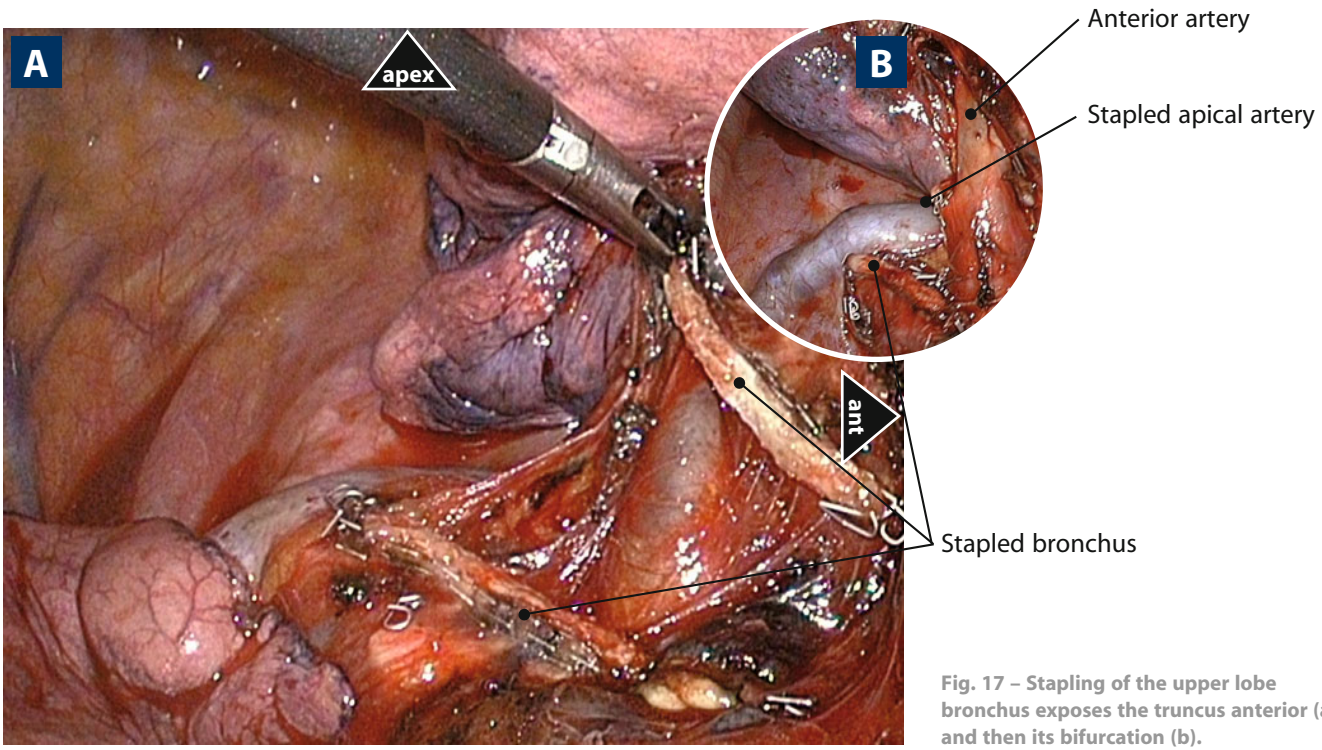


Fig. 17 – Stapling of the upper lobe bronchus exposes the truncus anterior (a) and then its bifurcation (b).

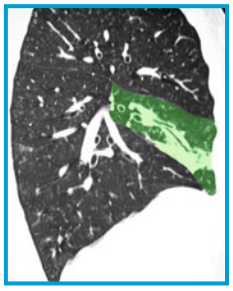
The other steps are similar to those described in the "anterior approach" section.

: The video of this technique can be consulted on WEBSURG at the following adress: http://www.websurg.com/ref/doi-vd01en2978.htm

Chapter IV

Middle lobe

Chapter IV Middle lobe



Contrary to other lobectomies, it is usually preferable to divide the middle lobe pulmonary vein at an early stage. Its occlusion does not cause significant venous congestion, and it is the key to access the arteries and the bronchus.

Anatomical landmarks (Fig. 1)

- **Bronchus:** The middle lobe bronchus lies in a groove between the two segmental arteries. It gives two segmental bronchi that are usually not seen during a middle lobectomy. It is advisable to first control the medial artery to open the space and facilitate the access to the lobar bronchus.

- **Arteries:** There are usually two arteries arising separately from the pulmonary artery in the fissure: the lateral segmental artery whose origin is just below the confluence of the oblique and transverse fissures, opposite to the superior segmental artery, and the medial artery, which lies deeper and is hidden by the lobar bronchus. In some cases, the arterial supply is from a single artery that originates from the anterior surface of the pulmonary artery, opposite to the ascending posterior branch to the upper lobe.

- **Vein:** The middle lobe vein is the inferior root of the superior pulmonary vein. It is the most anterior element. Its division facilitates the access to the bronchus and the medial segmental artery.

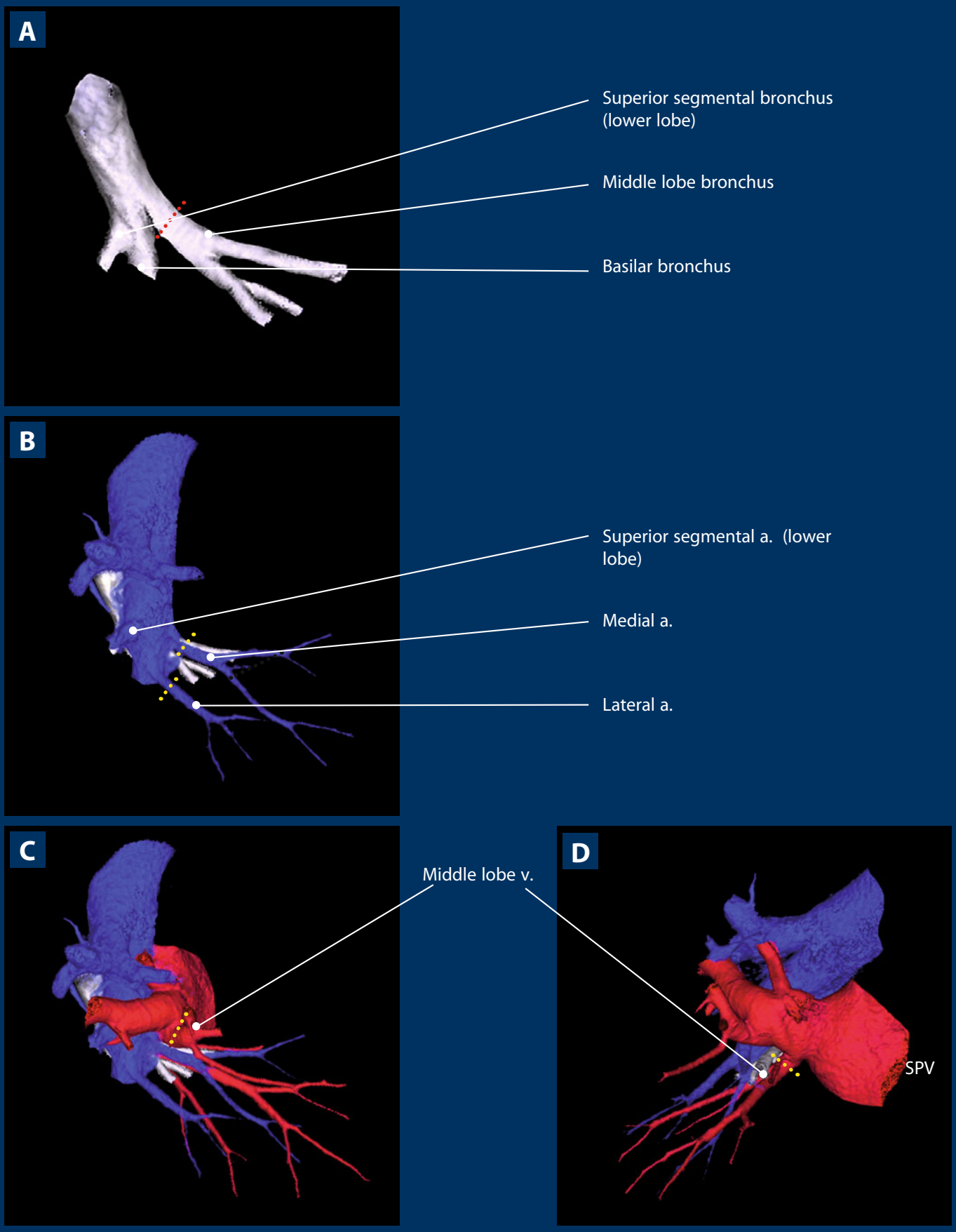


Fig. 1 – Anatomical landmarks. (a) Middle lobe bronchus (lateral view). (b) Arterial supply to the middle lobe: lateral and medial arteries (lateral view). (c, d) Bronchovascular pedicle of the middle lobe (anterior view). a: artery, v: vein, SPV: superior pulmonary vein, dotted lines: level of division.

Technique

1. Fissure and lateral segmental artery

The pulmonary artery is approached at the junction of the transverse and oblique fissures (**Fig. 2a**). This step can be tedious in case of a thick and/or fused fissure. The sheath of the pulmonary artery is entered, seeking for the branch that arises from its anterior aspect (**Fig. 2b**). This branch is the lateral segmental artery. It is divided after application of clips or a vessel sealing device or a combination of both. At this stage, if is usually difficult to find the medial segmental artery, which is hidden inside a groove. It is thus preferable to first control the vein before dissecting the other elements.

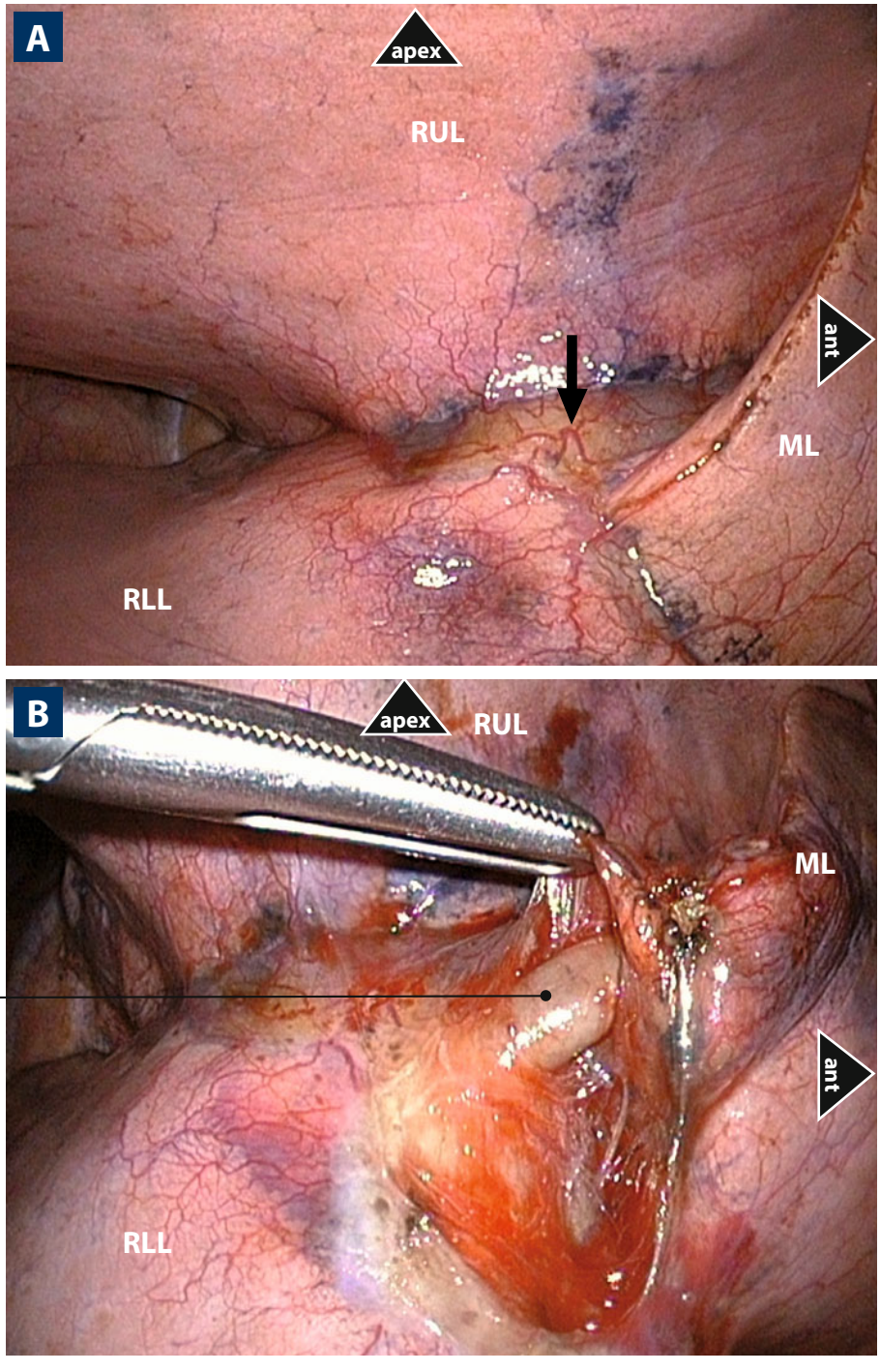


Fig. 2 – Opening the confluence of the oblique and transverse fissures (*arrow*) (a) leads to exposure of the lateral segmental artery (b).

2. Fissure and vein

The anterior portion of the oblique fissure is opened (**Fig. 3**). Depending on its length and thickness, this can be done by simple diathermy or by bipolar sealing or stapling. The lobe is then retracted posteriorly until the phrenic nerve is seen. The mediastinal pleura is incised posterior to the phrenic nerve, at the level of the superior pulmonary vein. Dissection of the vein is achieved by a combination of bipolar cautery and gentle sweeping motion with an endopeanut. The lowermost branch of the superior pulmonary vein is identified. The vein to the middle lobe is taped or lifted up with a retractor, and either clipped or stapled (**Fig. 4**). In some patients, two separate segmental branches – instead of a single trunk – have to be controlled.

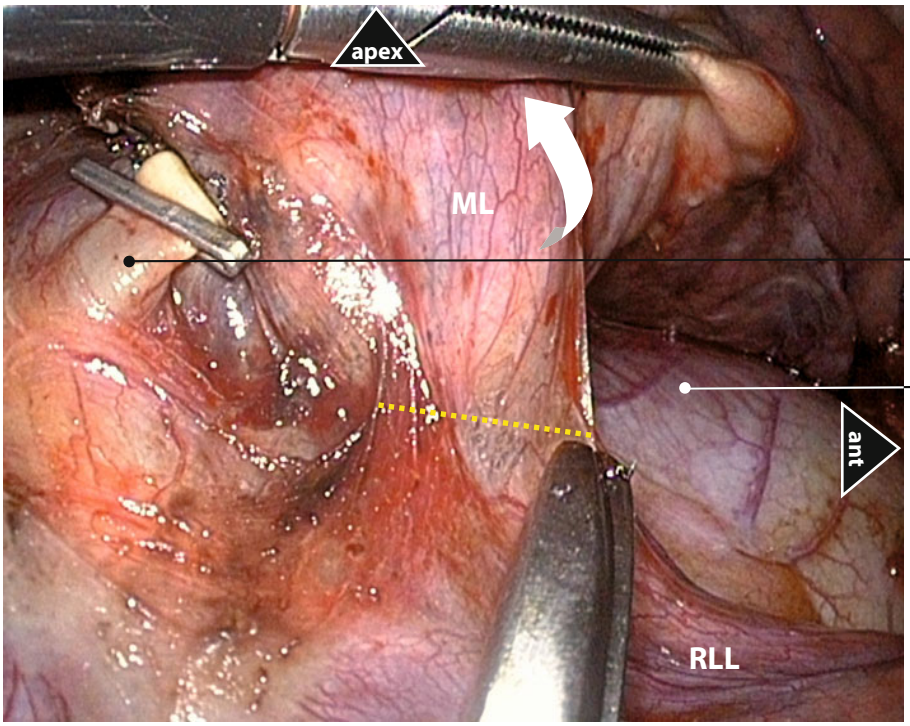


Fig. 3 – Opening of the anterior portion of the oblique fissure between the middle and the lower lobe (*dotted line*).

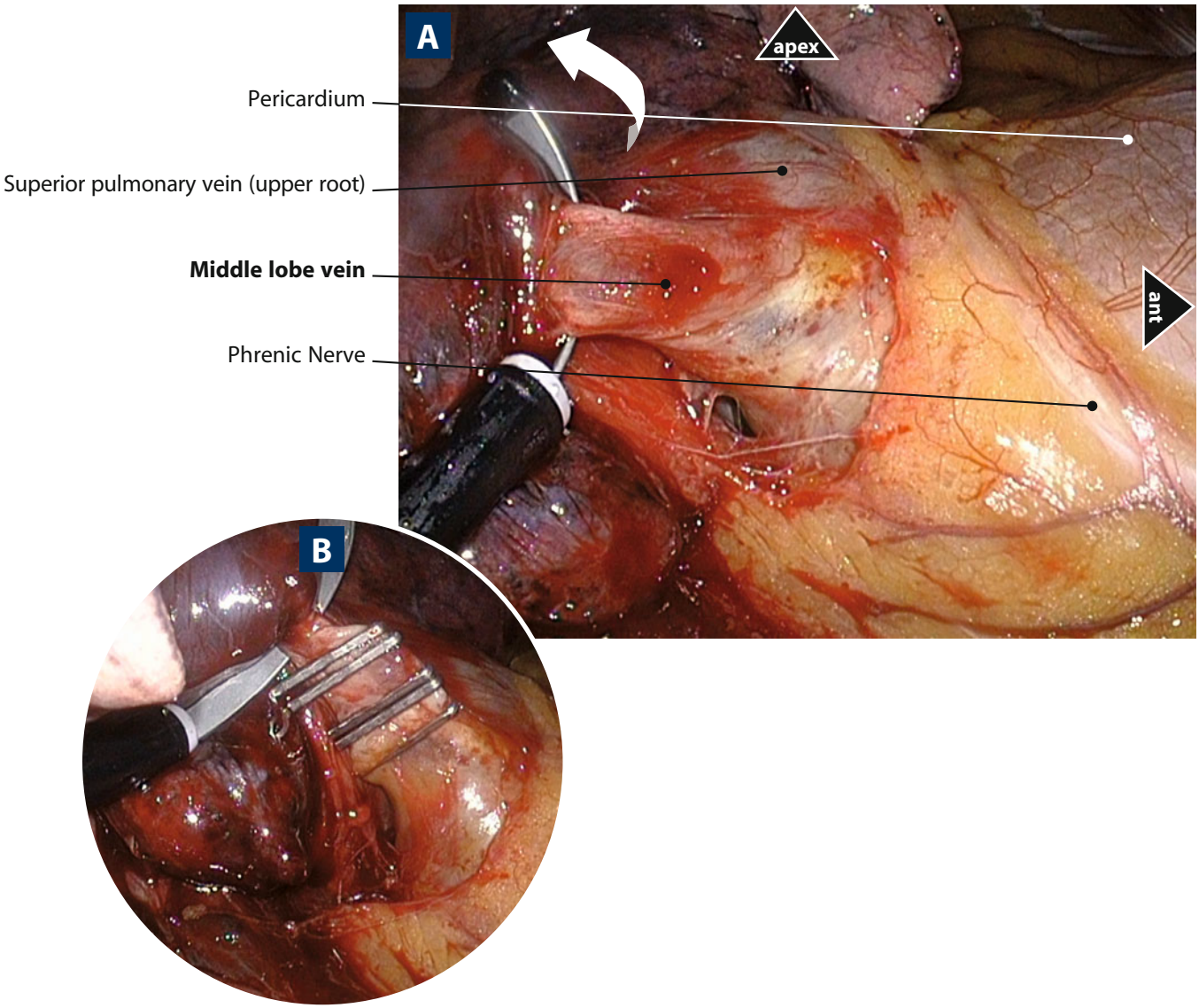


Fig. 4 – Dissection (a) and clipping (b) of the vein to the middle lobe.

Depending on the anatomic features of each patient, these two first steps can be inverted.

3. Bronchus

Division of the vein gives access to the bronchus, which is mobilized by blunt dissection (**Fig. 5**). It is then stapled at its takeoff.

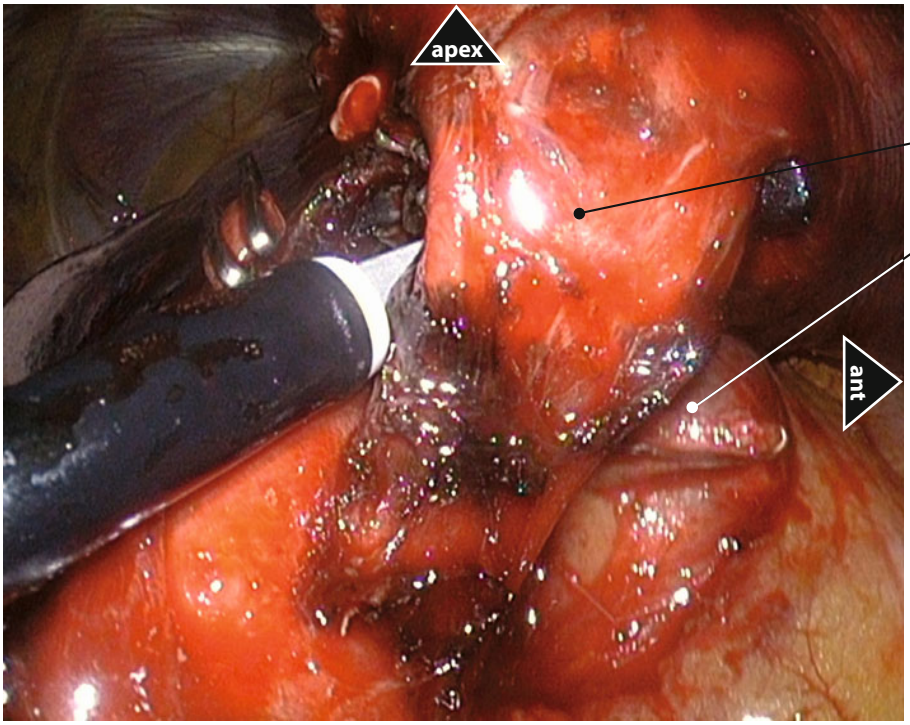


Fig. 5 – Division of the middle lobe vein gives access to the lobar bronchus.

4. Medial segmental artery

Division of the bronchus provides room to dissect the medial artery, which is clipped or coagulated by a vessel sealing device (**Fig. 6**).

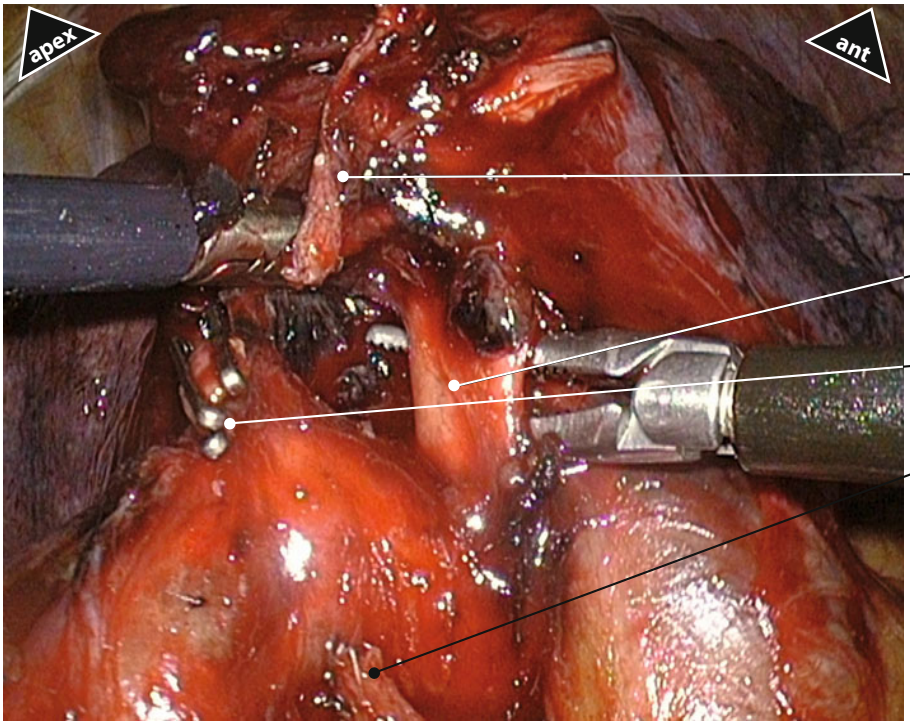


Fig. 6 – Dissection of the medial segmental artery.

5. Transverse fissure

The middle lobe is now fully mobile. A clamp is applied on the transverse fissure, the lung is reventilated to check the exact border between the two lobes, and the parenchyma is then stapled (**Fig. 7**).

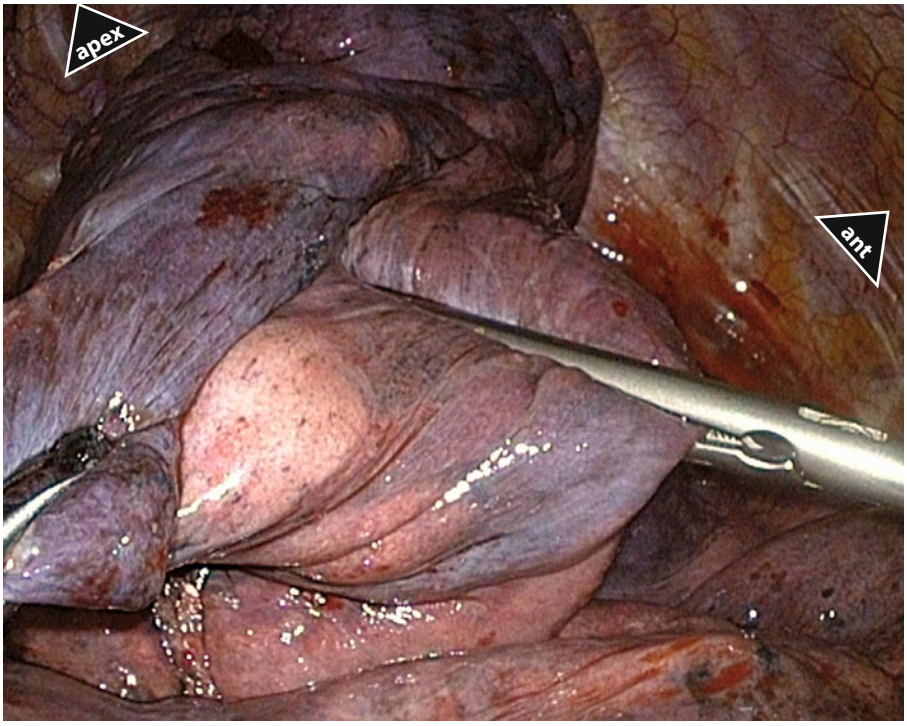


Fig. 7 – Clamping of the parenchyma before stapling.

The specimen is taken out in the usual fashion. A small bag and a minimal enlargement of the anterior port are sufficient to retrieve the specimen (**Fig. 8**).

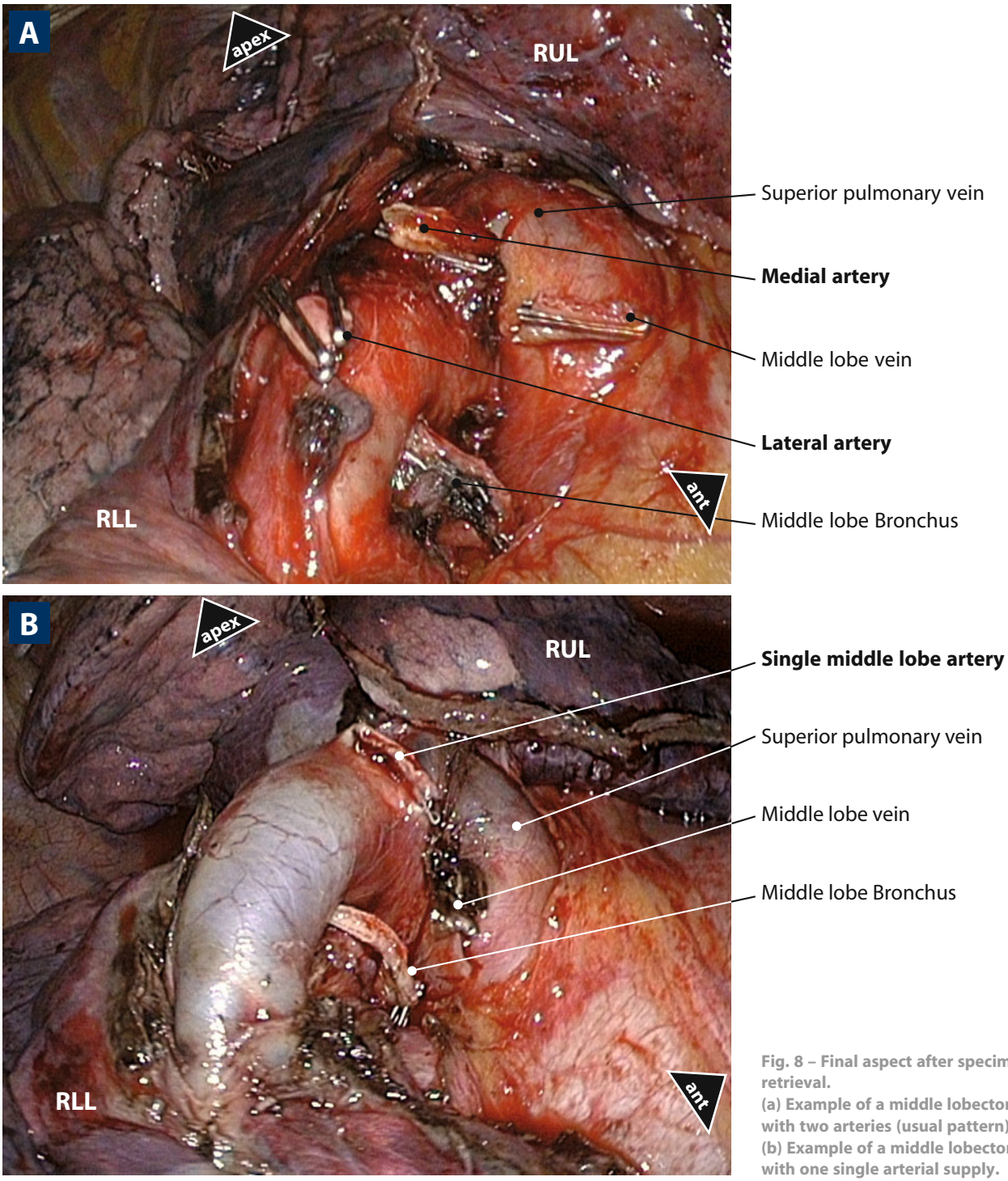
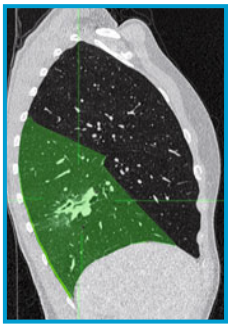


Fig. 8 – Final aspect after specimen retrieval.
(a) Example of a middle lobectomy with two arteries (usual pattern).
(b) Example of a middle lobectomy with one single arterial supply.

Chapter V

Right lower lobe

Chapter V Right lower lobe



The right lower lobectomy can be rather straightforward when the fissure is separate but difficult in case of a fused fissure. However, even in case of an incomplete fissure, the dissection and control of the arterial branches are usually easier than for an upper lobectomy. In addition, preserving the middle lobe vein is not the same concern as during an upper lobectomy.

Anatomical landmarks (Fig. 1)

- **Bronchus**: The lower bronchus is the termination of the bronchus intermedius and the latest element to be divided. It bifurcates into the superior segmental bronchus and the basal bronchi, which are four in number . The superior segmental bronchus originates from the posterior surface of the truncus intermedius opposite to the middle lobe bronchus. Stapling should not be done after having clearly visualized the origin of the middle lobe bronchus. When in doubt, reventilation or intraoperative fiber-optic bronchoscopy should be performed before stapling.

- **Arteries**: The arteries to the lower lobe are approached at the confluence of the oblique and transverse fissures. There are two main arteries: the basilar trunk, which sends four to five branches to the basal segments, and the superior segmental branch, which can be single or double. The basilar trunk and the superior artery can sometimes be stapled together, but they must usually be divided separately. Care must be taken that the posterior segmental artery to the upper lobe does not arise from the superior artery before clipping or stapling. Both arteries must be clearly identified. The same is true for an accessory artery to the middle lobe, which can arise from the basal trunk.

- **Vein**: The inferior pulmonary vein is found by freeing the inferior pulmonary ligament.

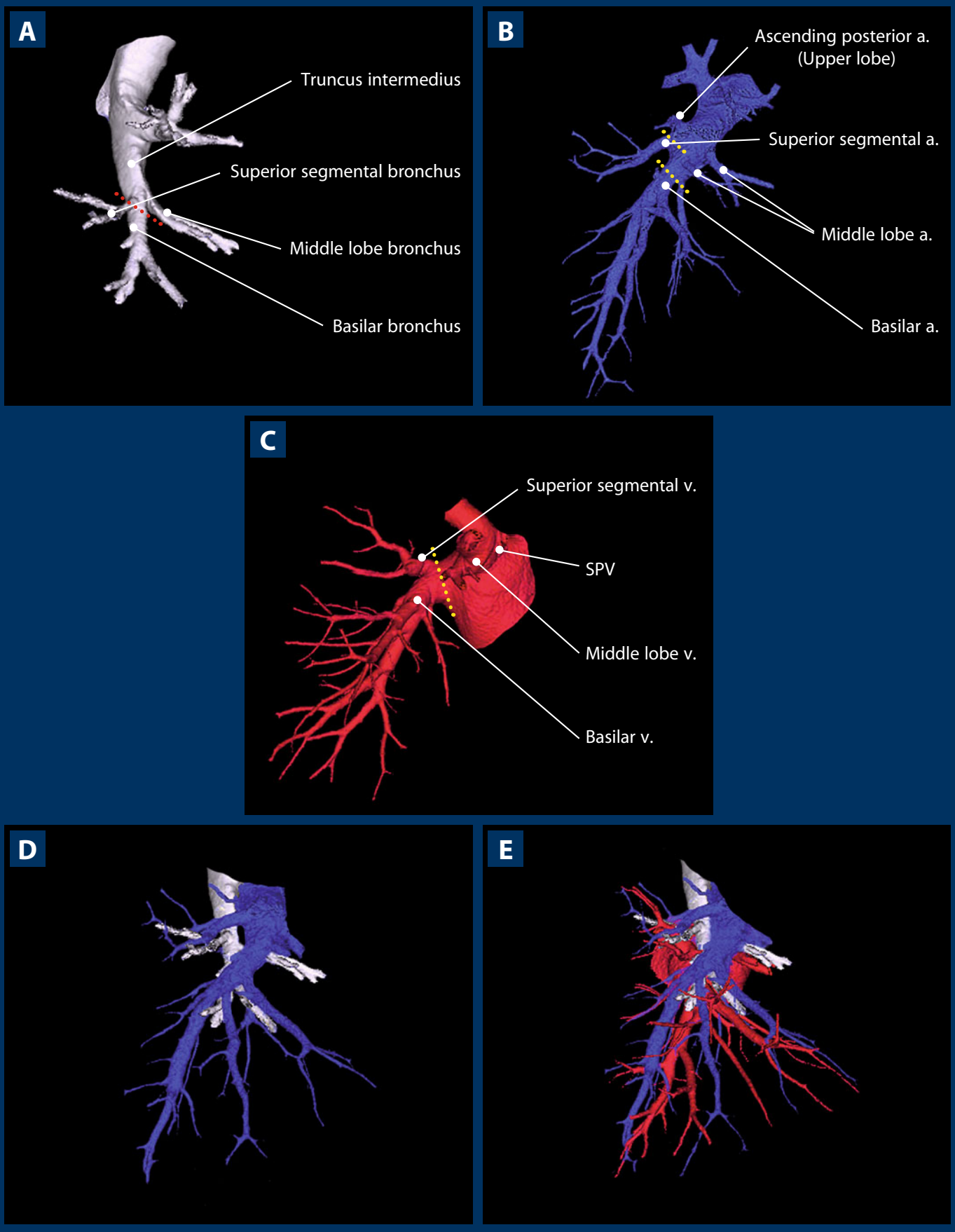


Fig. 1 – Anatomical landmarks. (a) Lower lobe bronchus (lateral view). (b) Arterial supply to the lower lobe (lateral view). (c) Inferior pulmonary vein (lateral view). (d) Relationships between bronchi and arteries of the right lower lobe. (e) Relationships between bronchi, arteries, and veins of the right lower lobe. SPV: superior pulmonary vein, a: artery, v: vein, dotted lines: level of division.

Technique

1. Fissure and arteries

If necessary, traction and countertraction are applied on the upper and lower lobes to help opening the major fissure. When the fissure is incomplete or inflammatory, this step can be tiresome and time-consuming. Opening the fissure may lead to pulmonary tears and troublesome oozing. Thorough progression using a combination of bipolar diathermy and blunt dissection is required until the artery is discovered (**Fig. 2**). The sheath of the artery is entered. No section is done until the branch to the middle lobe and the posterior segmental artery to the upper lobe are identified (**Fig. 3**).

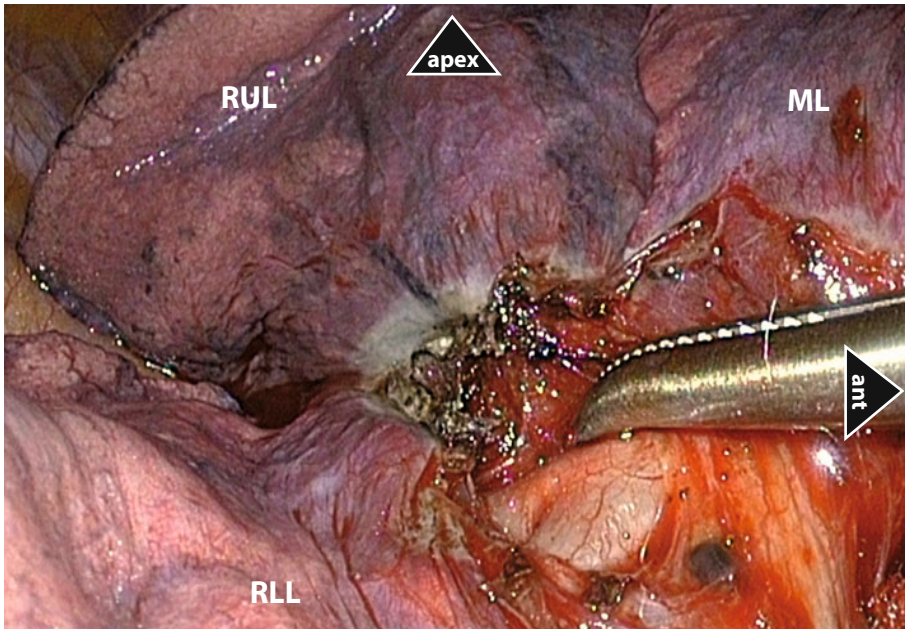


Fig. 2 – Dissection of the basilar trunk after opening of the oblique fissure.

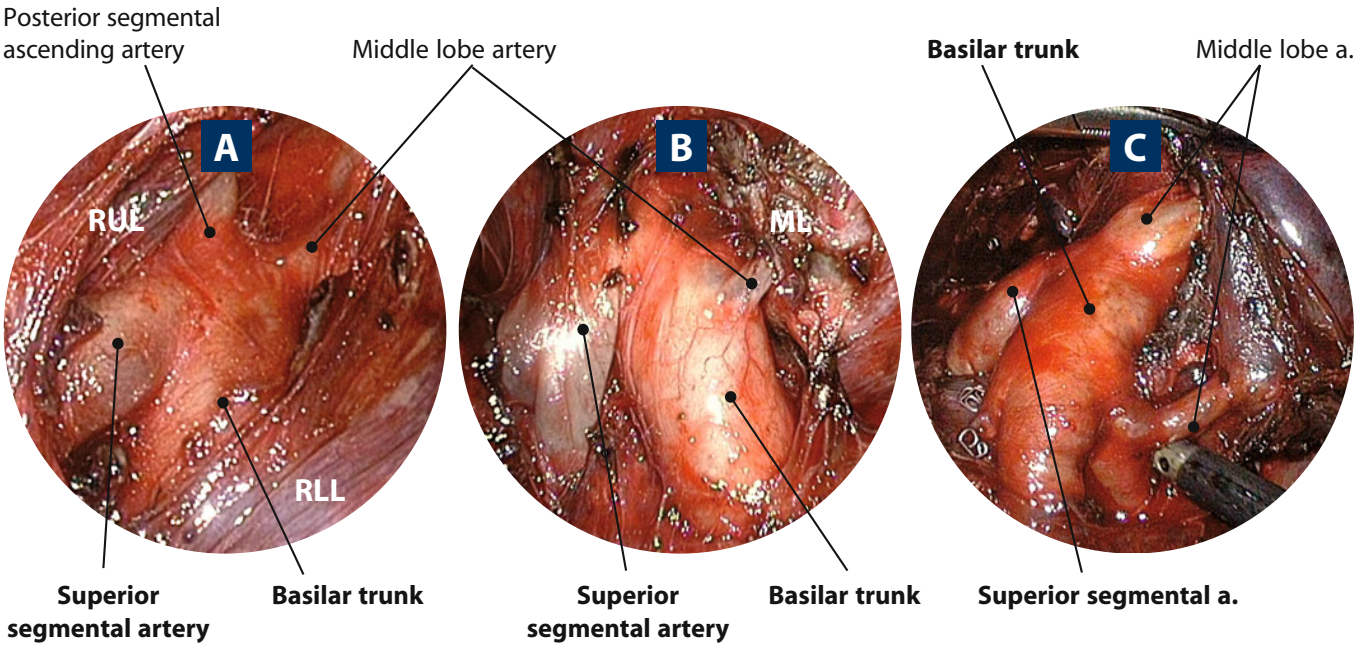
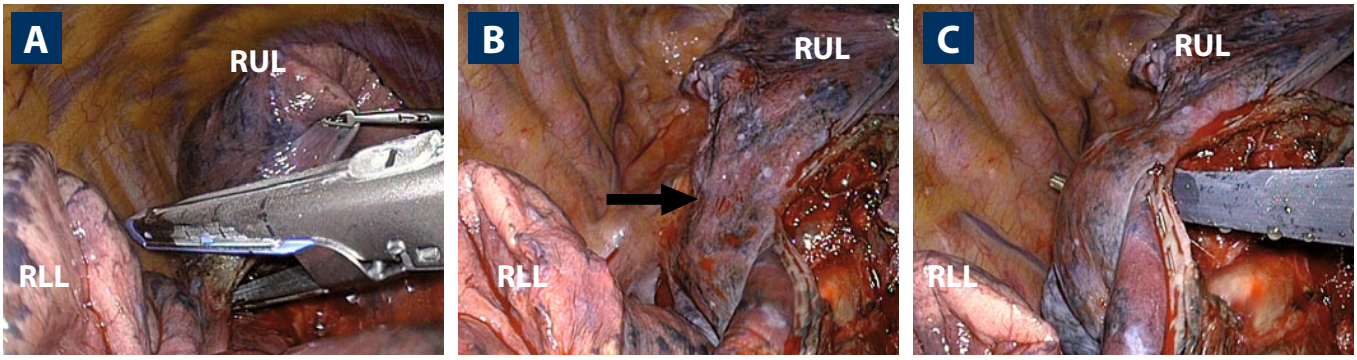


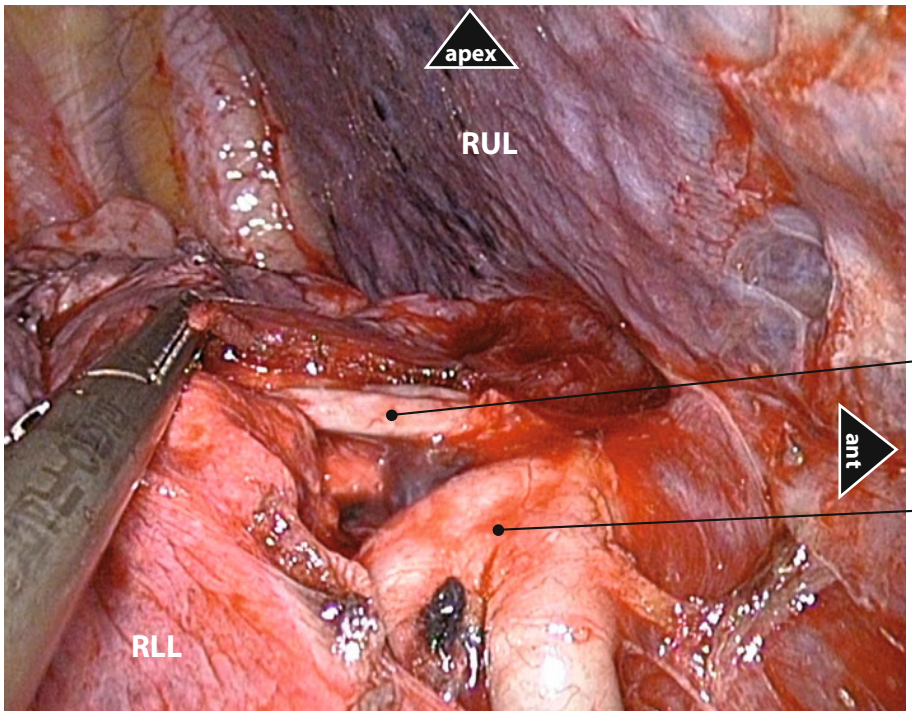
Fig. 3 – The arterial anatomy in the oblique fissure. (a) Usual «X-shape». (b) Artery to the middle lobe arising from the basilar trunk (a posterior ascending artery can also arise from the apical artery). This underlines the need for an extended arterial dissection. (c) Middle lobe artery arising from a branch of the basilar arterial trunk.

In some cases, the lower lobe trunk can be divided at its origin, but usually, the apical artery and the basilar trunk are divided separately, the former by clipping and the latter by stapling. Division of the posterior portion of the major fissure is done as described for a right upper lobectomy (see page 40) (**Figs. 4 and 5**).

Fig. 4 – Division of the posterior part of the oblique fissure.



When the posterior portion of the major fissure is too large, it may be advisable to partially staple the fissure from the periphery to the hilum (Fig. 4a). This is done by retracting the lower lobe and the upper lobe anteriorly. This allows to better see the point where the mediastinal pleura must be opened (*arrow*) to complete the fissure division (Figs. 4b and 4c).



Superior segmental artery

Basilar arterial trunk

Fig. 5 – Complete identification of the arterial tributaries to the lower lobe.

Stapling of the posterior aspect of the major fissure should not be done before the posterior segmental artery to the upper lobe has been identified since it may arise from the apical lower segmental artery.

The lobe is then retracted downward, and the anterior portion of the oblique fissure between the middle lobe and the lower lobe is divided. It is usually thin, and this can be achieved by bipolar or ultrasonic dissection. If its central portion is too thick, stapling can be necessary (**Fig. 6**).

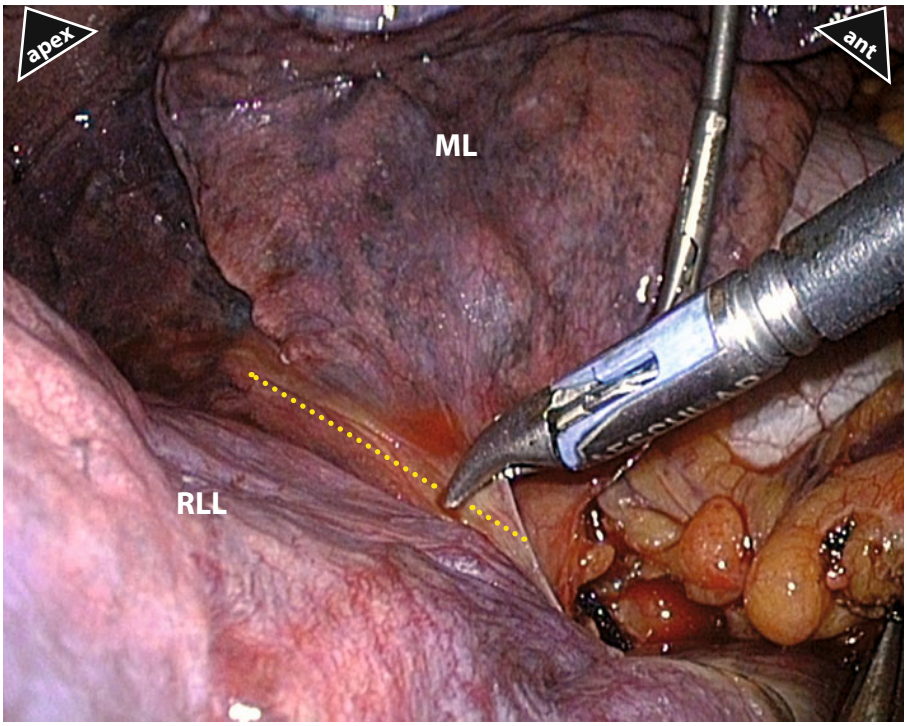


Fig. 6 – Opening the anterior part of the oblique fissure (*dotted line*).

2. Inferior pulmonary vein

The lobe is pulled upward to expose the inferior pulmonary ligament, which is divided by simple application of cautery using shears or hooks. The vein is cleared of the surrounding fatty tissues, then taped, and stapled. This facilitates the access to the bronchus (**Figs. 7 and 8**).

In some patients, the inferior pulmonary ligament is thin and short. Cautery must be used with caution to avoid injury of the inferior pulmonary vein.

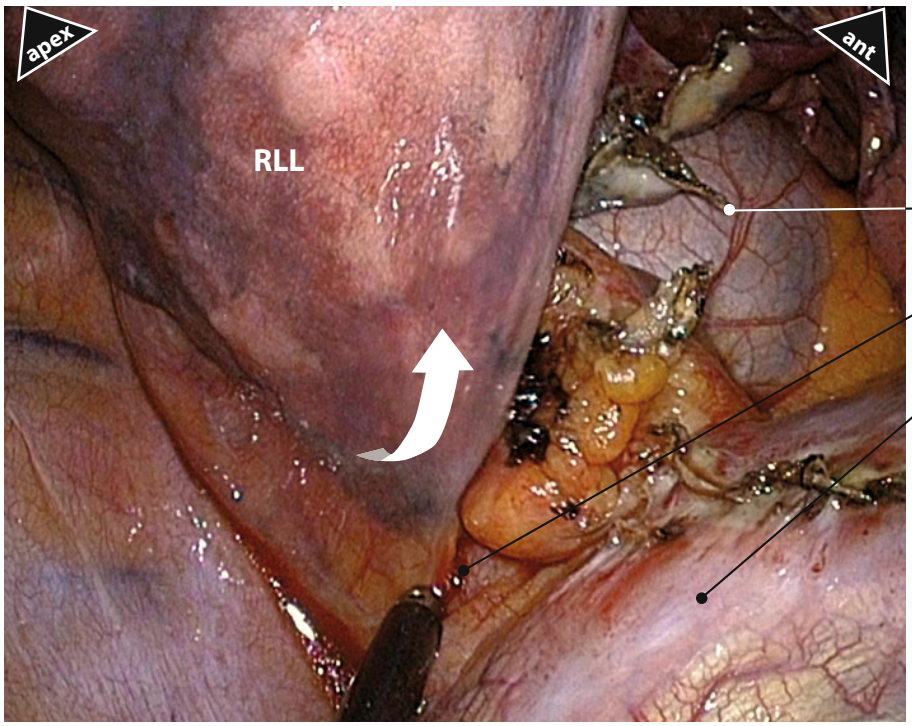


Fig. 7 – Division of the pulmonary ligament.

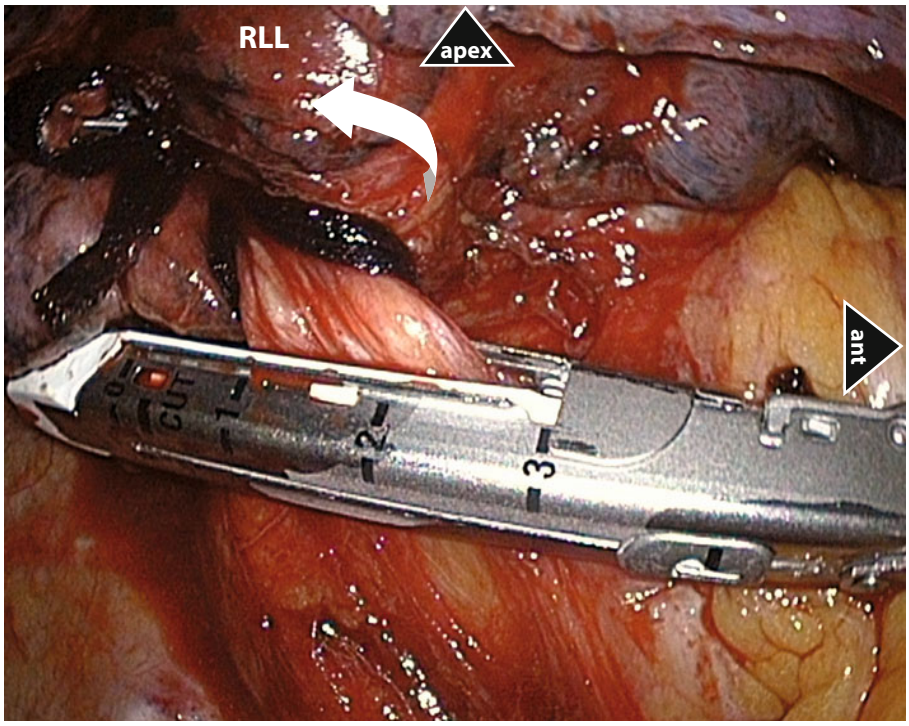


Fig. 8 – Passing a sling around the inferior pulmonary vein facilitates stapling.

3. Bronchus

The peribronchial tissues and lymph nodes are cleared. The origin of the middle lobe bronchus should be identified, and the lower lobe bronchus can then be stapled. The specimen is then retrieved (**Fig. 9**).

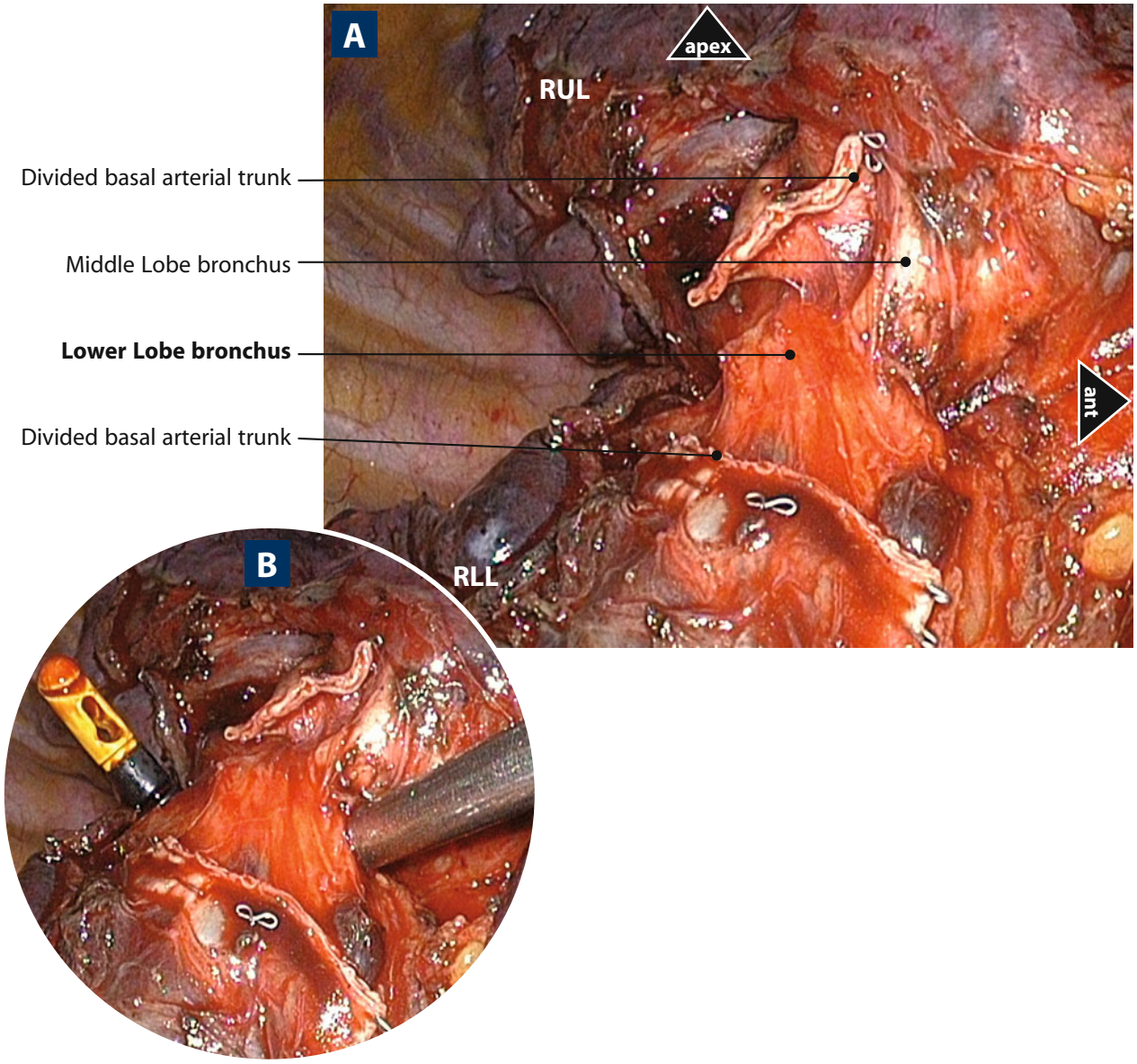


Fig. 9 – (a) Dissection of the lower lobe bronchus. (b) Use of a deflectable retractor to lift the lower lobe bronchus up.

If there is any doubt that the origin of the middle lobe bronchus could be stuck within the stapler jaws, a reventilation test should be performed before firing (**Fig. 10**).

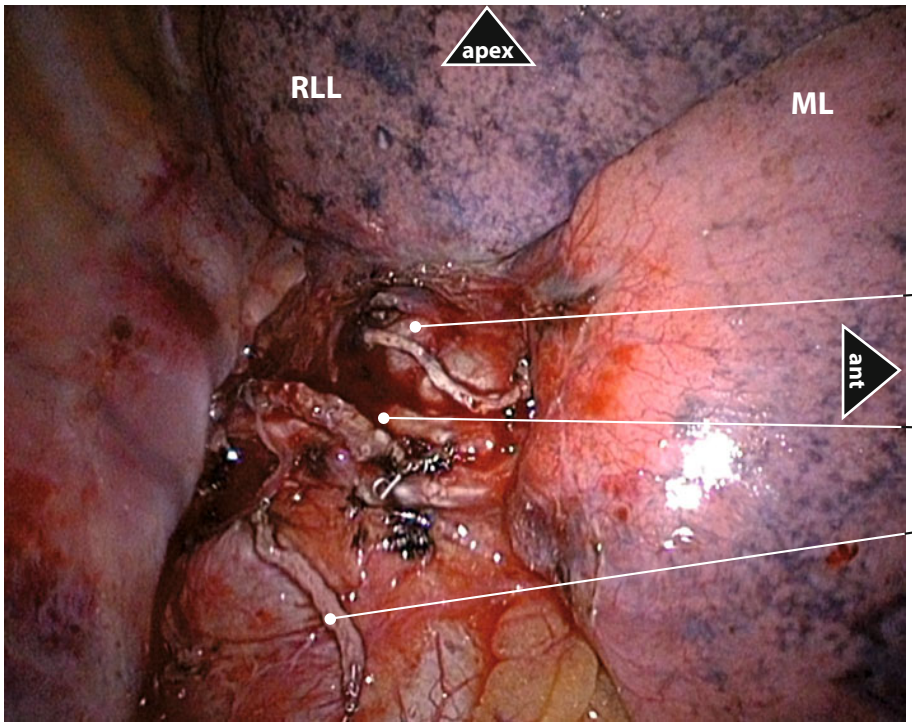
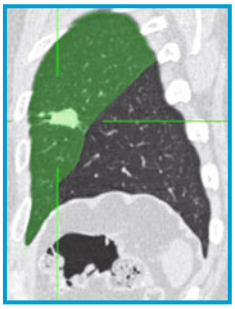


Fig. 10 – Final aspect after specimen retrieval.

Chapter VI

Left upper lobe

Chapter VI Left upper lobe



Left upper lobectomies are reputed to be hazardous because of the need of controlling the mediastinal branches of the pulmonary artery, which can be short and fragile. Any tear would cause massive hemorrhage and would require immediate conversion to thoracotomy. Thus, an endoscopic approach for left upper lobectomy may seem unreasonable. However, thanks to the close-up vision and magnification provided by the thoracoscope, dissection can be accurate and safe. Two anomalies should lead to abandon the procedure and convert to thoracotomy: (1) a very short truncus anterior, especially if it is partly obscured by the lobar bronchus, and (2) adherent lymph nodes.

As for any left pulmonary resection, performing the mediastinal lymph node dissection first facilitates the procedure.

Anatomical landmarks (Fig. 1)

- **Bronchus**: The bronchus is hidden by the arteries and the vein. It is the last element to be divided.

- **Arteries**: The arterial supply to the left upper lobe is the most variable. The number of branches ranges from one to seven (actually from three to four in most patients). There are two different supplies to the lobe: the truncus anterior and the posterior arteries. The truncus anterior is large and short. It supplies the apicoposterior and anterior segments, usually via two separate branches. In one-quarter of patients, it gives a deep and hidden branch to the lingula and/or anterior segment. The posterior segmental arteries originate in the fissure, along the curve of the pulmonary artery, and pass into the posterior aspect of the left upper lobe. Their number varies from one to five, most often from two to three. Since the truncus anterior is often partially hidden by the superior pulmonary vein, it can be advisable to perform part of the dissection from a posterior approach.

- **Vein**: The superior vein is the most anterior element. In rare cases, the left pulmonary vein can be single. This must be verified before stapling.

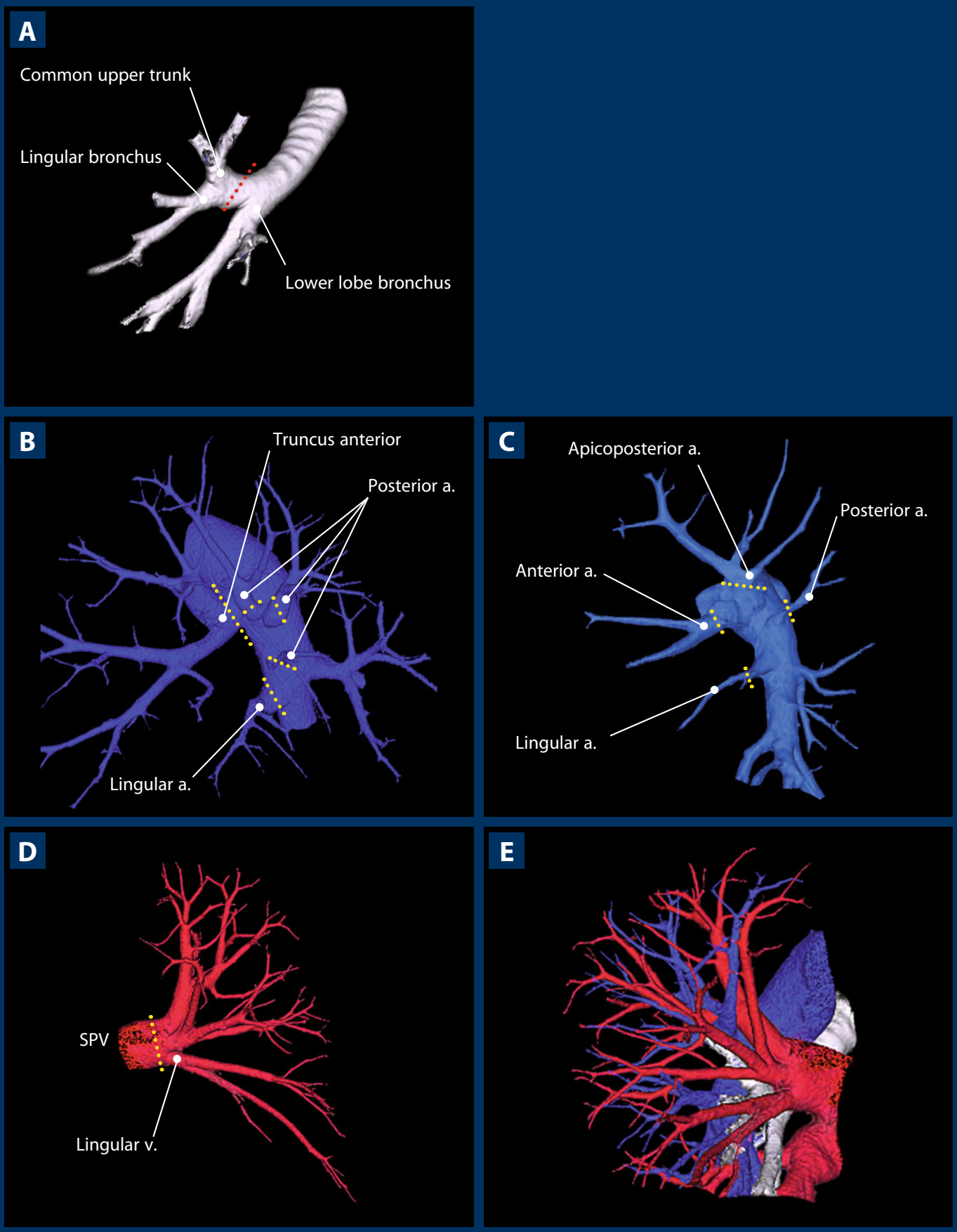


Fig. 1 – Anatomical landmarks. (a) Bronchi (lateral view). (b) Usual pattern of the pulmonary artery (lateral view), with three posterior arteries and the truncus anterior bifurcating into 2 main branches (apicoposterior and anterior arteries). (c) Other frequently seen arterial pattern: independent apicoposterior and anterior (or sometimes lingular) artery. (d) Pulmonary vein (anterior view). (e) Bronchi, arteries, and veins (posterior view). SPV: superior pulmonary vein, a: artery, b: vein, dotted lines: level of division.

Technique

For convenience, the anterior and posterior approaches will be described separately. However, in practice, both approaches can be used simultaneously, depending on the anatomical relationships in the hilum.

Posterior approach

1. Fissure and lingular artery

If the lung is properly deflated, the fissure can be approached without the help of retractors. Otherwise, both lobes should be spread apart to expose the middle portion of the fissure. The pulmonary artery may be visible or concealed if the fissure is fused (**Fig. 2**).
The lingular artery is dissected first.

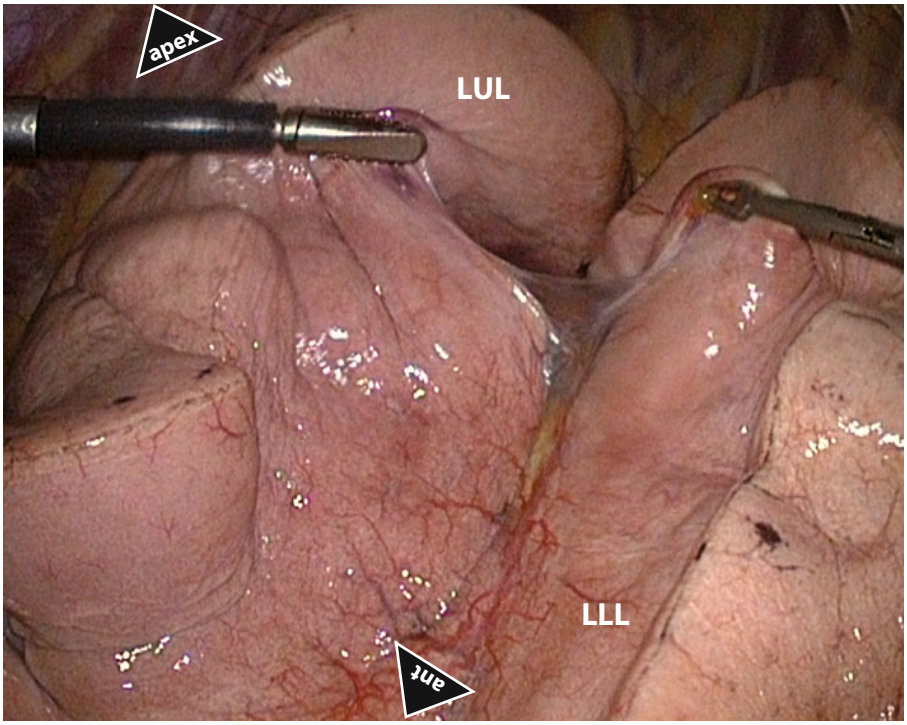


Fig. 2 – Exposing the fissure.

In case of a long fused fissure, it is advisable to first divide the anterior portion of the fissure, taking care not to injure the lingular artery. This maneuver facilitates the exposure of the arteries (**Fig. 3**).

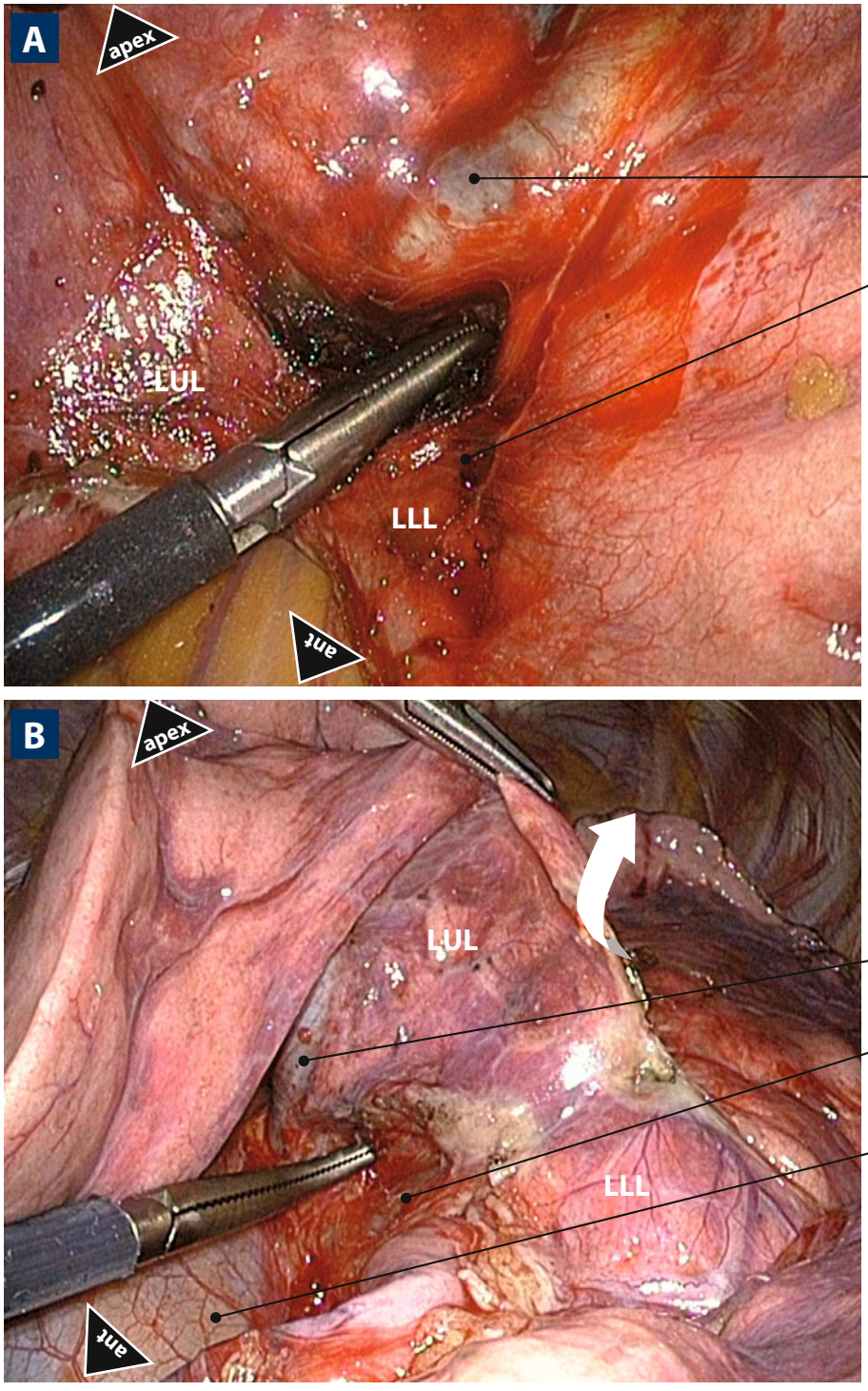


Fig. 3 – Completing division of the anterior fissure by creating a passage between the anterior aspect of the lingular artery and the anterior mediastinal pleura.
(a) View from above.
(b) View from below.

The lingular artery – its trunk or the two segmental branches – is divided after clipping or stapling, depending on its diameter (**Fig. 4**).

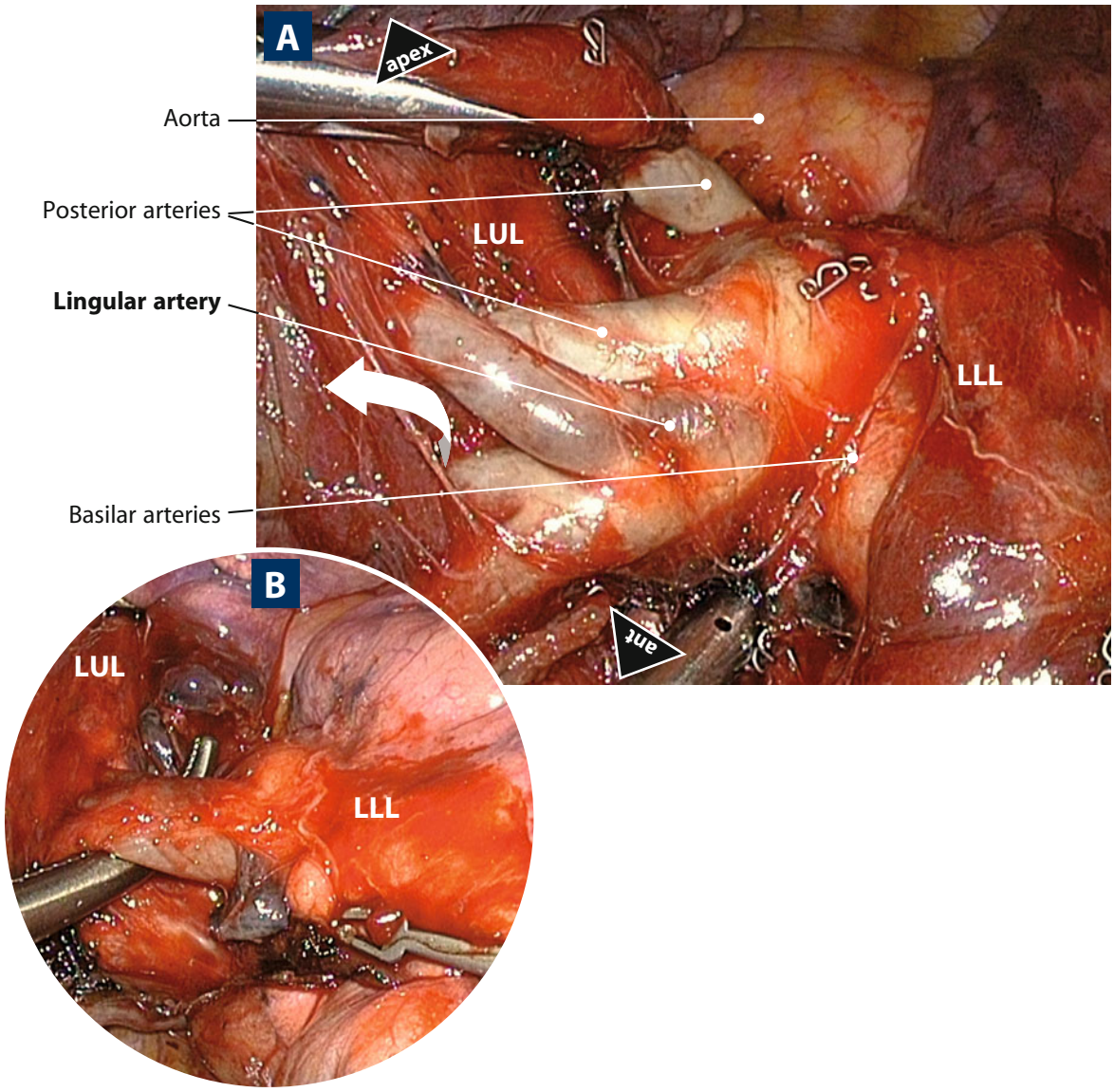


Fig. 4 – Lingular arteries: (a) identification and (b) dissection.

2. Posterior arteries

Once the lingular artery has been divided, the upper lobe is gently pulled forward, avoiding any undue traction that could lead to injure the vessels. Dissection is conducted cephalad, and all encountered posterior arteries are divided by turn. Traction helps exposing the first segmental artery whose dissection is usually easy. It is controlled by clipping or a vessel sealing device or a combination of both (**Figs. 5 and 6**).

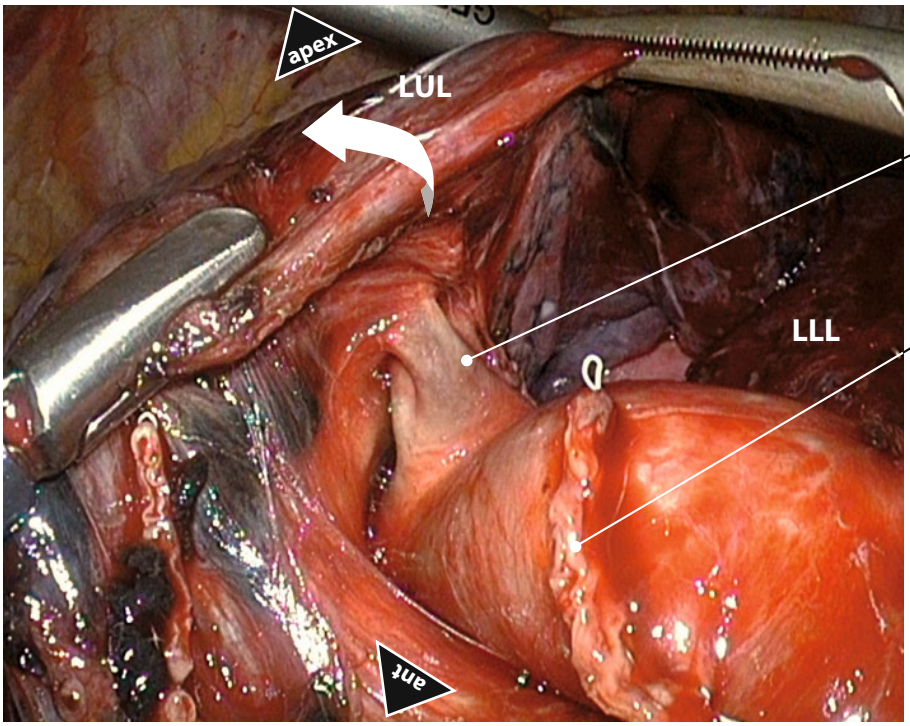
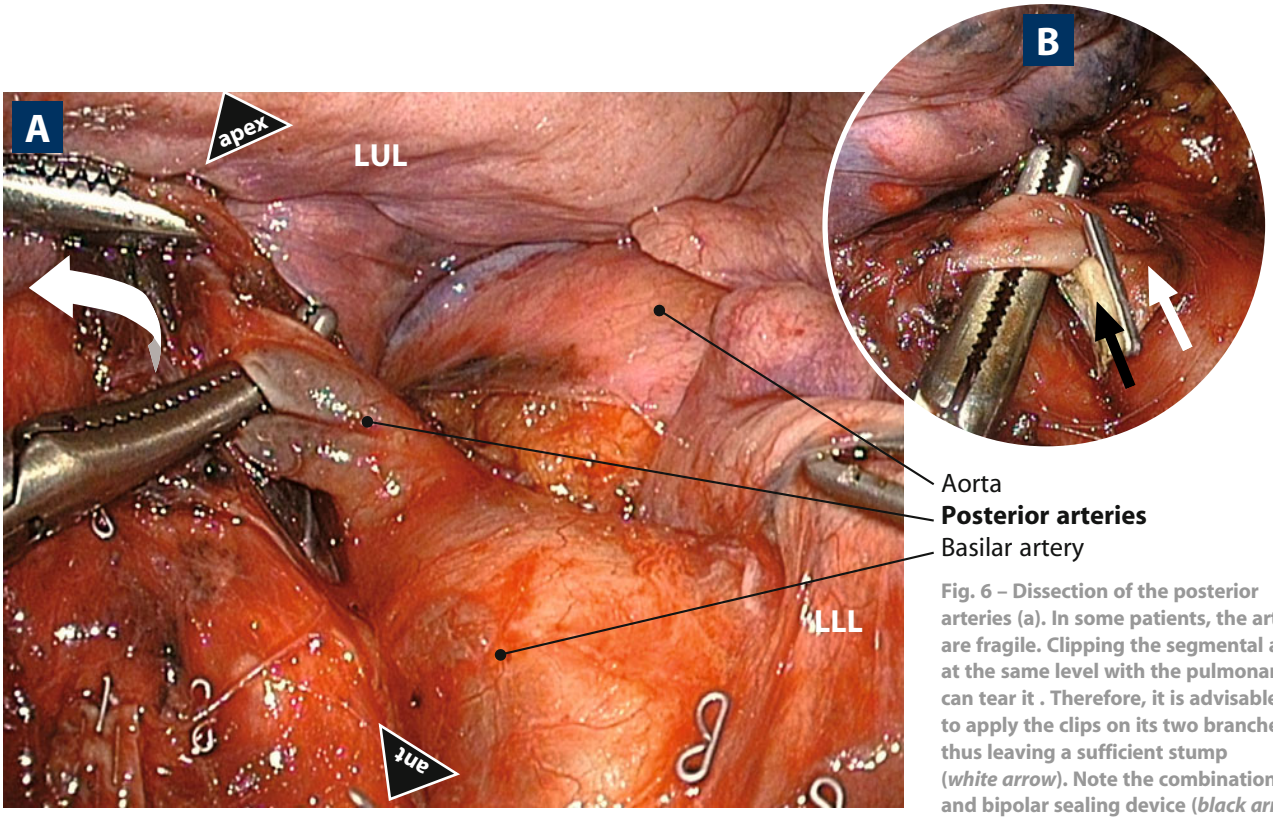


Fig. 5 – Exposure of the posterior arteries by retracting the upper lobe anteriorly.

Posterior arteries

Stapled lingular artery



Aorta

Posterior arteries

Basilar artery

Fig. 6 – Dissection of the posterior arteries (a). In some patients, the arteries are fragile. Clipping the segmental arteries at the same level with the pulmonary artery can tear it . Therefore, it is advisable to apply the clips on its two branches, thus leaving a sufficient stump (*white arrow*). Note the combination of clip and bipolar sealing device (*black arrow*) (b).

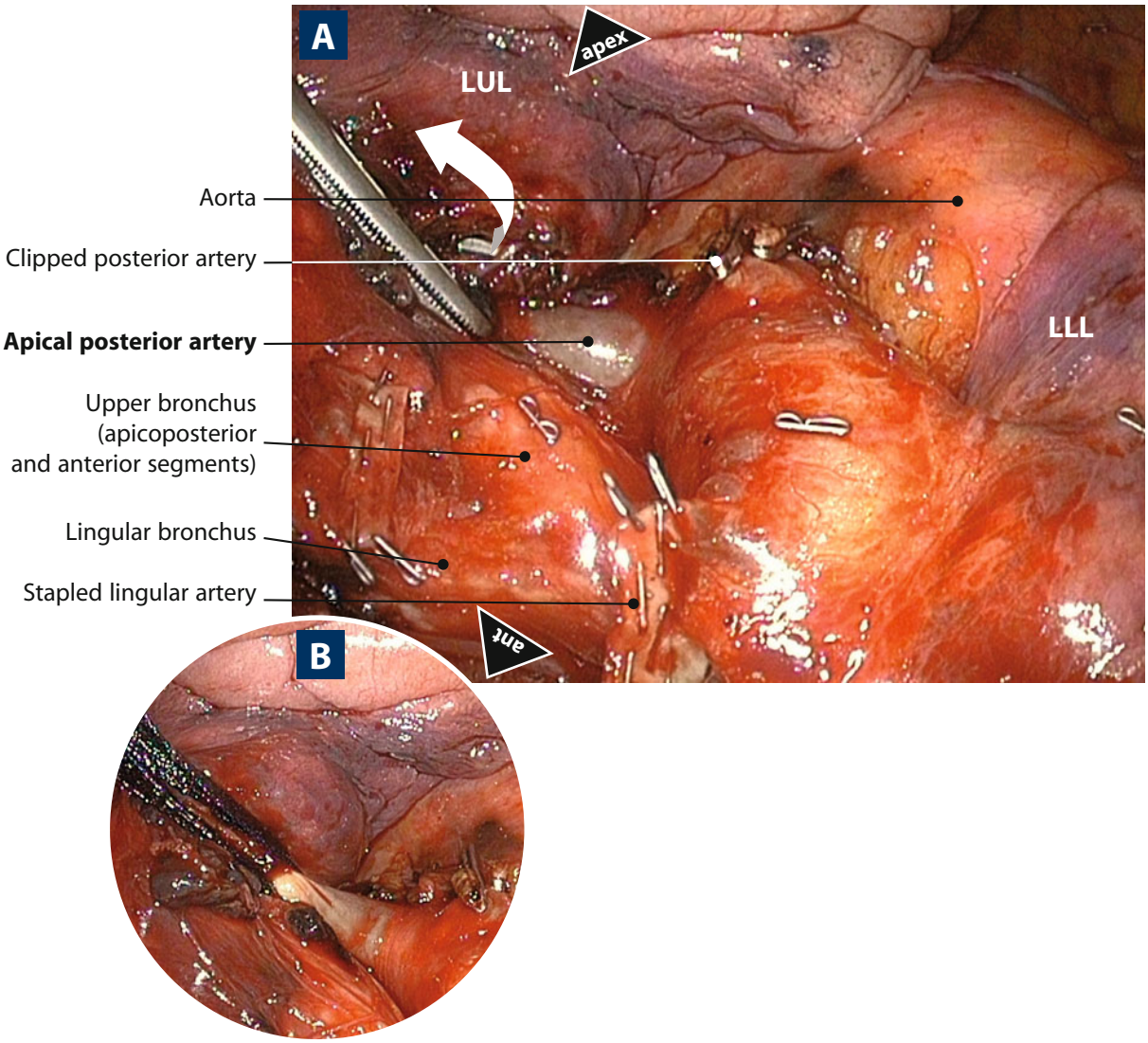


Fig. 7 – Apical posterior superior artery: (a) identification and (b) exposure. Since the artery can be partially covered by the bronchus, it should be retracted by a tape before clipping or stapling.

Note that, in this case, the artery is very short. If its dissection seems at risk, it may be advisable to switch to an approach from the front or from above.

Dissecting the apical posterior segmental artery may be more difficult since it is sometimes hidden by the bronchus. Again, gentle traction and smooth blunt dissection with an endopeanut help exposure. Contrary to open surgery, it is easier to approach this artery from behind. It is advisable to pass a sling around the vessel before applying the stapler or the clip applier.

3. Truncus anterior

As the posterior segmental arteries are gradually divided, the upper lobe unfolds and uncovers the truncus anterior, which can be approached posteriorly. It is then also dissected from above and from the front, using various visions, thanks to the deflectable scope. Gentle blunt dissection is used to clear the origin of the trunk. If the trunk bifurcates into large branches, these are dissected with caution and stapled independently (**Figs. 8 and 9**).

At this stage, the presence of unusual fibrosis or adherent lymph nodes or very short and non-dissectable arterial branches should lead to conversion.

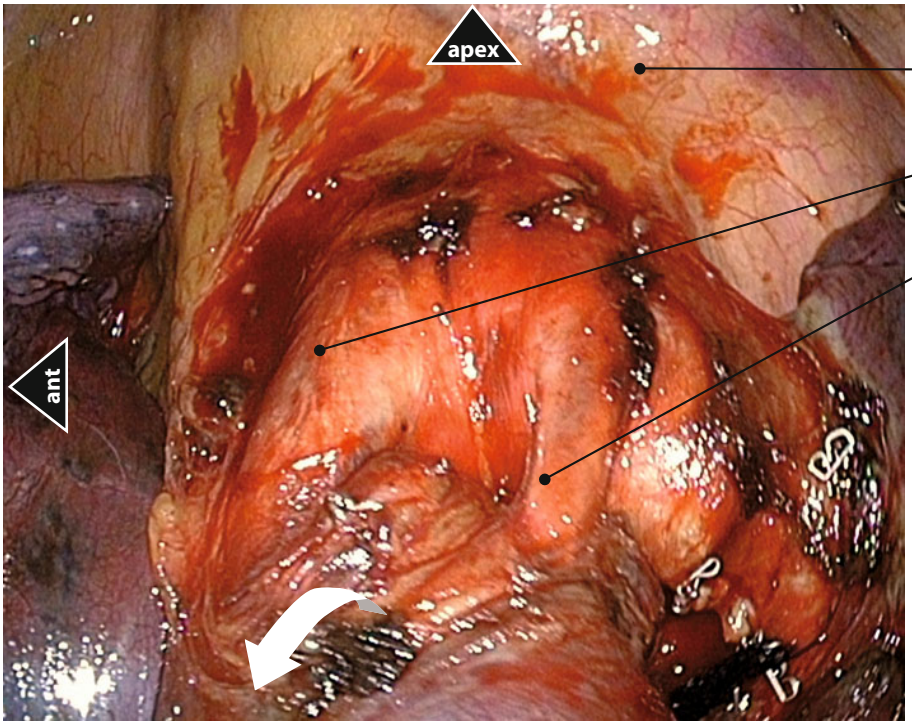


Fig. 8 – Exposure of a posterior artery and truncus anterior.

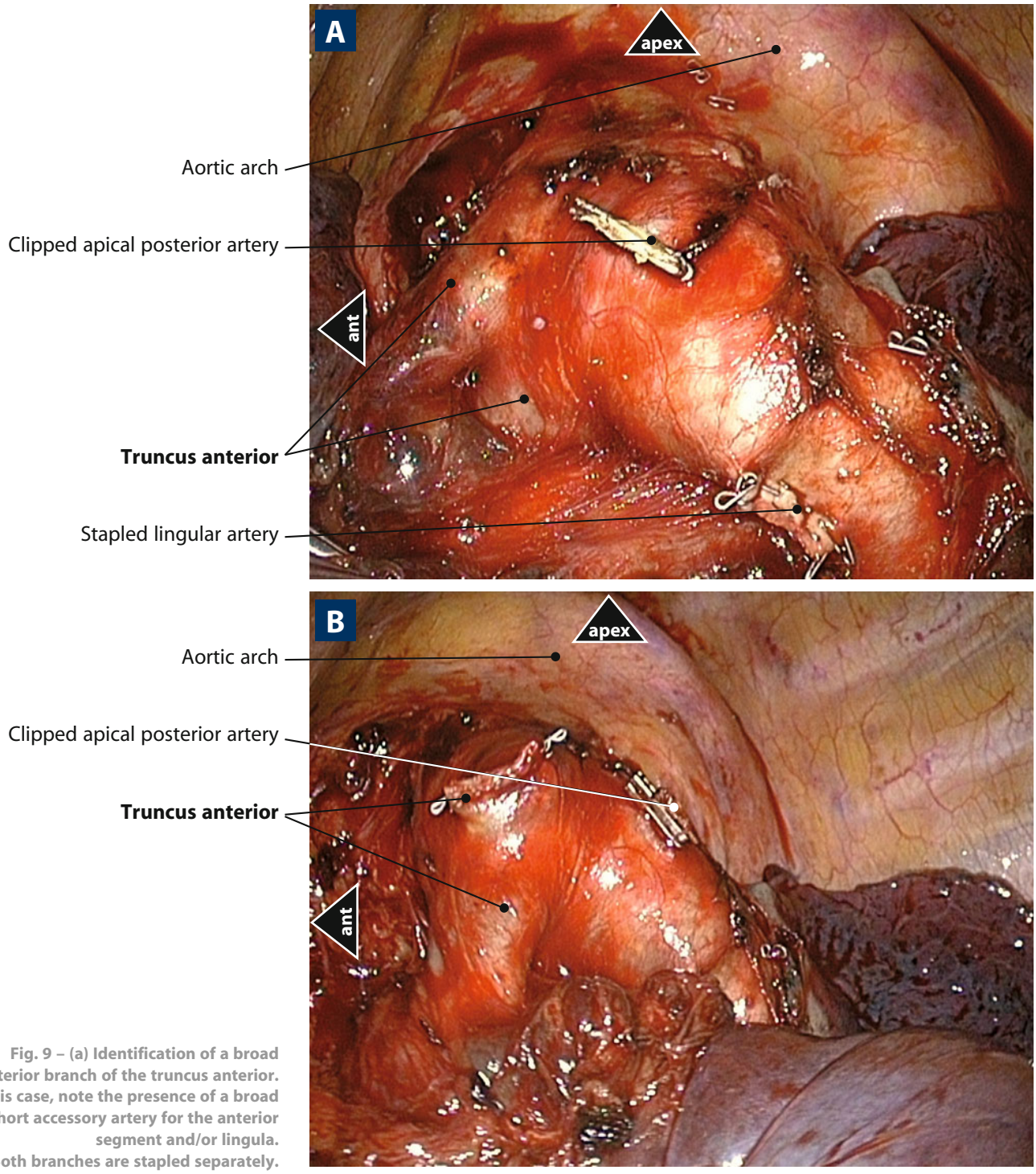


Fig. 9 – (a) Identification of a broad anterior branch of the truncus anterior. In this case, note the presence of a broad and short accessory artery for the anterior segment and/or lingula. (b) Both branches are stapled separately.

4. Superior vein

The upper lobe is pulled backward. The mediastinal pleura is incised posterior to the phrenic nerve, down to the superior pulmonary vein. Dissection of the vein is achieved by a combination of bipolar cautery and gentle sweeping motion with an endopeanut. It is then retracted forward to ease the passage of an endostapler (**Fig. 10**).

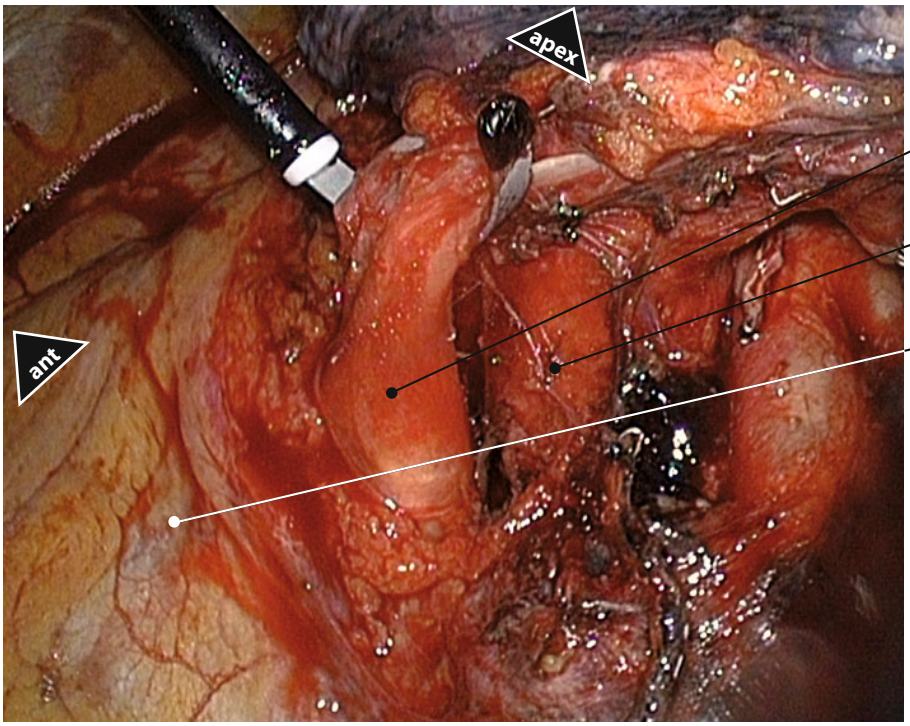


Fig. 10 – Exposure of the superior pulmonary vein and lobar bronchus.

5. Upper lobe bronchus

Once the vein and the truncus anterior have been divided, the upper lobe can be lifted up, thus exposing the lobar bronchus. It is cleared from lymph nodes, surrounding tissues, and bronchial arteries and then stapled flush with the lobar bifurcation (**Fig. 11**).

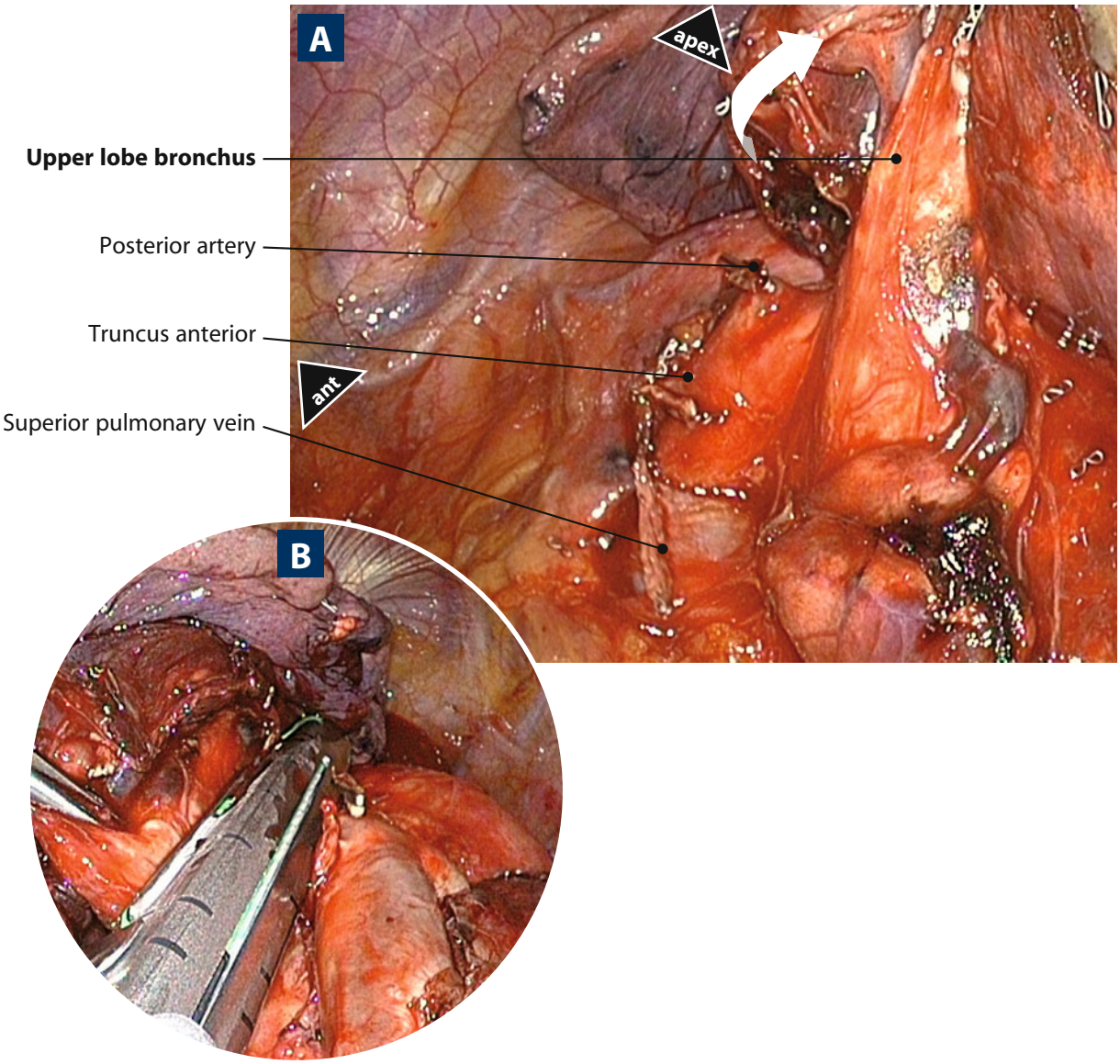


Fig. 11 – Upper lobe bronchus. (a) It is lifted up and cleared of nodes and surrounding tissues. (b) Stapling.

6. Pulmonary ligament

The pulmonary ligament is then divided up to the inferior pulmonary vein using both diathermy and gentle traction on the lower lobe (**Fig. 12**). The specimen is then retrieved in the usual manner (**Fig. 13**).

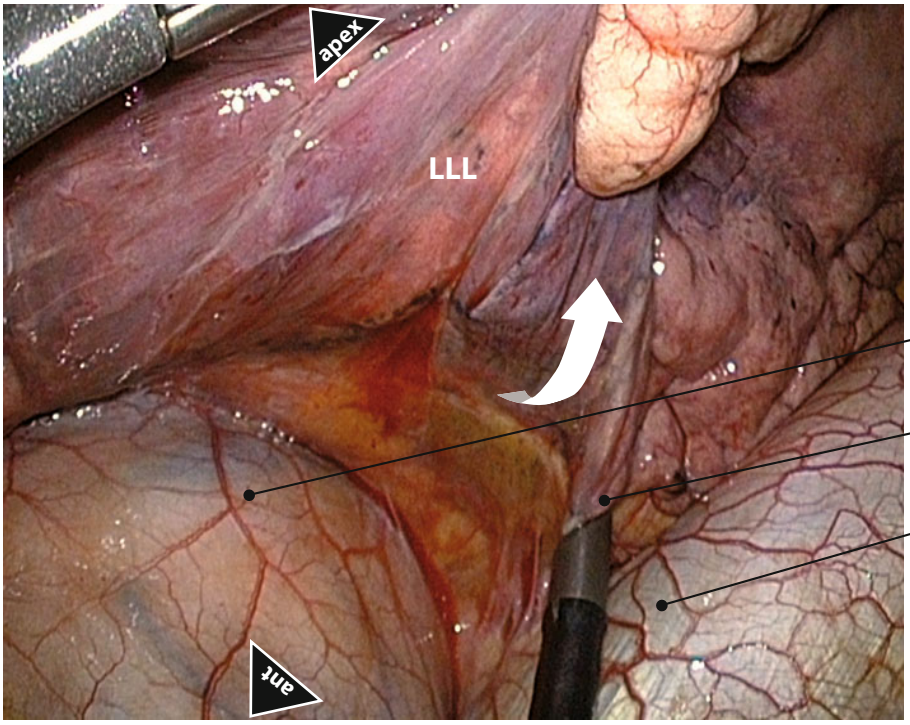


Fig. 12 – Division of the inferior pulmonary ligament.

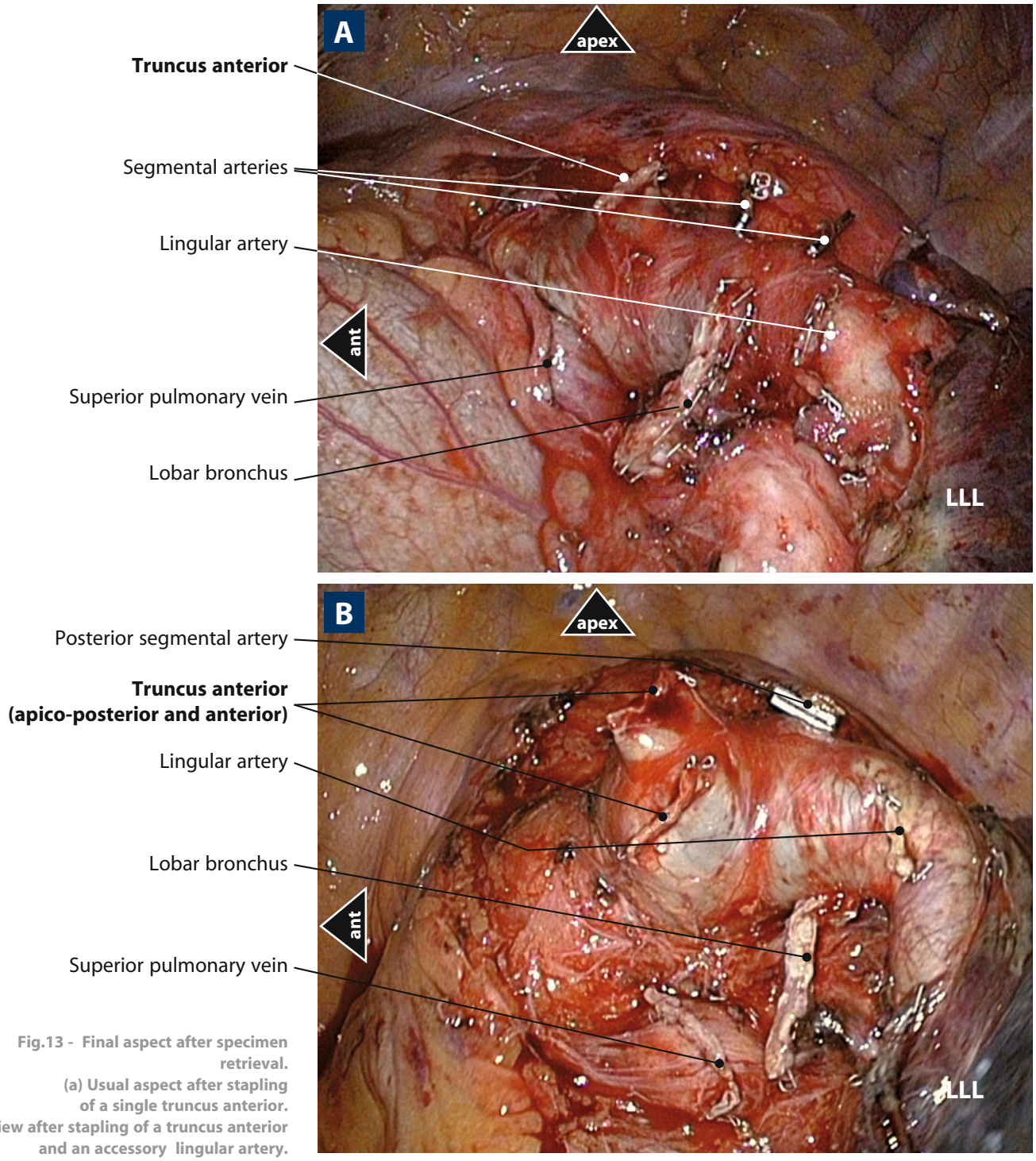


Fig.13 - Final aspect after specimen retrieval.
(a) Usual aspect after stapling of a single truncus anterior.
(b) View after stapling of a truncus anterior and an accessory lingular artery.

Anterior approach

The anterior dissection of the hilum is commonly used during open left upper lobectomy because dissection from above, via the thoracotomy, makes it quite simple to control both the superior pulmonary vein and the truncus anterior. However, when the truncus anterior and the superior vein are close to one another, an endoscopic dissection can be difficult.
The main interest of the anterior approach – when possible – during endoscopic surgery is to control the vein first, in order to access to the truncus anterior. This is, however, not always possible, and it can be preferable to use a combination of anterior and posterior dissection.

1. Vein

The upper lobe is pulled backward and downward. The mediastinal pleura is incised posterior to the phrenic nerve. Dissection of the vein is achieved by a combination of bipolar cautery and gentle sweeping motion. The vein is usually readily dissected and retracted forward to facilitate its stapling (**Fig. 14**).

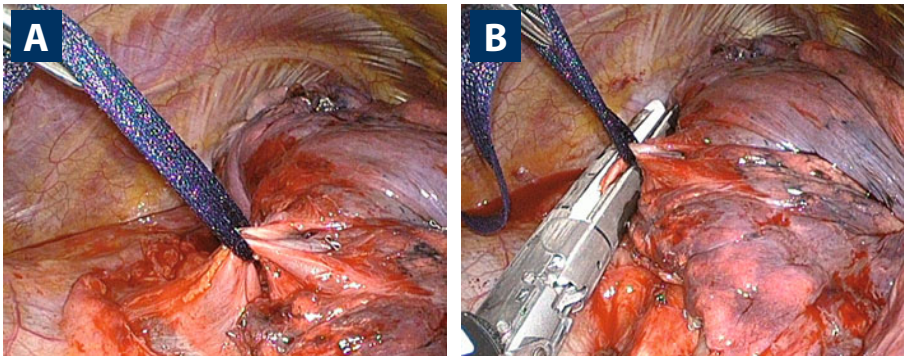


Fig. 14 – Exposure (a) and stapling (b) of the superior pulmonary vein.

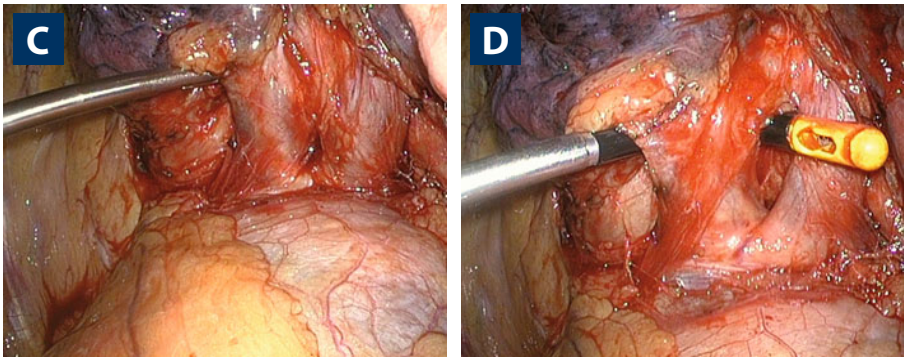


Fig. 14c and d – Example of 2 main pulmonary veins ending by a common opening into the left atrium.

2. Truncus anterior

Division of the vein helps exposing the anterior aspect of the truncus anterior. It should not be encircled and stapled before its superior and posterior surfaces are perfectly visible and free.

It is recommended to keep away from the takeoff of the arterial trunk and rather dissect the apicoposterior and anterior branches, making a potential arterial injury easier to handle (**Fig. 15**).

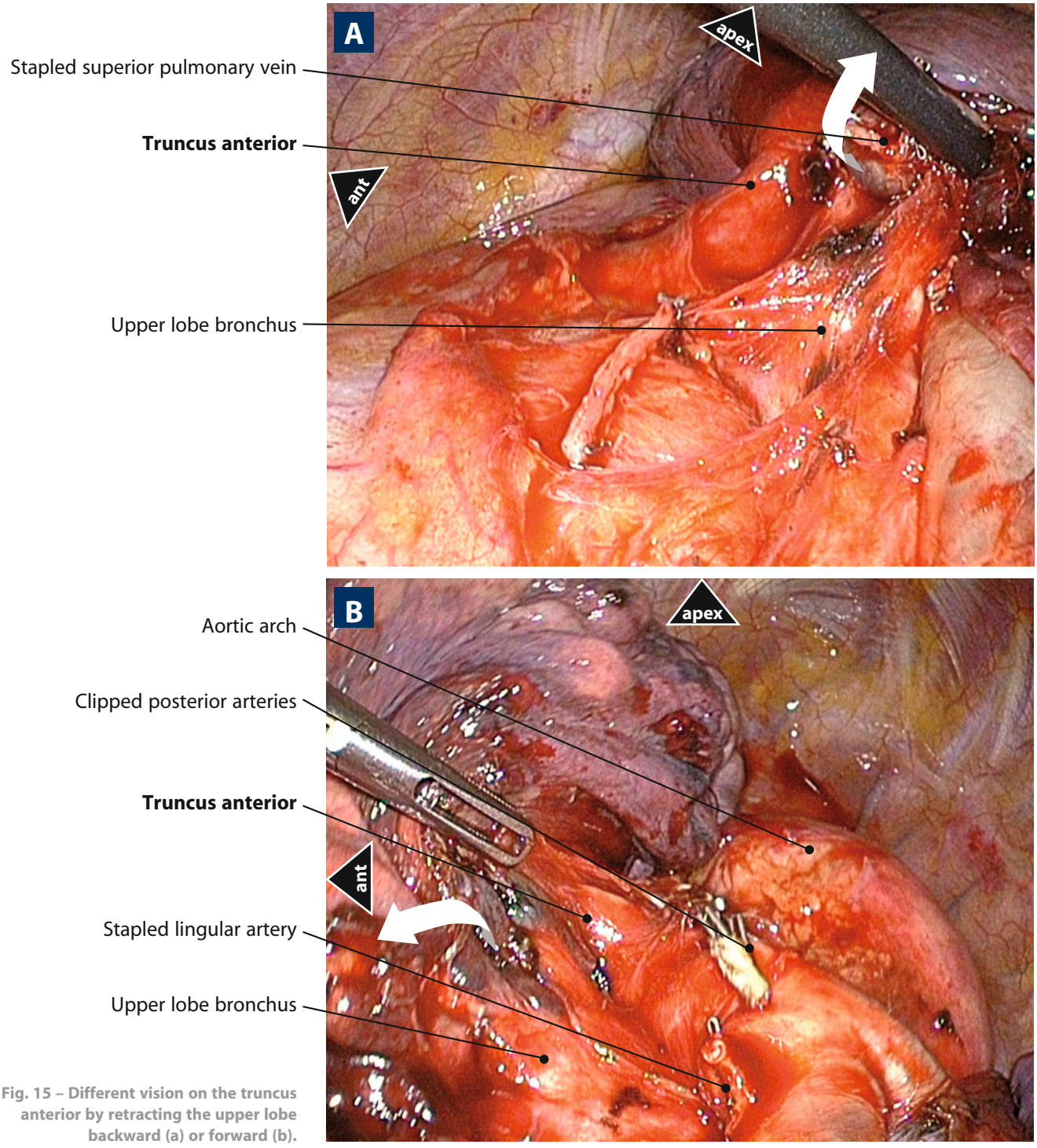


Fig. 15 – Different vision on the truncus anterior by retracting the upper lobe backward (a) or forward (b).

3. Next steps

The next steps are similar to those described in the "Posterior Approach" section.

: The video of this technique can be consulted on WEBSURG at the following address: http://www.websurg.com/ref/doi-vd01en2869.htm

Chapter VII

Left lower lobe

Chapter VII Left lower lobe

The left lower lobectomy is usually the most straightforward endoscopic lobectomy. However, when the fissure is fused, identification of the pulmonary artery can be tedious. The technique described herewith is performed by controlling the fissure and the arteries first. In some cases, it can be preferable to start by the division of the inferior pulmonary vein, which gives access to the bronchus and the pulmonary artery .

When the procedure is done for lung carcinoma, lymph node dissection of station 7 can be difficult because the venous and bronchial stumps can hamper the approach to the subcarinal region (see page 25). It may be preferable performing the lymphadenectomy before the lobectomy.

Anatomical landmarks (Fig. 1)

- **Bronchus**: The lower lobe bronchus arises with the upper bronchus at the termination of the left main bronchus. It lies beneath the arterial branches and is easily exposed once these have been divided.

- **Arteries**: Both the basal trunk and the superior segmental artery must be controlled. The superior segmental artery is single in most patients, but can be double. It takes off from the posterior aspect of the pulmonary artery. The lingular artery can arise from the basal trunk and must be clearly identified before stapling.

- **Vein**: The inferior pulmonary vein is approached from below by dividing the pulmonary ligament. It must not be stapled before having checked that the two left veins do not end by a common opening into the left atrium.

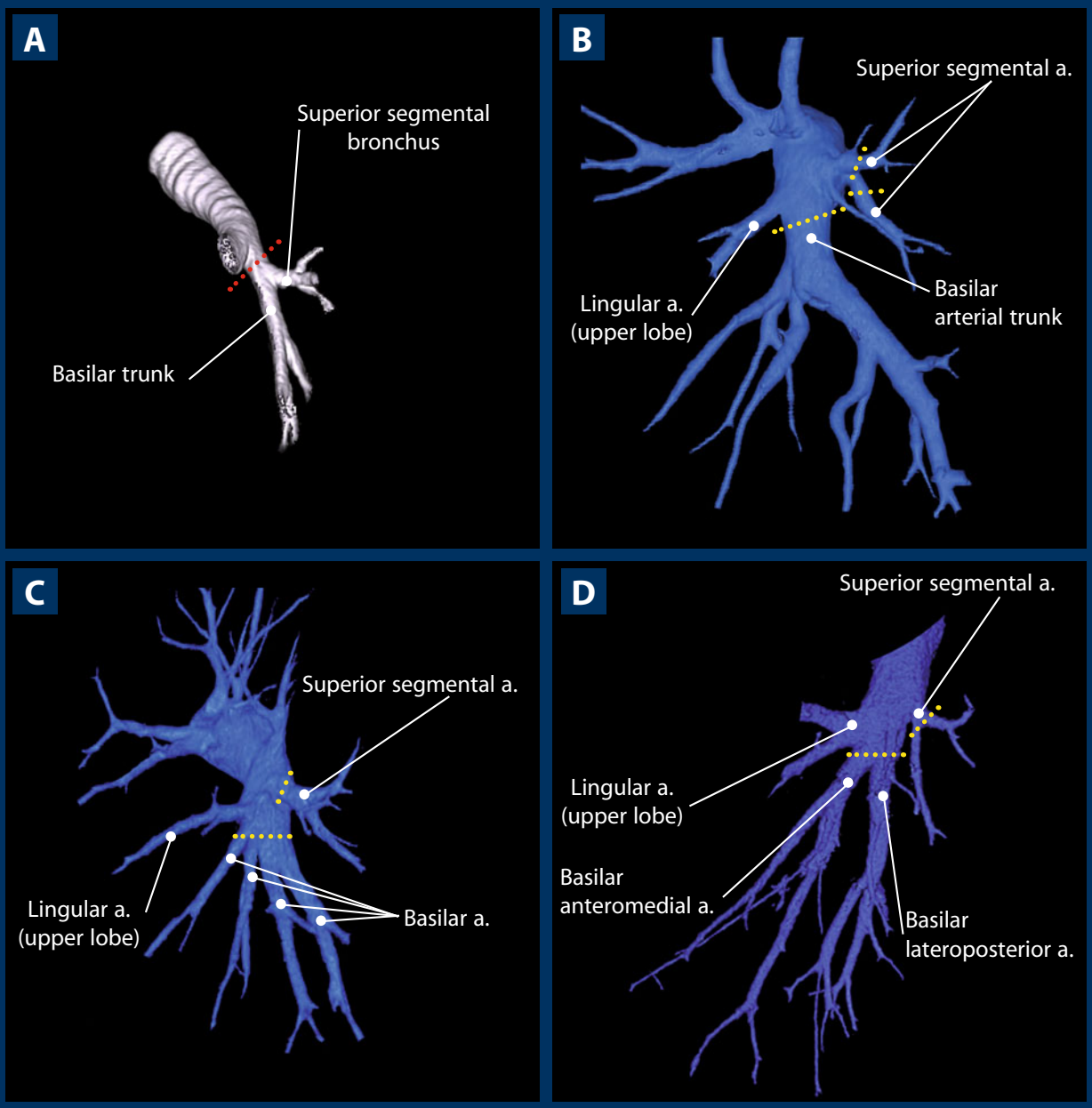
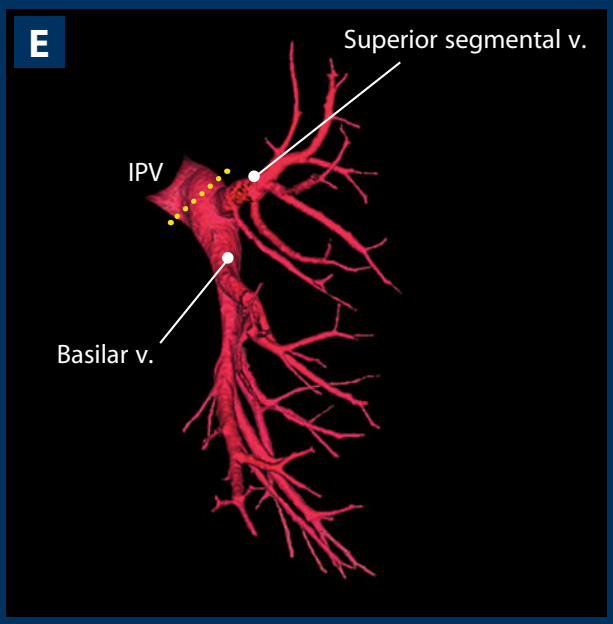
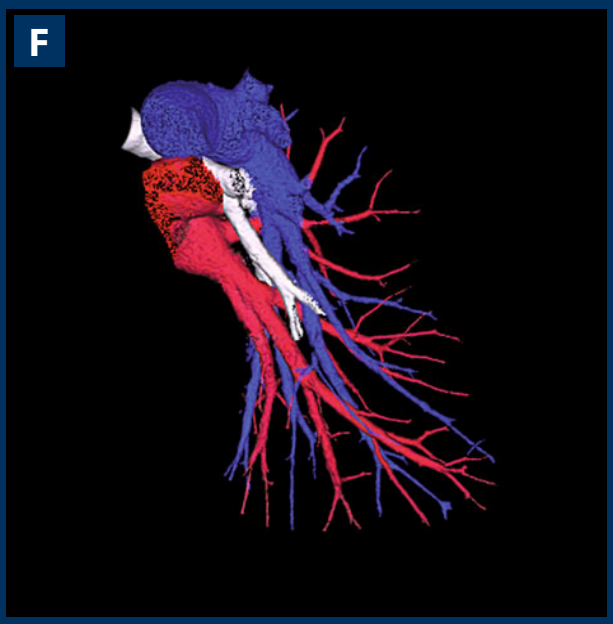
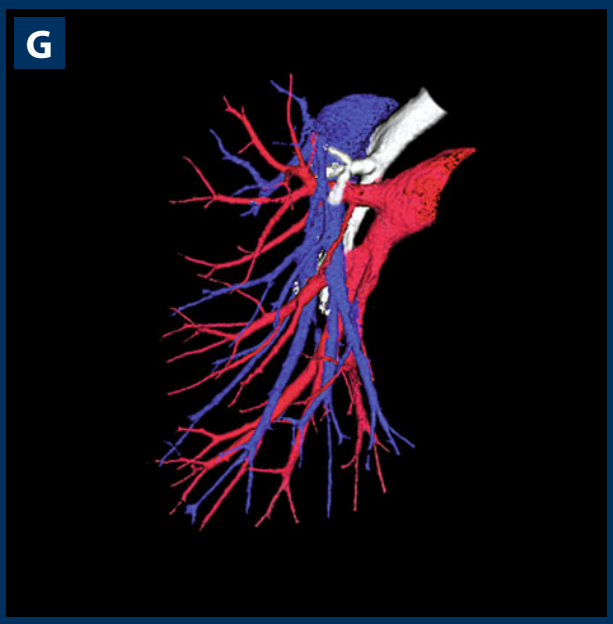


Fig. 1 – Anatomical landmarks. (a) Lower lobe bronchus (lateral view). (b) Two superior segmental arteries and basilar arterial trunk with distal division (lateral view). (c) Single superior segmental artery and early division of basilar arteries (lateral view). (d) Two main arterial trunks, one for the anteromedial segments and one for the posterior and lateral segments (lateral view).







(e) Inferior pulmonary vein (lateral view). (f) Bronchus, arteries, and veins (anterior view). (g) Bronchus, arteries, and veins (posterior view). a: artery, v: vein, IPV: inferior pulmonary vein, dotted lines: level of division.

Technique

1. Fissure and arteries

If the lung is fully deflated, the fissure can be approached without the help of retractors. Otherwise, both lobes should be spread apart to expose the middle portion of the fissure. The pulmonary artery may be visible or hidden if the fissure is fused (**Fig. 2**).

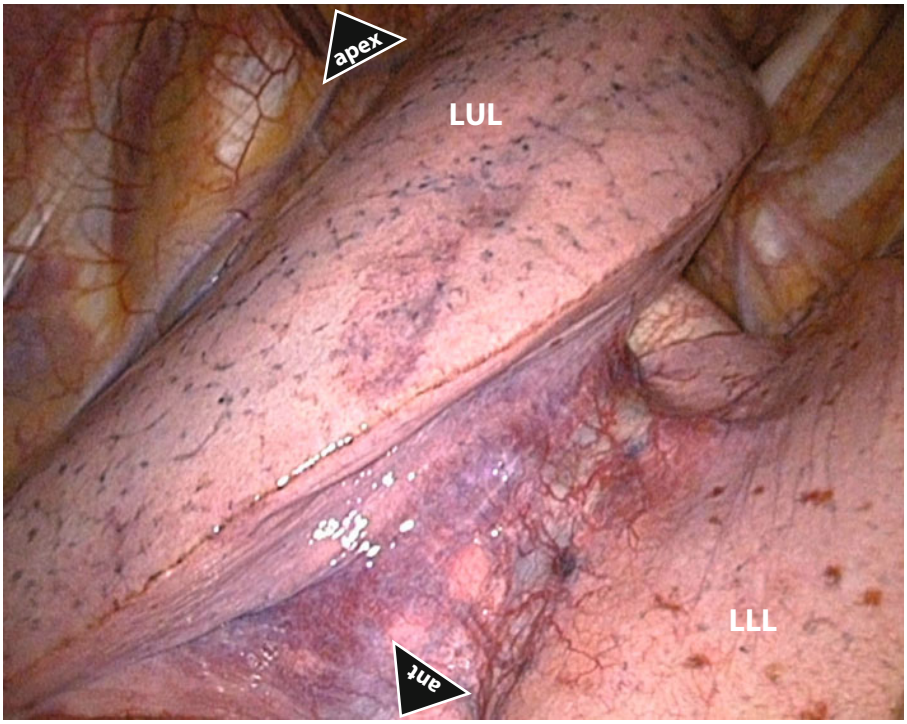


Fig. 2 – Exposure of the fissure.

In case of a fused and long fissure, it is advisable to first divide the anterior portion of the fissure, taking care not to injure the lingular artery, in order to facilitate mobilization and exposure of the arteries (**Fig. 3**).

The hilar portion of the fissure must not be divided until the origin of the lingular artery has been identified.

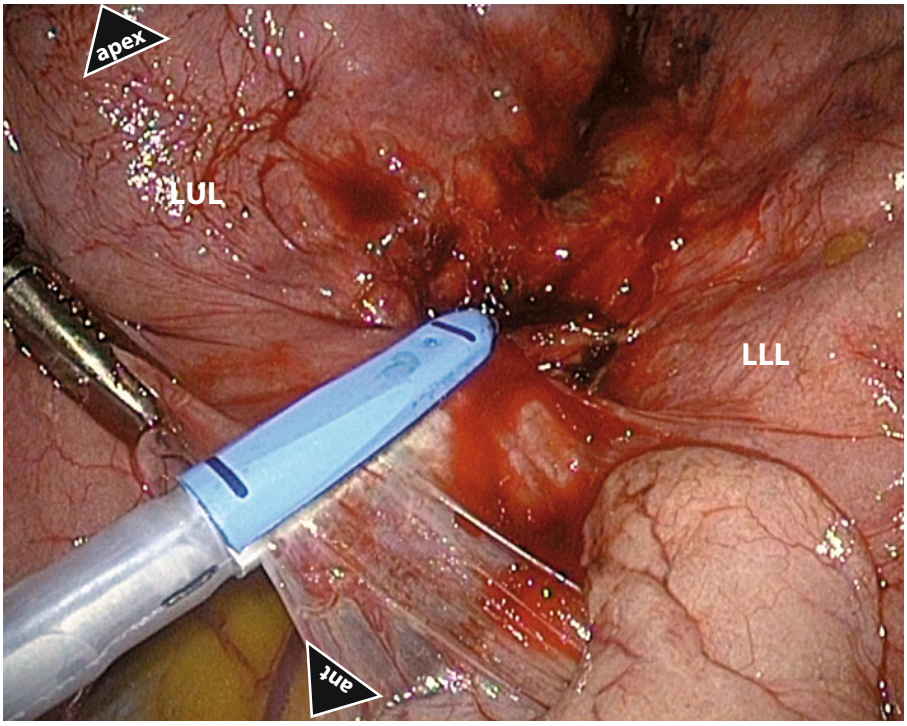


Fig. 3 – Division of the peripheral and thin portion of the fissure using bipolar sealing.

Once the peripheral portion of the fissure has been divided, it becomes easier to display the reflection of the mediastinal pleura, between the two pulmonary veins. The pleura is opened with diathermy, and a dissector can then be passed toward the pulmonary artery. This allows completing the division of the anterior fissure (**Fig. 4**).

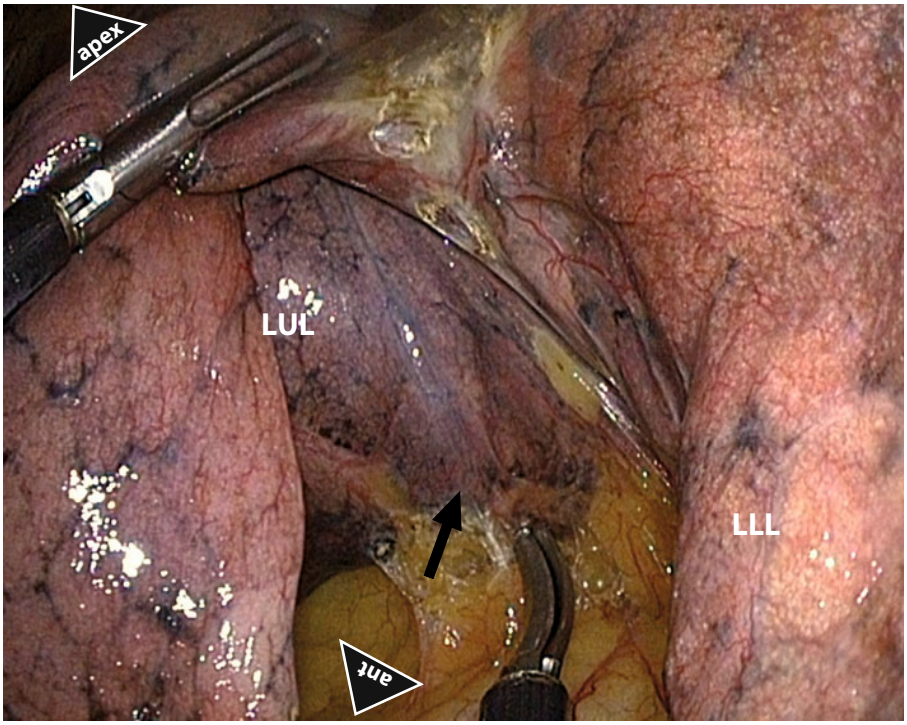


Fig. 4 – Opening of the anterior mediastinal pleura between the two pulmonary veins (*arrow*).

If the space is too narrow to allow inserting the stapler jaws, a tape can be passed to retract the fissure (**Fig. 5**).

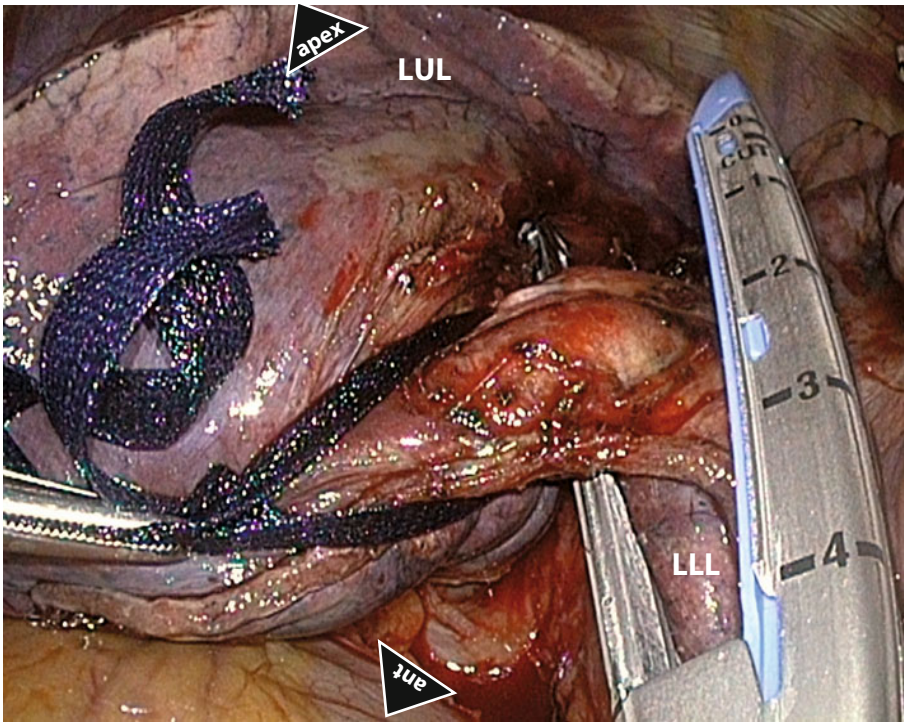


Fig. 5 – Completing the division of the anterior portion of the fissure.

Completion of the anterior fissure division helps exposing the pulmonary artery whose sheath is opened (**Fig. 6**).

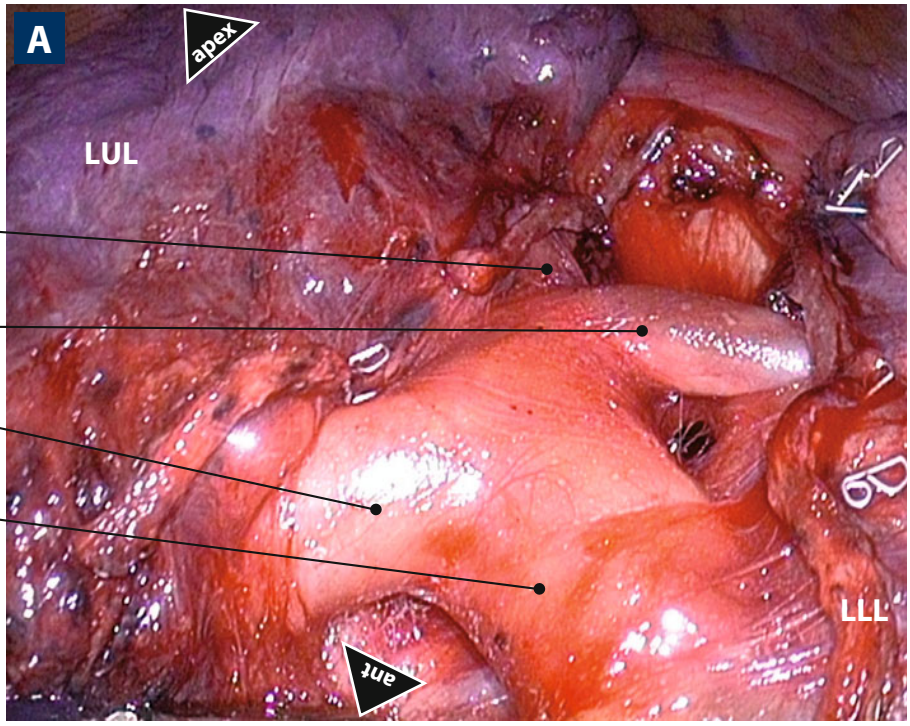


Fig. 6 – Arterial supply to the left lower lobe (typical X-shaped pattern of the pulmonary artery in the fissure).

The posterior fissure is then opened by inserting the tip of the right angle from the posterior aspect of the pulmonary artery to the posterior mediastinum. This may require retracting the lobes forward to expose the mediastinal pleura. The oblique-viewing or deflectable scope is helpful to control this maneuver (**Fig. 7**). The posterior fissure is then stapled.

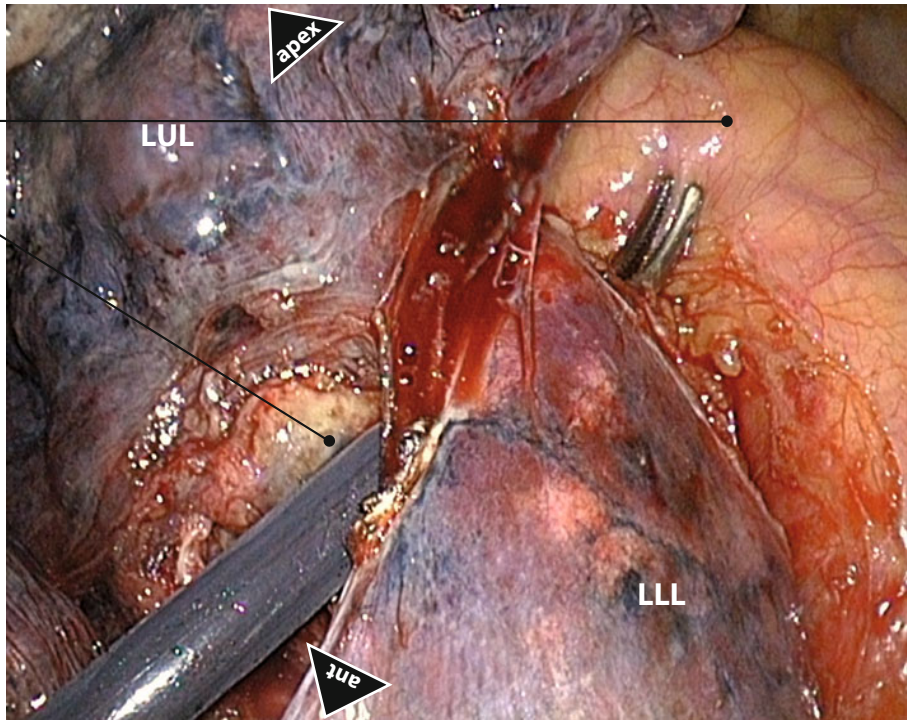


Fig. 7 – Division of the posterior fissure.

The apical lower artery and the basilar trunk are divided separately or together depending on each patient's anatomic features (**Fig. 8**).

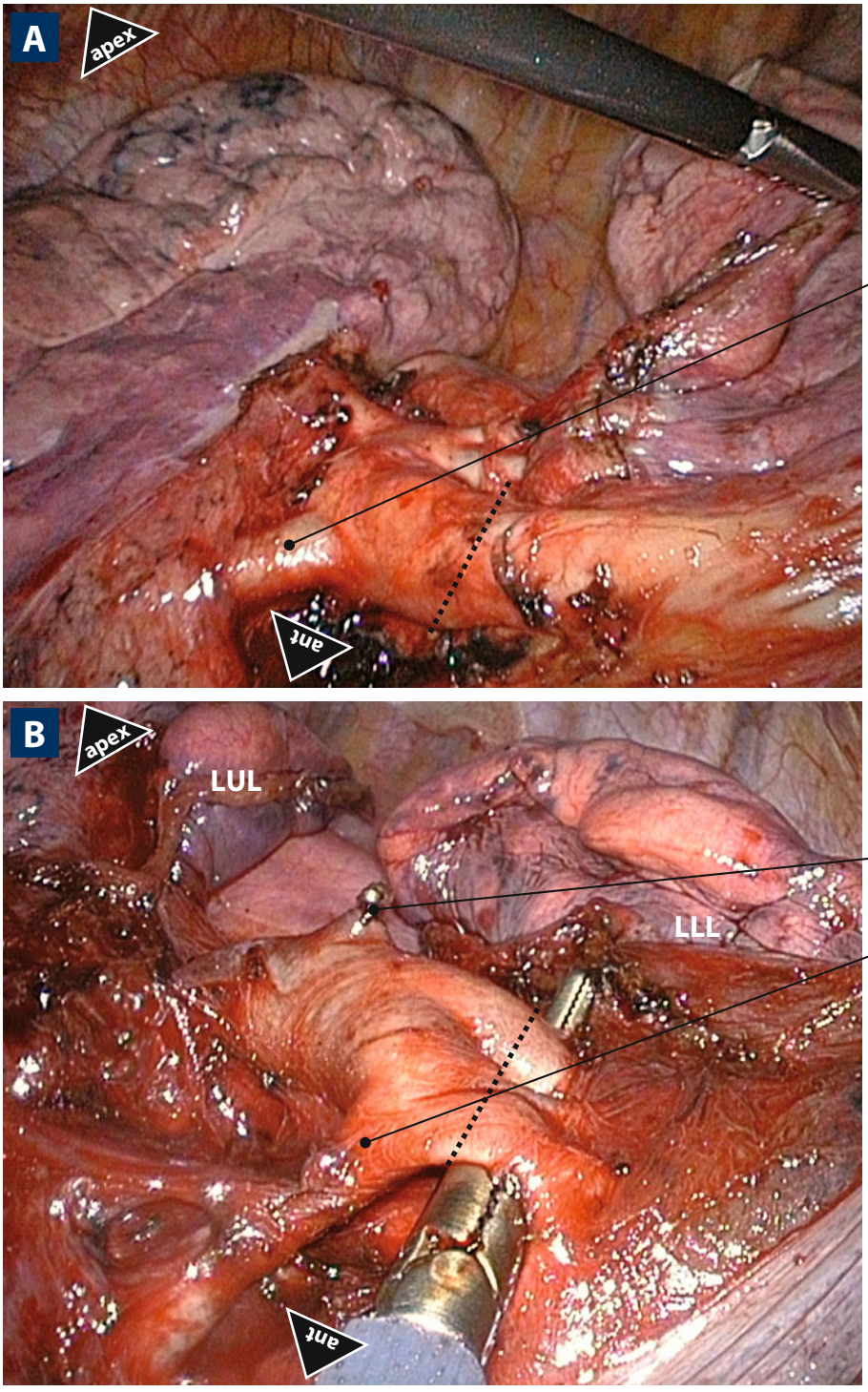


Fig. 8 – Dissection of the basal arterial trunk.
(a) Usual pattern.
(b) Less frequent aspect: the lingular artery originates from the basal trunk and should be preserved during stapling (*dotted line*).

2. Vein

The pulmonary ligament is incised up to the lower vein using both diathermy and gentle traction on the lower lobe (**Fig. 9**).

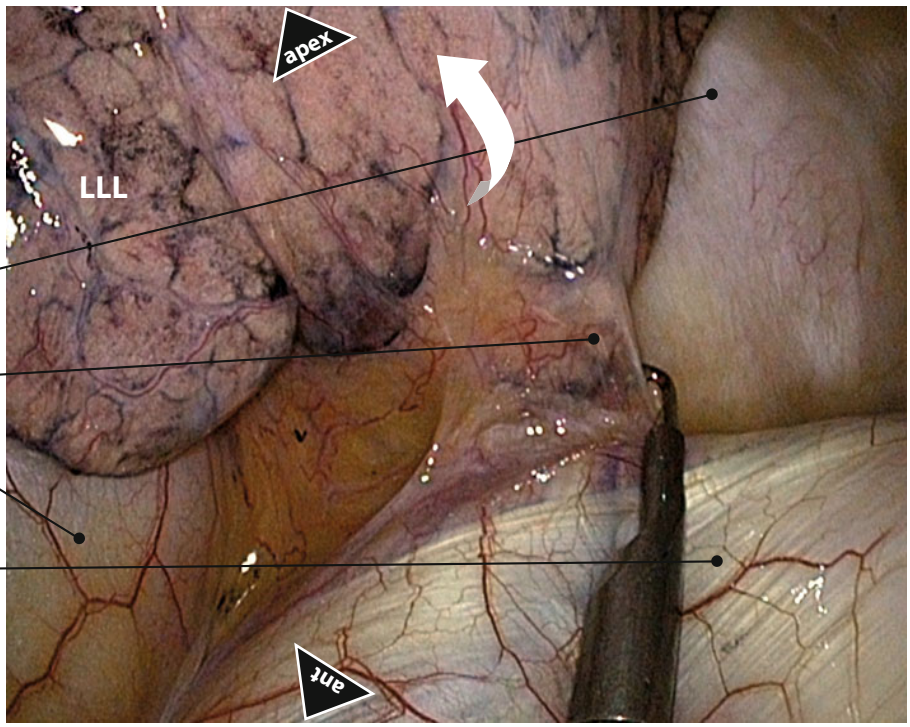


Fig. 9 – Division of the pulmonary ligament.

The vein is cleared from the surrounding tissues – what can be tedious in some overweight patients – and stapled. Taping the vein can facilitate stapling (**Fig. 10**).

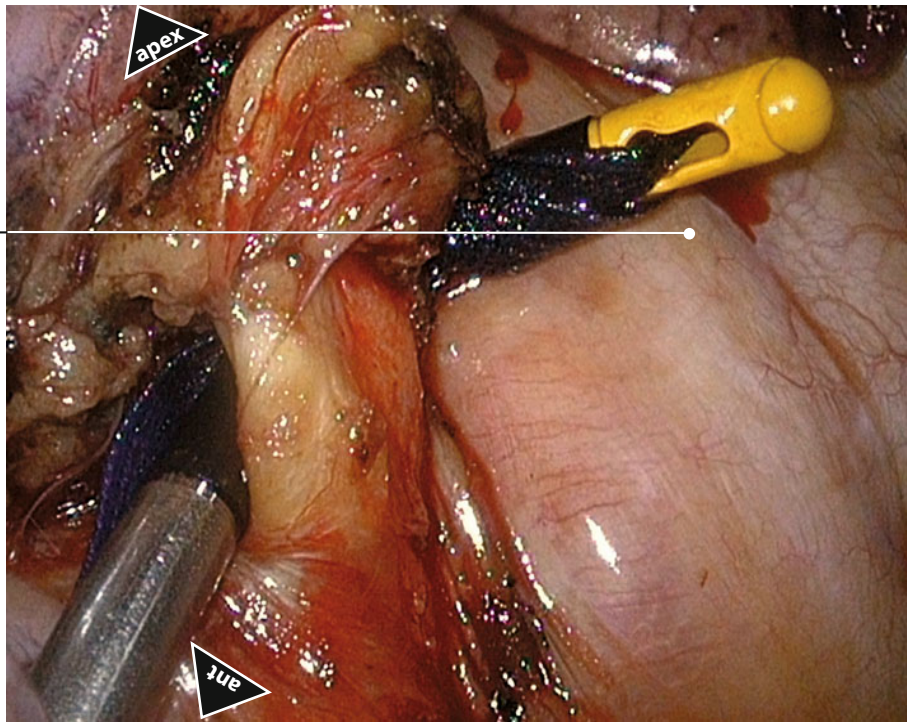


Fig. 10 – Exposure of the inferior pulmonary vein.

Before any division of the inferior pulmonary vein, it must be checked that the left pulmonary vein is not single.

3. Bronchus

Division of the lower vein gives access to the lobar bronchus, which is cleared and divided, with the avoidance of impingement on the upper lobe bronchus. If any doubt, a reventilation test can be helpful (**Fig. 11**). The specimen is retrieved in the usual fashion (**Fig. 12**).

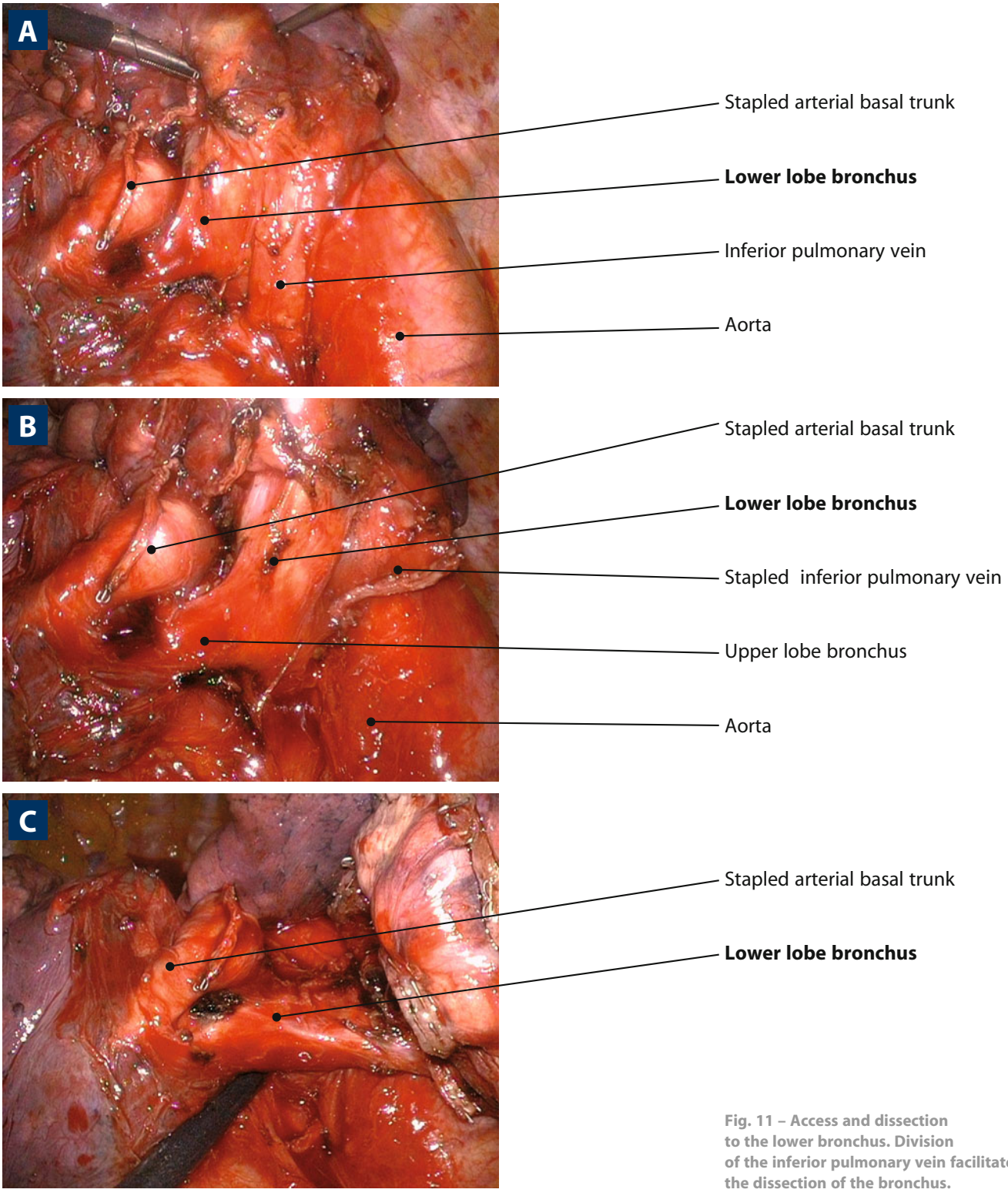


Fig. 11 – Access and dissection to the lower bronchus. Division of the inferior pulmonary vein facilitates the dissection of the bronchus.

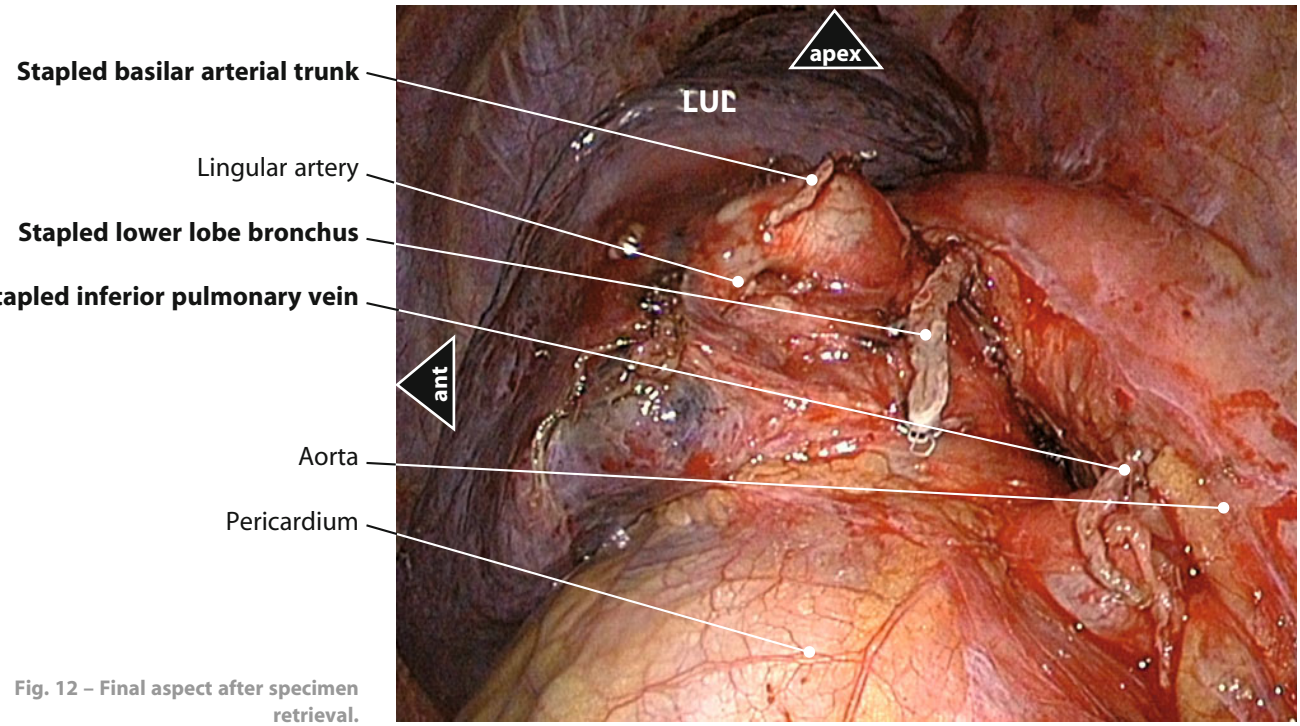


Fig. 12 – Final aspect after specimen retrieval.

: The video of this technique can be consulted on WEBSurg at the following address: http://www.websurg.com/ref/doi-vd01en2908.htm

Segmentectomies

VIII – Right upper lobe: apicoposterior segments

IX – Right lower lobe: superior segment

X – Right lower lobe: basal segments

XI – Left upper lobe: superior segments

XII – Left upper lobe: lingula

XIII – Left lower lobe: superior segment

XIV – Left lower lobe: basal segments

Chapter VIII

Right upper lobe: apicoposterior segments

Chapter VIII

Right upper lobe: apicoposterior segments

The right upper lobe consists of three segments: apical (S1), posterior (S2), and anterior (S3). The three segmentectomies of the right upper lobe are feasible. However, in case of tumor or inflammatory disease of the apical or posterior segment, the posterior and apical segments are most often removed together. With respect to the anterior segment, dissection is considered as one of the most challenging for the following reasons: the segmental bronchus is not easily accessible, the anterior segmental artery is covered by the apical vein, and the preservation of the anterior segmental vein is tedious. For these reasons, only the apicoposterior segmentectomy will be described thereafter.

The apicoposterior segmentectomy of the right upper lobe comprises two types of difficulties: the dissection of the segmental bronchi at their entrance into the parenchyma and the control of segmental arteries.

Anatomical landmarks (Fig. 1)

- **Arteries**: The arteries to the apical and posterior segments have to be divided. They arise from the truncus anterior and the ascending arteries. The truncus anterior duplicates into the apical artery and the anterior artery, which must be preserved. The posterior segment is supplied by the posterior segmental branch, which originates within the fissure from the posterior aspect of the pulmonary artery, opposite the middle lobe artery. It ascends to the posterior segment and lies anteriorly to the lobar bronchus. In the majority of patients, there is only one artery, while there are none or two in some patients. In about 10% of patients, this artery originates from the superior supply of the lower lobe. The posterior segmental artery must not be mistaken for an inconstant anterior ascending branch that supplies the anterior segment and that should be respected.

- **Veins**: The upper root of the right superior pulmonary vein consists of three segmental branches: apical, posterior, and anterior. It is safer dividing only the apical vein. The control of the posterior vein will be done in the fissure if it is visible. If not visible, this posterior vein can be neglected and will be divided during the parenchymal stapling.

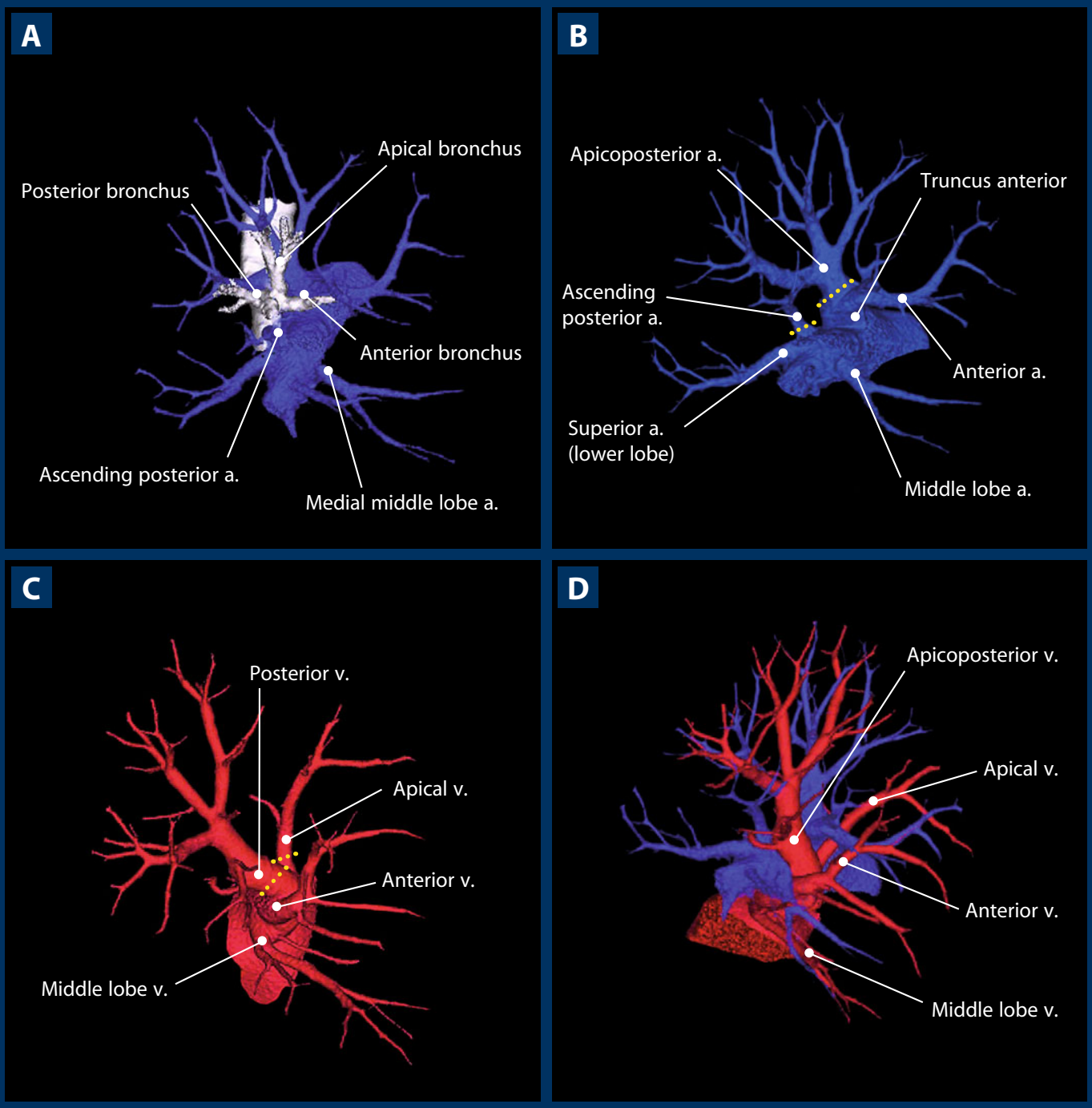


Fig. 1 – Anatomical landmarks. (a) Upper lobe bronchus and segmental arteries (lateral view). (b) Arterial supply to the apicoposterior segments (anterior view). (c) Venous drainage (anterior view). (d) Relationships between bronchi and arteries of the apicoposterior segments (lateral view). Dotted lines: level of division, a: artery, v: vein.

- **Bronchus**: As it enters the parenchyma, the upper lobe bronchus triplicates into segmental bronchi. The anterior bronchus, which must be preserved, is the lowest one and is identifiable by its anterior direction. The apical and posterior bronchi will be divided separately or as a stem.

Technique

1. Fissure and ascending posterior artery

As for some right upper lobectomies, it is more convenient to start the resection by controlling and dividing the bronchi. However, this can be done only if the ascending posterior artery, which hides the upper lobe bronchus, is severed. The posterior aspect of the oblique fissure is opened as described for right upper lobectomies (see page 41).
This is achieved by stretching the upper lobe or lower lobe anteriorly, until the posterior mediastinum is fully exposed. The pleura facing the inferior aspect of the upper bronchus is opened using either cautery or blunt dissection or both. A dissecting forceps is then passed from the hilum – at the level of the posterior aspect of the pulmonary artery – to the periphery under vision control, thanks to the deflectable scope. A 60-mm endostapler can then be applied. This helps exposing the posterior artery, which is then dissected and clipped or severed after bipolar sealing (**Fig. 2**).

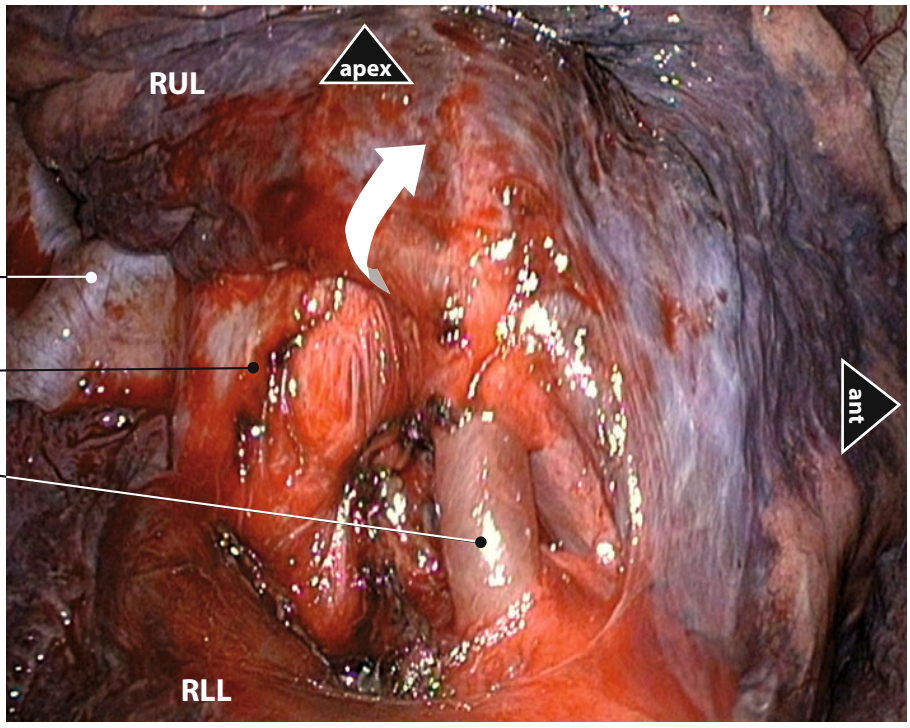


Fig. 2 – Exposure of the ascending artery to the posterior segment after division of the posterior part of the oblique fissure.

The presence of large and/or multiple venous branches within the fissure can increase the difficulty in controlling the arterial branches. These must be controlled one by one, avoiding clip application, which could conflict with later stapling.

2. Segmental bronchi

Once the ascending posterior arterial branch has been divided, the posterior surface of the right upper bronchus is fully exposed. The tissues overlying its superior aspect are freed using a cautery hook. Clearing of the upper lobe bronchus must be pursued forward until the apical segmental bronchus becomes apparent (**Fig. 3**).

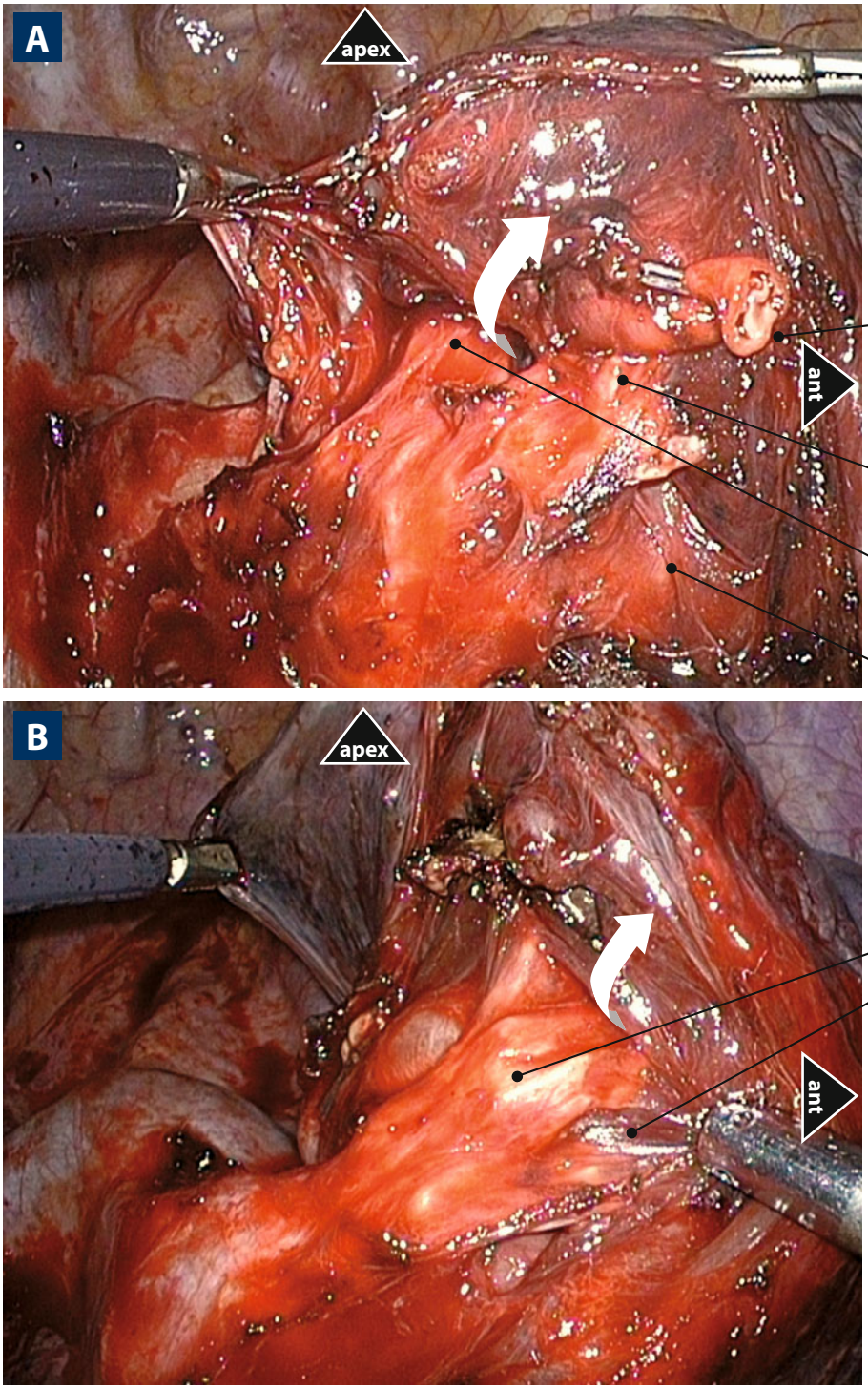


Fig. 3 – Exposure of the segmental bronchi of the right upper lobe.
(a) Independent bronchi.
(b) Common apicoposterior stem.

Dissection of the segmental bronchi is continued by a combination of gentle traction of the upper lobe and blunt dissection. This is best achieved by an endopeanut while any oozing or minor bleeding from small peribronchial arteries is immediately controlled. Finally, the trifurcation is exposed: the anterior segmental bronchus, which is the lowest branch, and the posterior and apical bronchi, which can take off independently or as a common stem (**Fig. 4**).

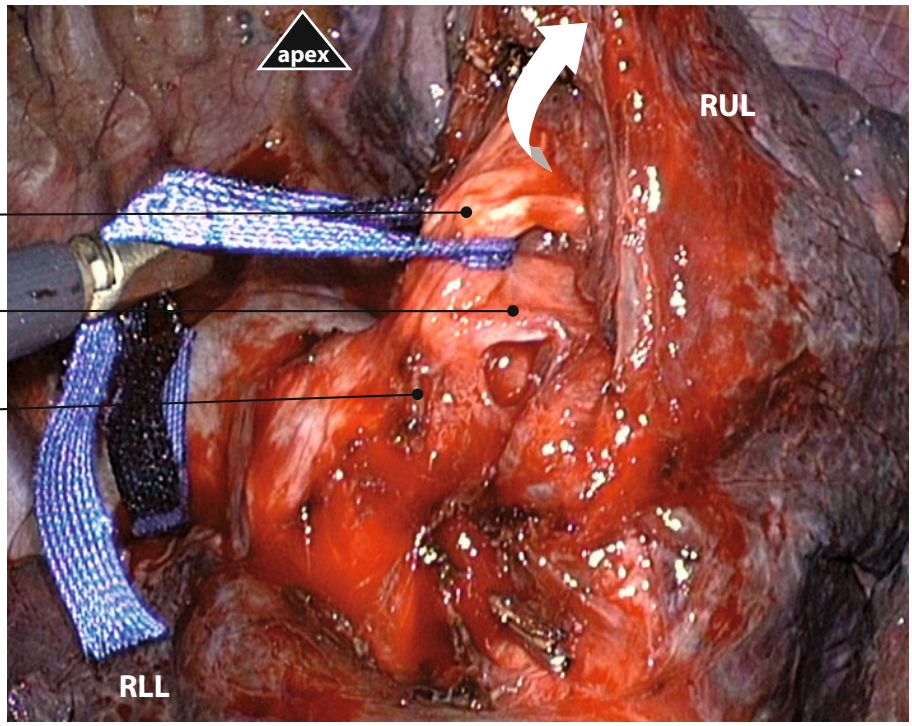


Fig. 4 – Retraction of the apicoposterior bronchus.

At this stage, two different situations can be faced: (1) dissection is easy because tissues are soft and anatomy is clear, and (2) dissection is uneasy. In the latter situation, getting around the bronchi is at risk of tearing the arteries that run anterior to the bronchi. One should prefer controlling the truncus anterior and the apical artery from the mediastinal side. But if the dissection is smooth, turning around the apical and posterior bronchi from the back is possible, always keeping in mind that the arteries run anteriorly to the bronchi. A blunt tip retractor is used to retract the bronchi backward and move them away from the arteries. The bronchi can then be stapled one by one or as a stem (**Fig. 5**).

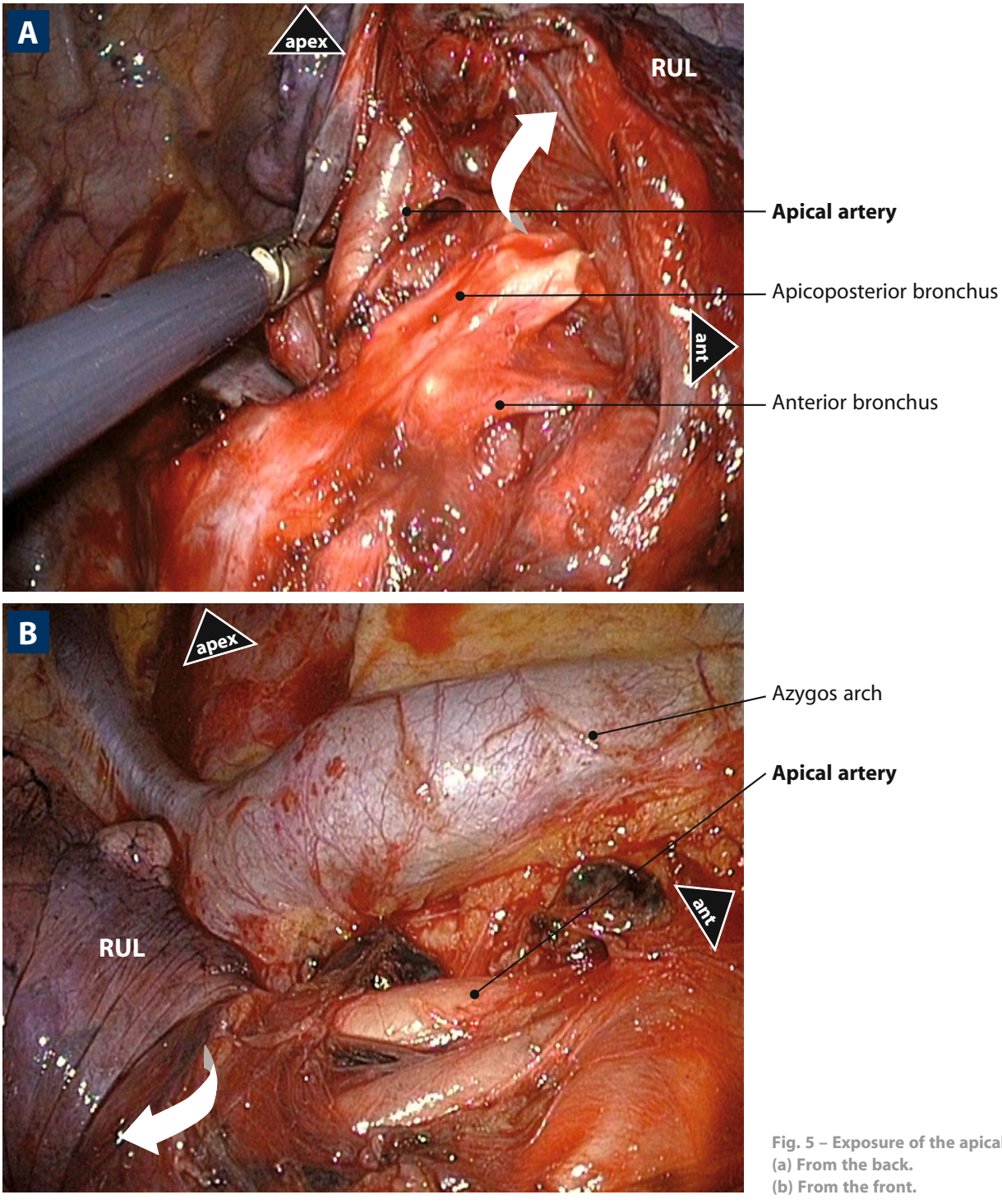


Fig. 5 – Exposure of the apical artery.
(a) From the back.
(b) From the front.

3. Apical artery

This maneuver liberates the apicoposterior segments that unfold forward, thus exposing the apical artery, which is the uppermost tributary of the truncus anterior. Dissection of its posterior and lateral aspects can be done from behind. If necessary, its anterior aspect can be freed from the front after exposure of the truncus anterior by retracting the upper lobe backward. The apical artery is stapled (**Fig. 6**).

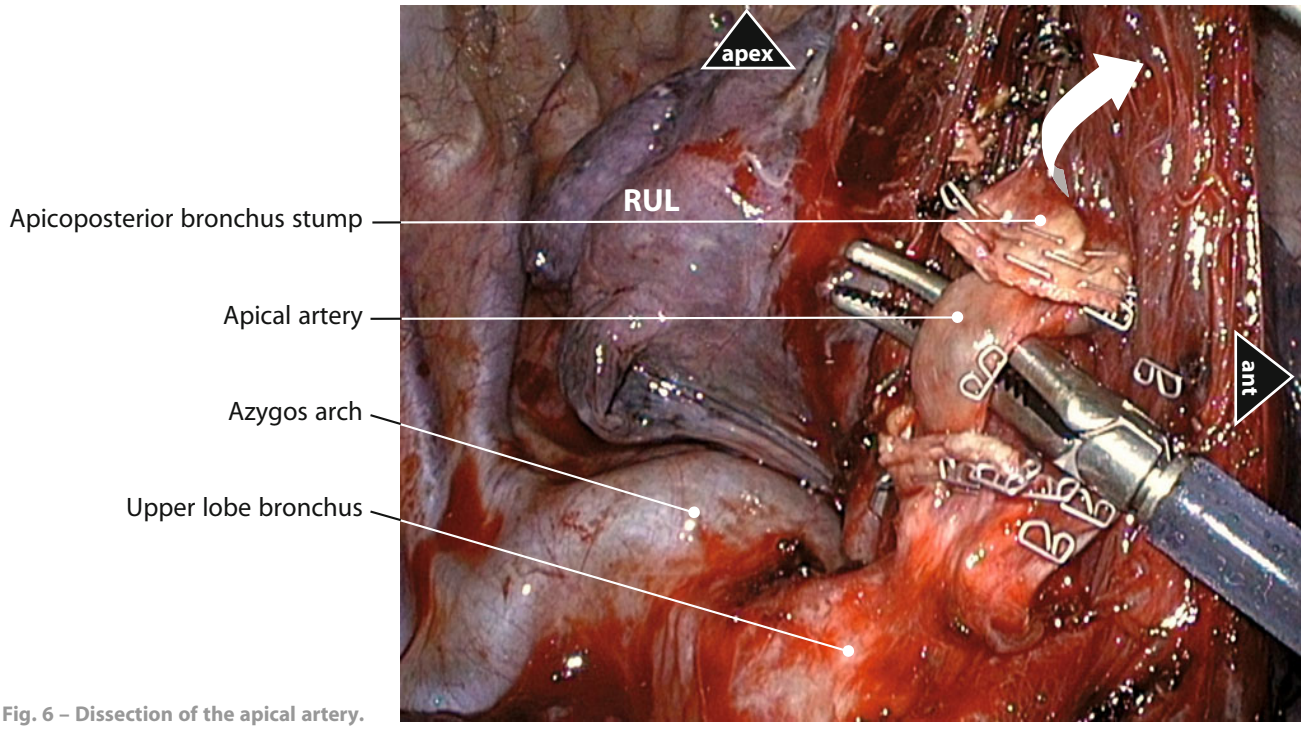


Fig. 6 – Dissection of the apical artery.

4. Apical vein

The superior pulmonary vein is exposed by retracting the upper lobe backward and incising the mediastinal pleura posterior to the phrenic nerve. Its dissection is achieved by a combination of bipolar cautery and gentle sweeping motion with an endopeanut. The three segmental branches of the upper root of the superior pulmonary vein as well as the origin of the middle lobe vein are exposed. Theoretically, both the apical and posterior venous branches should be divided. However, even if the segmental pattern of the vein is clear, it seems advisable to divide only its uppermost tributary, since one cannot asssert the branch in the middle of the trifurcation does only drain the posterior segment (**Fig. 7**).

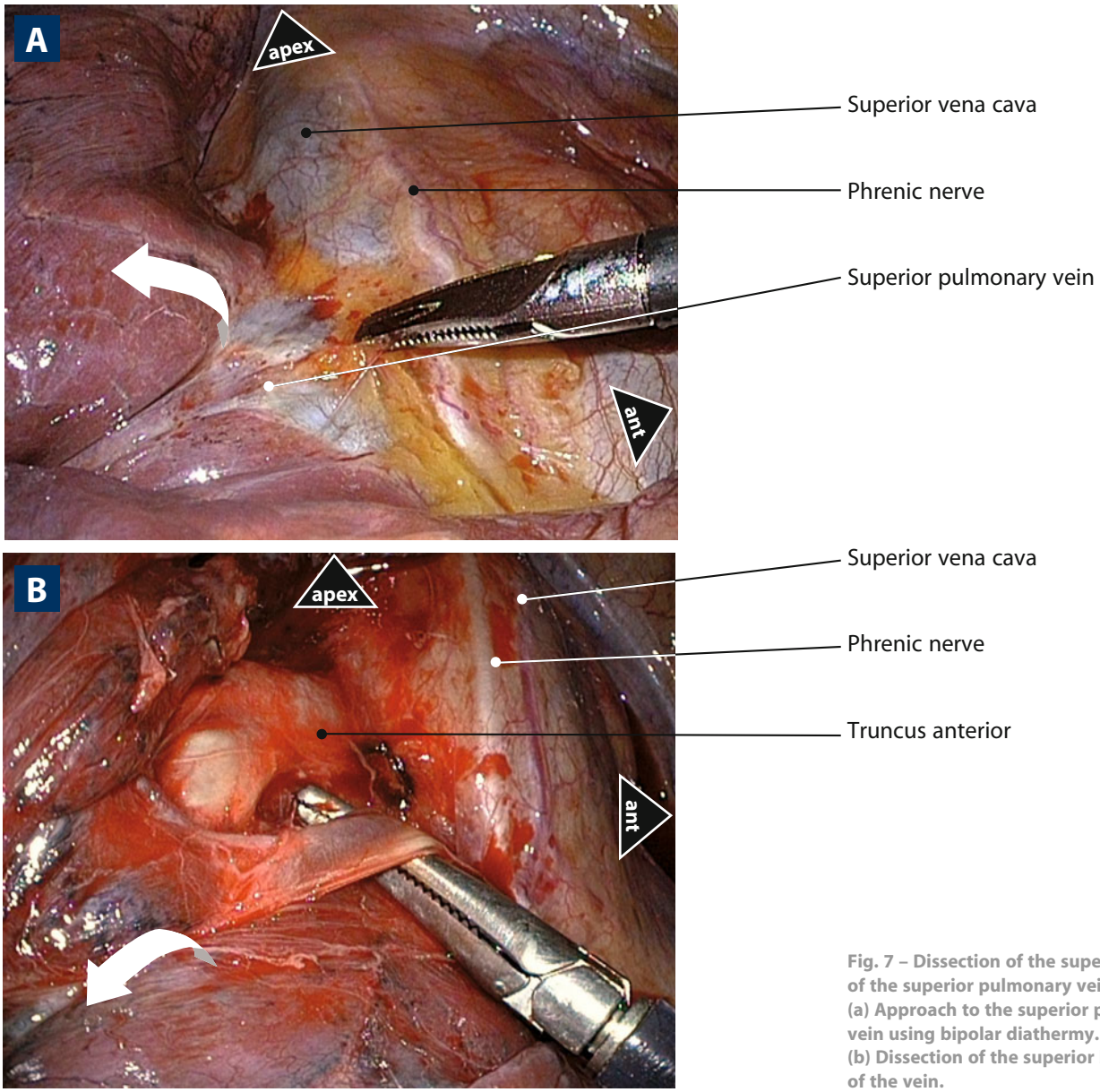


Fig. 7 – Dissection of the superior branch of the superior pulmonary vein. (a) Approach to the superior pulmonary vein using bipolar diathermy. (b) Dissection of the superior branch of the vein.

5. Division of the parenchyma

Once all segmental vascular and bronchial elements have been divided, the lobe can be lifted up and a clamp is applied on the parenchyma. Low-volume and low-pressure reventilation helps determining the intersegmental plane while the clamp is repositioned on the demarcation line between ventilated and non-ventilated zones. Some force is applied on the clamp to crush and flatten the parenchyma. The 60-mm endostapler with the 4.8-mm cartridge can then be applied. The specimen is retrieved in the usual fashion (**Fig. 8**).

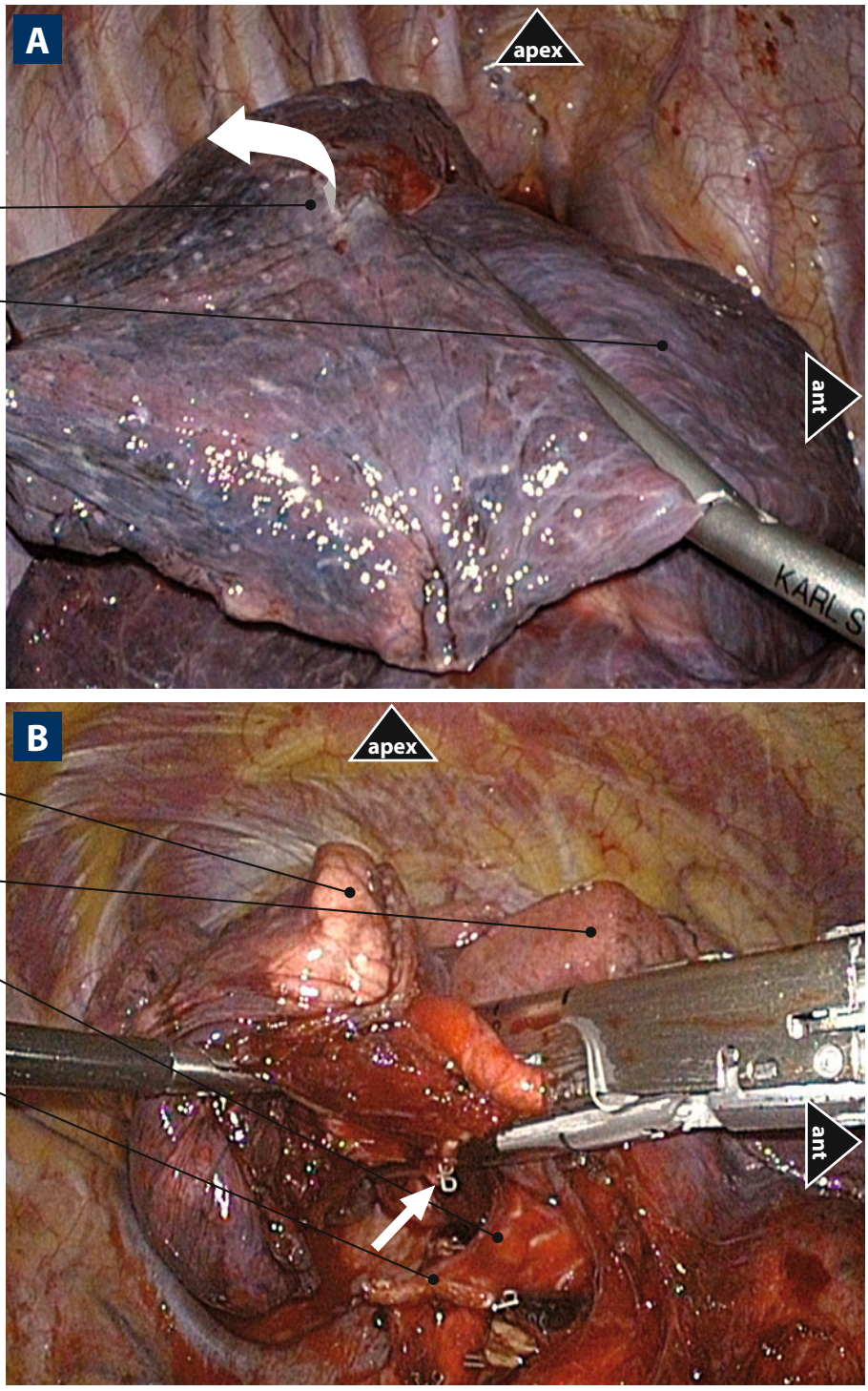


Fig. 8 – Division of the parenchyma. (a) Delineation of the intersegmental plane by clamping. (b) Stapling.

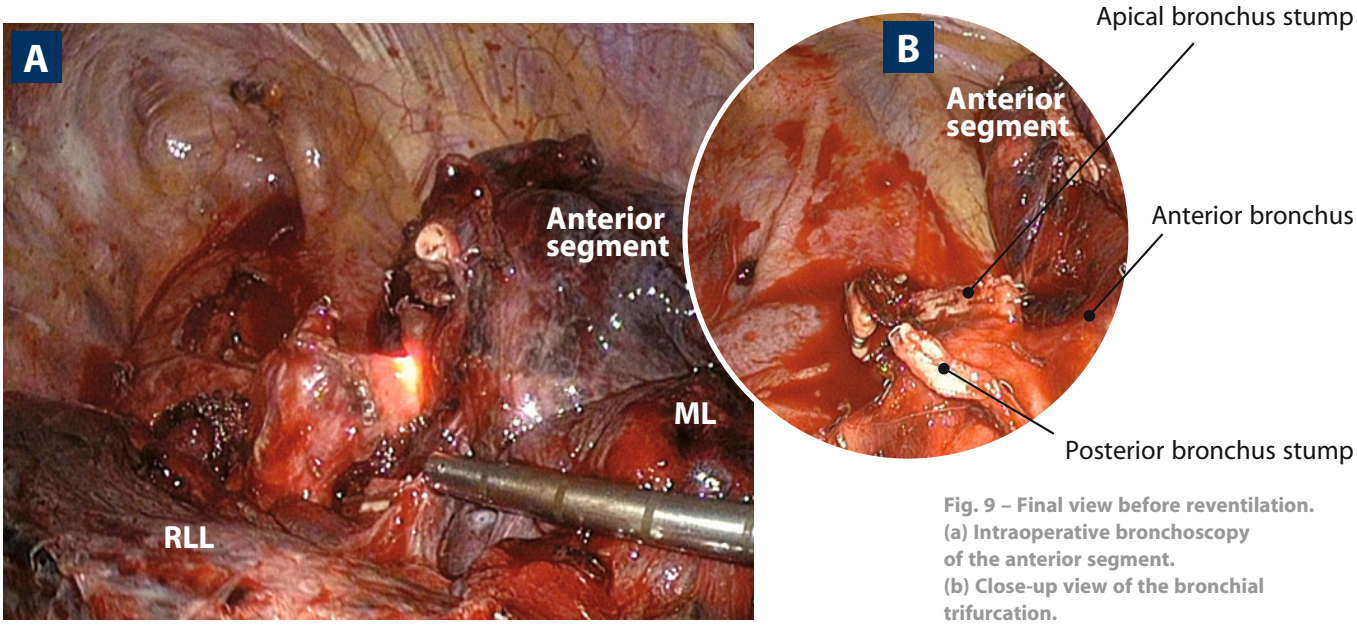


Fig. 9 – Final view before reventilation. (a) Intraoperative bronchoscopy of the anterior segment. (b) Close-up view of the bronchial trifurcation.

Since ventilation – even with low volumes – results in impaired vision, it can be advisable to reventilate only the remaining anterior segment via a selective bronchoscopy in the anterior segmental bronchus (Fig. 9).

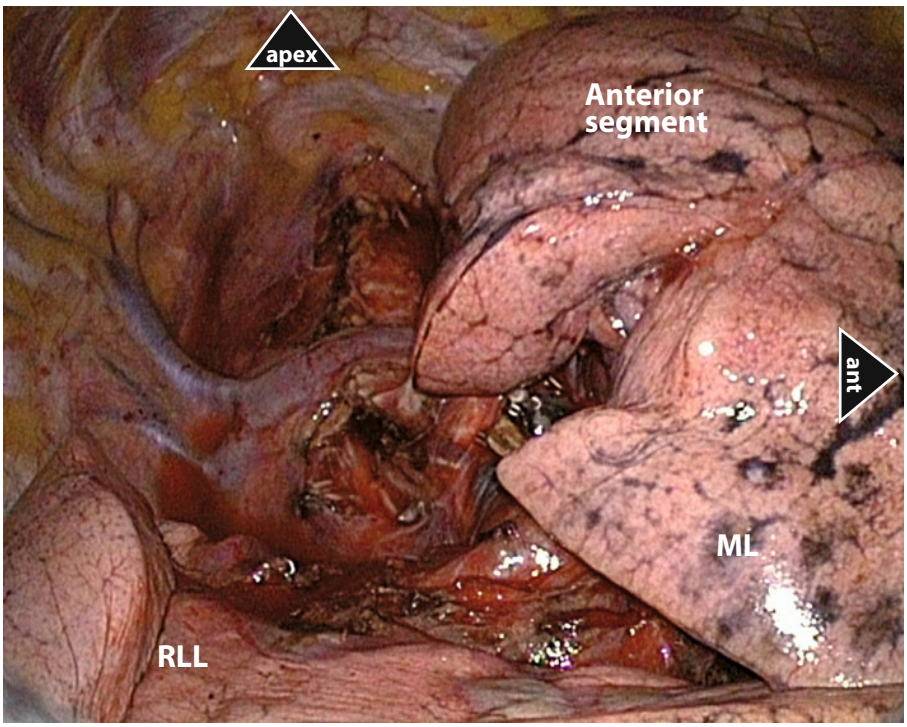


Fig. 10 – Final aspect after specimen retrieval and reventilation.

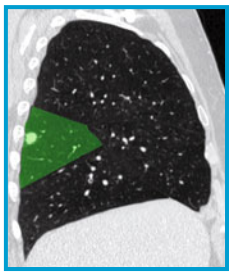
During positioning of the endostapler, it must be checked that no clip or staple conflicts with the forthcoming staple line. The same is true for the distal bronchial stump (*white arrow*), which must be kept away from the stapler jaws (Fig 8).

: The video of this technique can be consulted on weBSurg at the following address: http://www.websurg.com/ref/doi-vd01en2522.htm

Chapter IX

Right lower lobe: superior segment

Chapter IX Right lower lobe: superior segment



Resection of the superior segment (S6) of the right lower lobe is reasonably easy, thanks to the constant anatomical landmarks. However, as for a right lower lobectomy, the exposure of the pulmonary artery and its segmental branch can be tedious in case of fused fissure.

Anatomical landmarks (Fig. 1)

- **Bronchus**: The superior segmental bronchus originates opposite or slightly above the middle lobe bronchus. It lies posteriorly to the segmental artery. It is single in most patients but can rarely arise as two separate orifices.

- **Arteries**: The superior segment of the right lower lobe is supplied in most cases by a single segmental artery that originates within the fissure at the same level with the basal trunk. However, in some patients, the superior segmental artery originates from the ascending artery of the upper lobe or from the basal trunk. It is usually single but can be double.

- **Veins**: The vein to the superior segment is the uppermost and smaller segmental tributary of the inferior pulmonary vein.

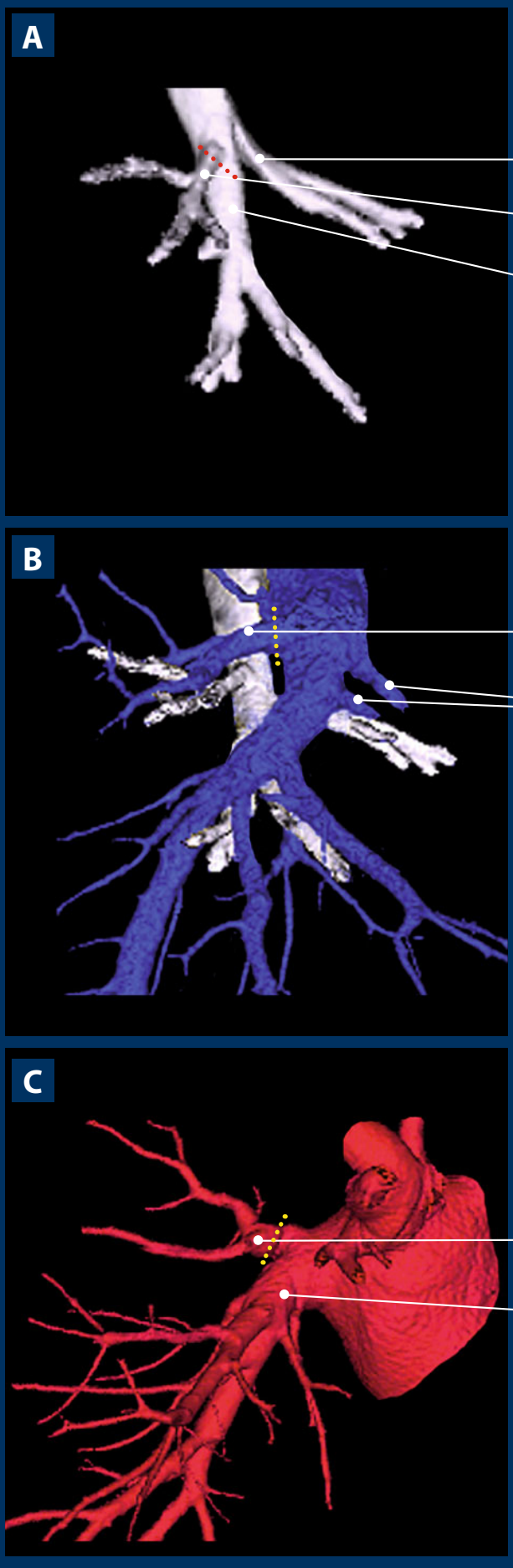


Fig. 1 – Anatomical landmarks. (a) Superior segmental bronchus (lateral view). (b) Superior segmental bronchus and artery (lateral view), and superior segmental vein (lateral view). a: artery, v: vein, dotted lines: level of division.

Technique

1. Fissure and artery

This step is similar to the dissection of the fissure during a right lower lobectomy. The pulmonary artery may be visible or hidden if the fissure is fused. Depending on the difficulty in identifying the arterial pattern, it can be advisable to first open the posterior part of the fissure or, on the contrary, to first dissect the pulmonary artery.

The posterior fissure is opened, as for a right lower lobectomy (see page 63). Once the pulmonary artery has been identified, a dissecting forceps is introduced from the posterior surface of the artery toward the posterior mediastinum. This may require to retract the lobes forward in order to expose the posterior mediastinal pleura. The pleura is incised at the level of the intermediate bronchus (*black arrow*). An oblique-viewing endoscope or a deflectable scope is helpful to control this maneuver. The posterior fissure is then stapled (**Fig. 2**).

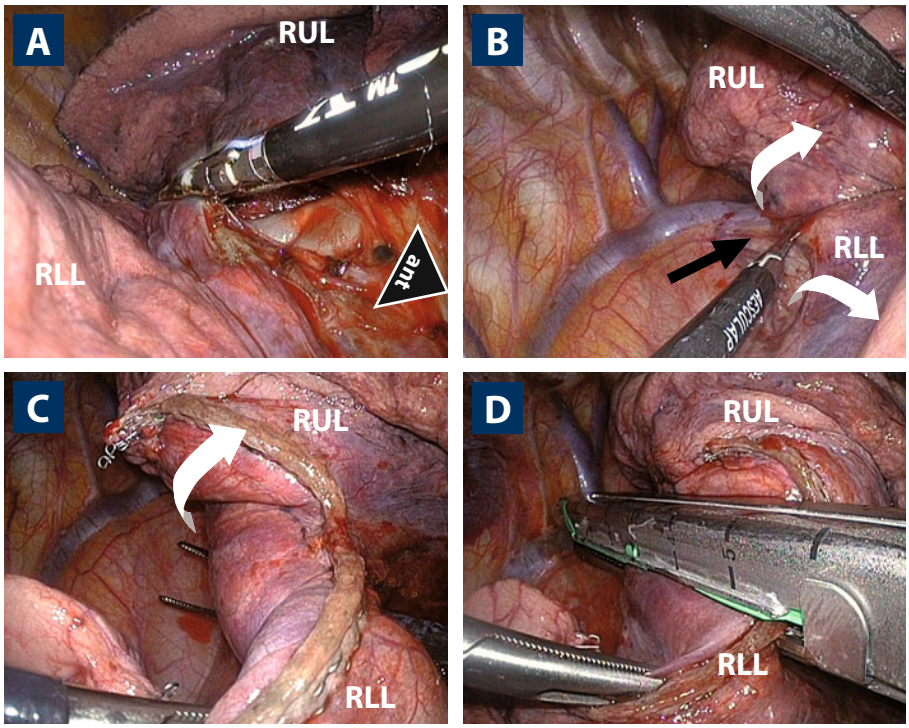


Fig. 2 – Division of the posterior part of the oblique fissure. (a) The thin inner part of the fissure is opened using bipolar sealing. (b) The lobes are retracted forward to allow stapling of the external portion of the fissure, thus exposing the posterior mediastinal pleura, which is incised at the level of the intermediate bronchus (*black arrow*). (c) A dissector creates a passage. (d) The central portion of the fissure can be stapled.

The pulmonary artery is dissected in the fissure. It is not necessary to expose the whole arterial crossroad, but the origin of the posterior ascending branch to the upper lobe and the origin of the basal trunk should at least be made out, making sure that no accessory branch originates from the superior artery. The superior segmental artery, which runs anteriorly to the segmental bronchus, is usually single. It is dissected, clipped, or stapled depending on its size (**Fig. 3**).

The superior segmental artery must be dissected on a sufficient length to make sure it does not provide an accessory ascending branch to the upper lobe.

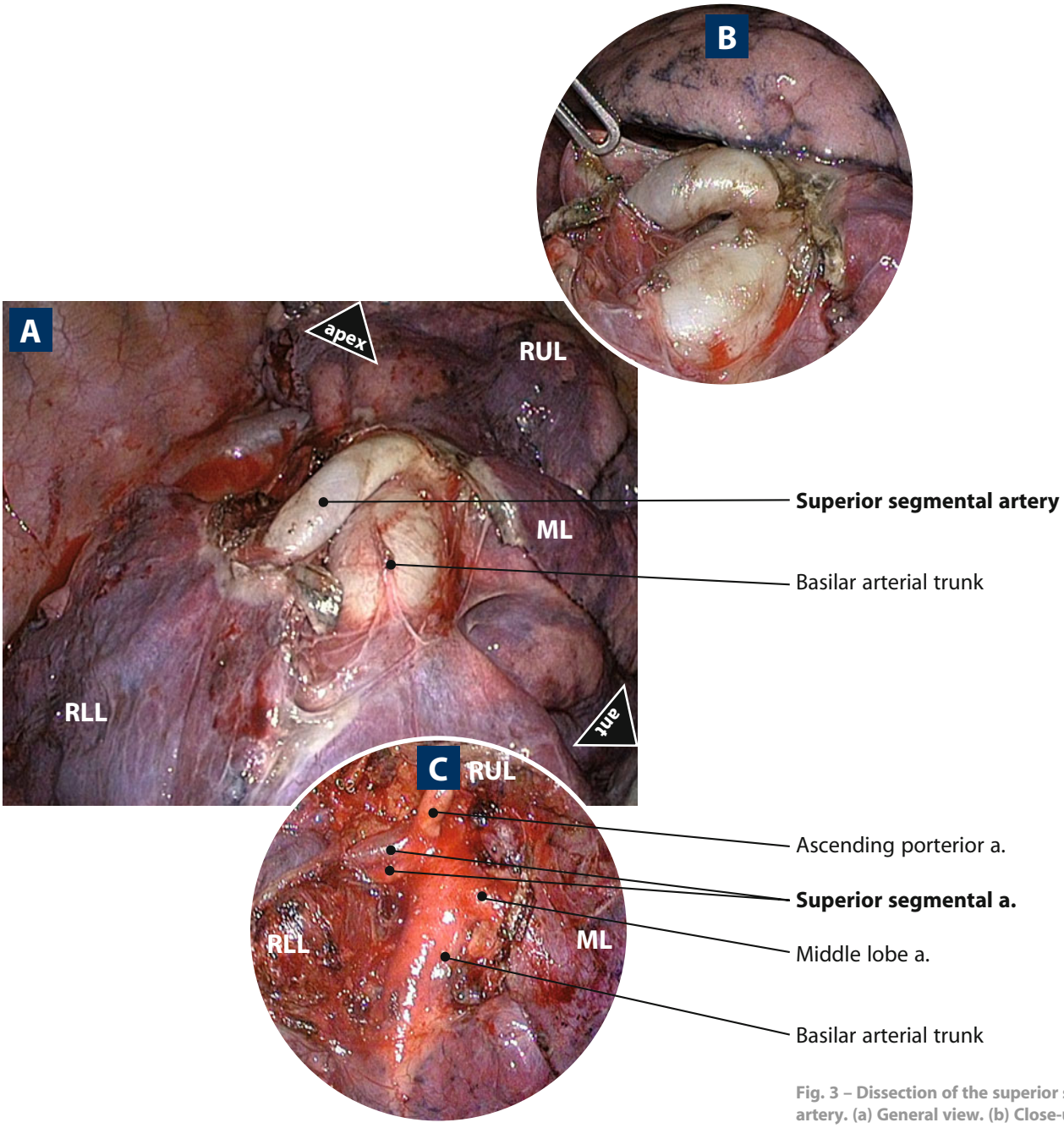


Fig. 3 – Dissection of the superior segmental artery. (a) General view. (b) Close-up view. (c) Double segmental superior artery arising from a common trunk with an ascending artery to the upper lobe.

2. Bronchus

The division of the segmental artery gives access to the segmental bronchus, which is cleared of peribronchial tissues and stapled (**Fig. 4**).

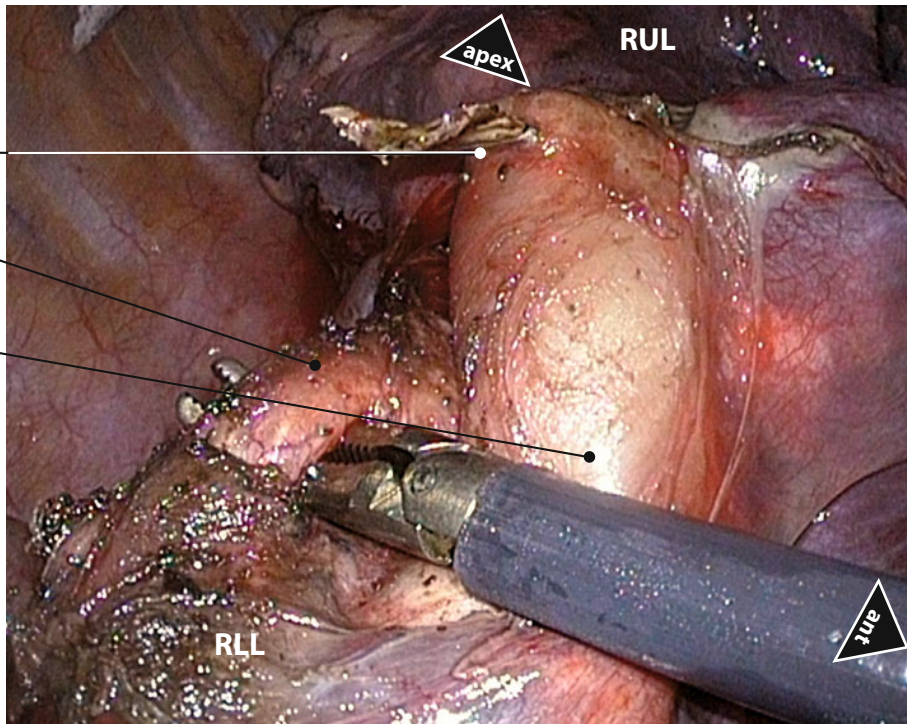


Fig. 4 – Dissection of the superior segmental bronchus after division of the superior segmental artery.

3. Vein

The pulmonary ligament is incised up to the lower vein using both diathermy and gentle traction on the lower lobe (**Fig. 5**). The inferior vein is cleared from the surrounding tissues until its uppermost tributary is identified. It lies usually inferior to the bronchus. It can be clipped or divided after application of bipolar sealing (**Fig. 6**).

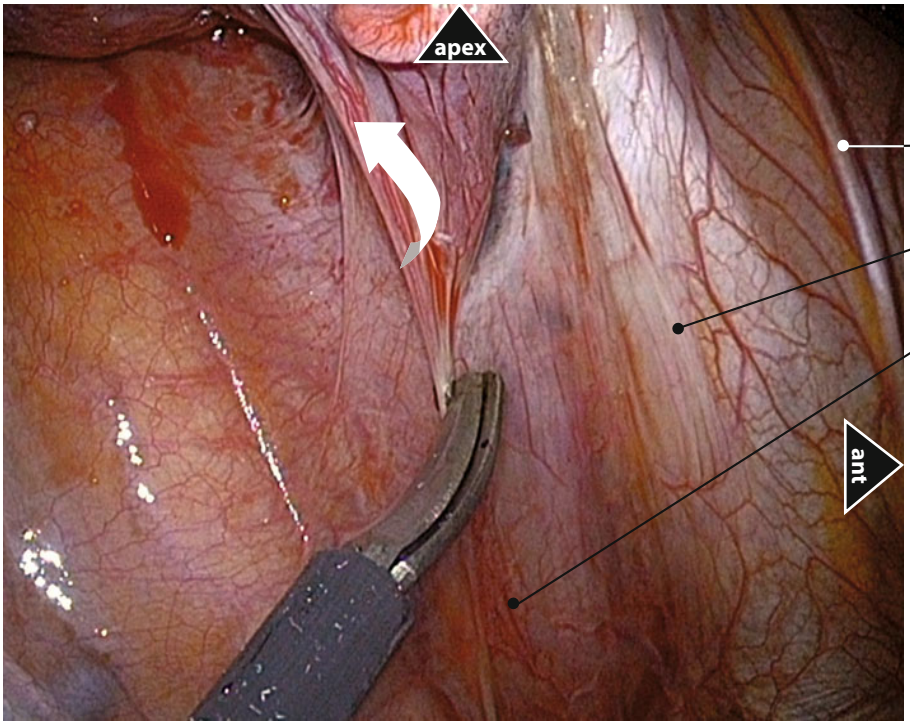


Fig. 5 – Freeing of the pulmonary ligament.

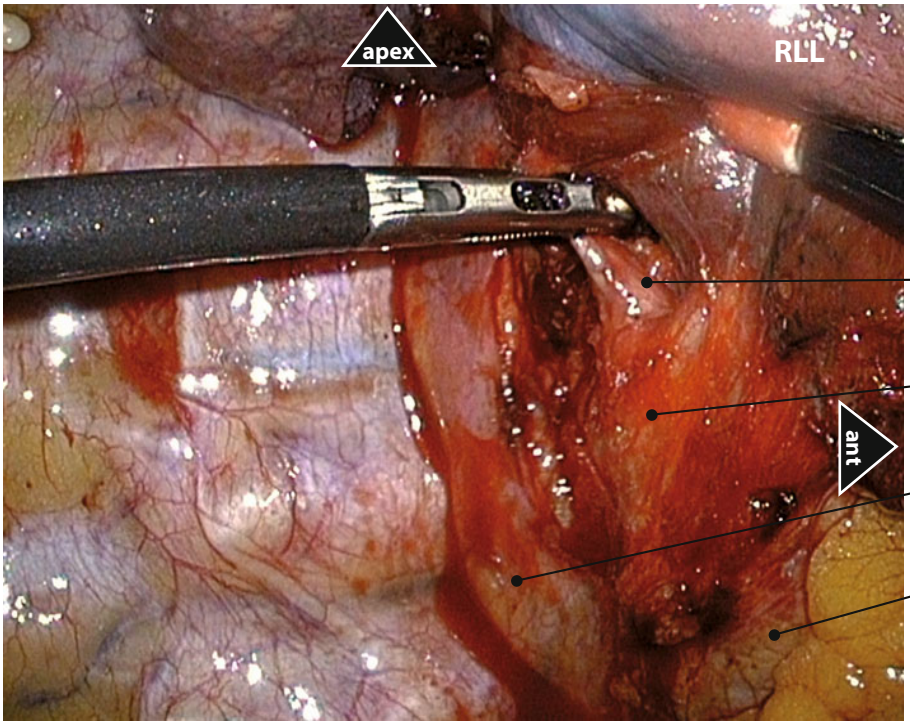


Fig. 6 – Dissection of the superior segmental vein.

4. Parenchymal division

Division of the vein helps lifting up the superior segment. A long clamp is applied on the parenchyma, checking that the bronchial stump keeps remote and will not get stuck within the stapler jaws. A reventilation test allows identification of the intersegmental plane. The parenchyma is compressed by the clamp to ease stapler application (**Fig. 7**).
The specimen is retrieved in the usual fashion (**Fig. 8**).

TIP

The limit between the inflated and deflated lung parenchyma can be marked with dots using diathermy.

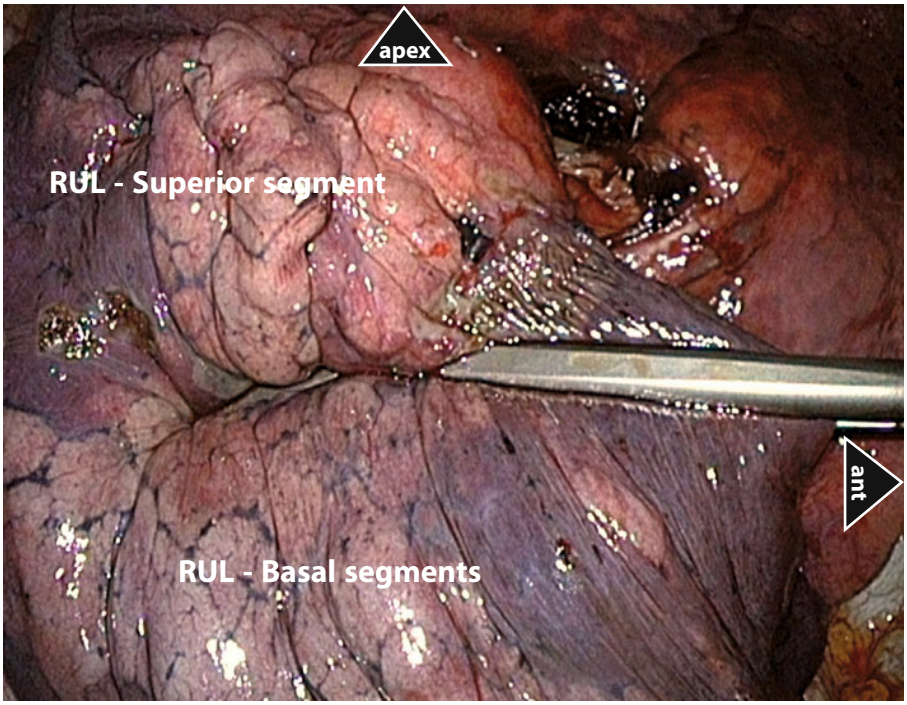


Fig. 7 – Clamping the intersegmental plane before stapling.

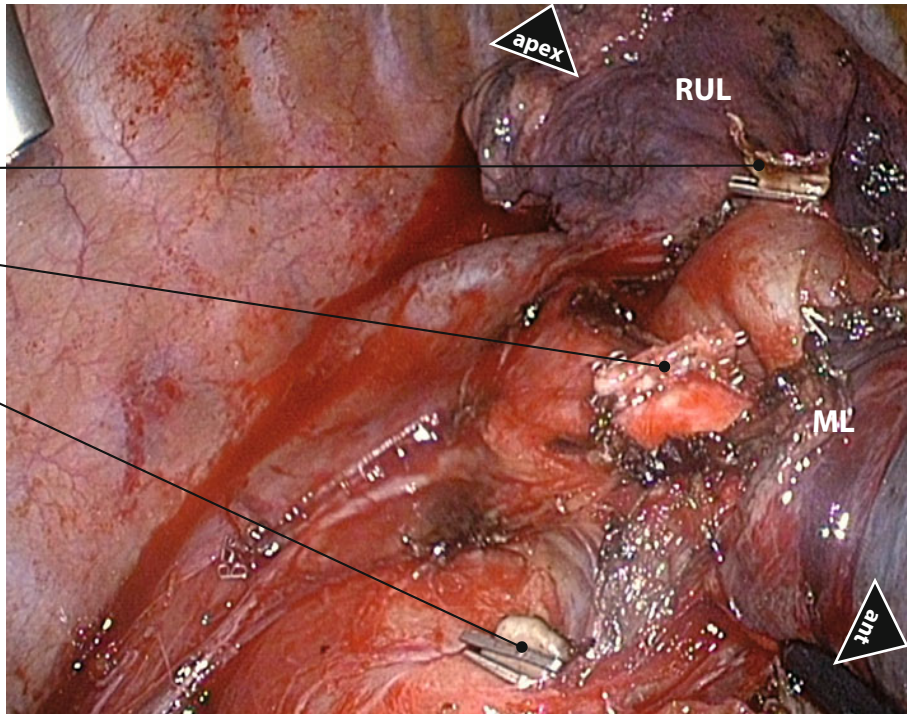
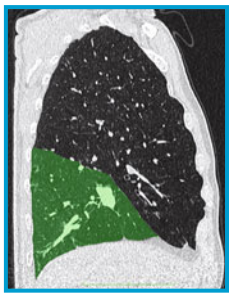


Fig. 8 – Final aspect after specimen retrieval.

Chapter X

Right lower lobe: basal segments

Chapter X Right lower lobe: basal segments



In addition to the superior segment (S6), the lower lobe comprises four basal segments: medial (S7), anterior (S8), lateral (S9), and posterior (S10). These segments are usually removed together since they depend from a single bronchial trunk. The main steps of the procedure are similar to those of a right lower lobectomy. The main concern is the preservation of the elements of the superior segment, especially the superior segmental vein.

Anatomical landmarks (Fig. 1)

- **Bronchus**: The basal bronchial trunk is the termination of the bronchus intermedius, just below the origin of the superior segmental bronchus and the middle lobe bronchus. These two bronchi must be clearly identified before any stapling of the basal trunk since the crossroads of these three elements is highly variable.

- **Arteries**: The basal segments of the right lower lobe are supplied by a large arterial trunk that duplicates and gives branches to the four basal segments.

- **Veins**: The vein to the basal segments is the common basal vein, which is the lower and largest segmental tributary of the inferior pulmonary vein. In some patients, there is not a single basal trunk, but there are multiple venous segmental branches that are controlled one by one.

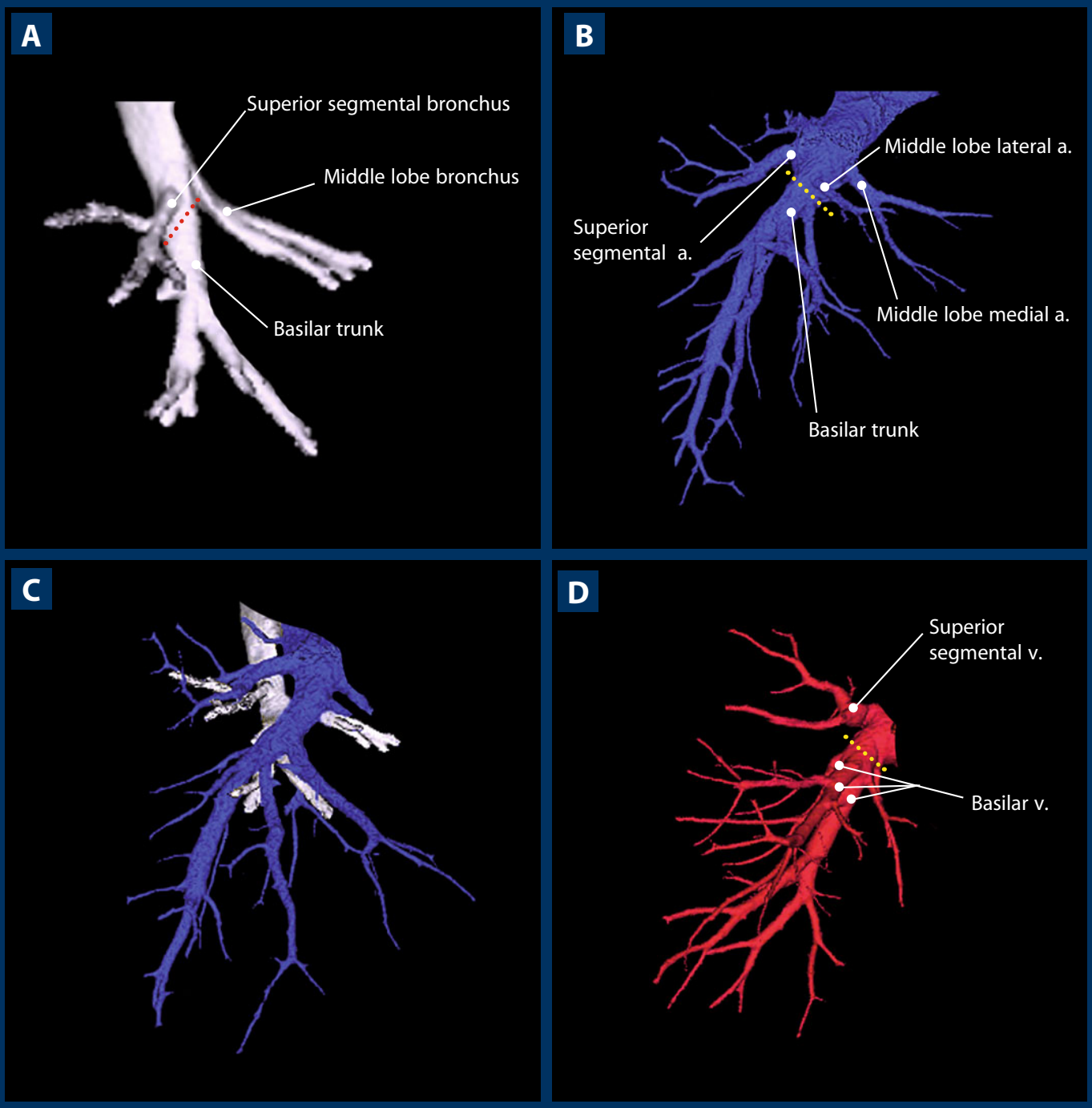


Fig. 1 – Anatomical landmarks. (a) Bronchi (lateral view). (b) Arterial supply (anterior view). (c) Bronchi and arteries (lateral view). (d) Venous drainage (anterior view). a: artery, v: vein, dotted line: level of division.

Technique

1. Fissure and artery

The dissection starts as for a lower lobectomy (see page 62). The pulmonary artery is identified at the junction of the oblique and the transverse fissure. When the fissure is incomplete or inflammatory, this step can be tedious. Opening the fissure can lead to pulmonary tears and troublesome oozing. Thorough progression using a combination of bipolar diathermy and blunt dissection is required until the artery is discovered. There is no need to divide the posterior portion of the oblique fissure.

Access to the basal trunk is facilitated by the division of the anterior portion of the oblique fissure between the middle lobe and the lower lobe. This part of the fissure is usually thin and can be split by bipolar or ultrasonic dissection. If its central portion is too thick, stapling can be necessary (**Fig. 2**).

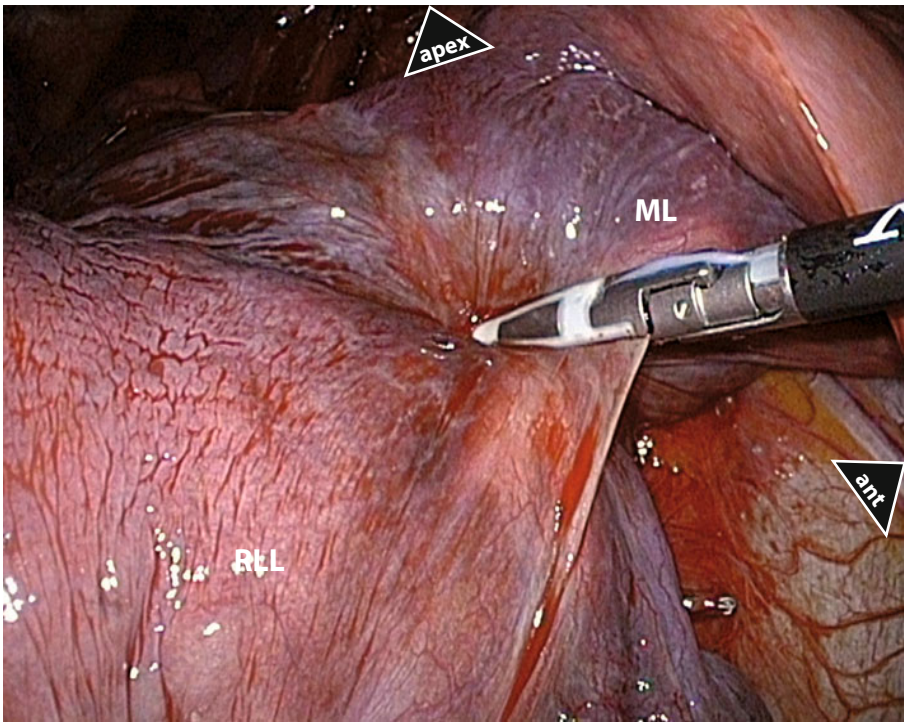


Fig. 2 – Division of the fissure between the middle lobe and the lower lobe.

The sheath of the artery is entered. The artery to the middle lobe and the posterior segmental artery to the upper lobe must be clearly visible before any division. The basal trunk can then be stapled (**Fig. 3**).

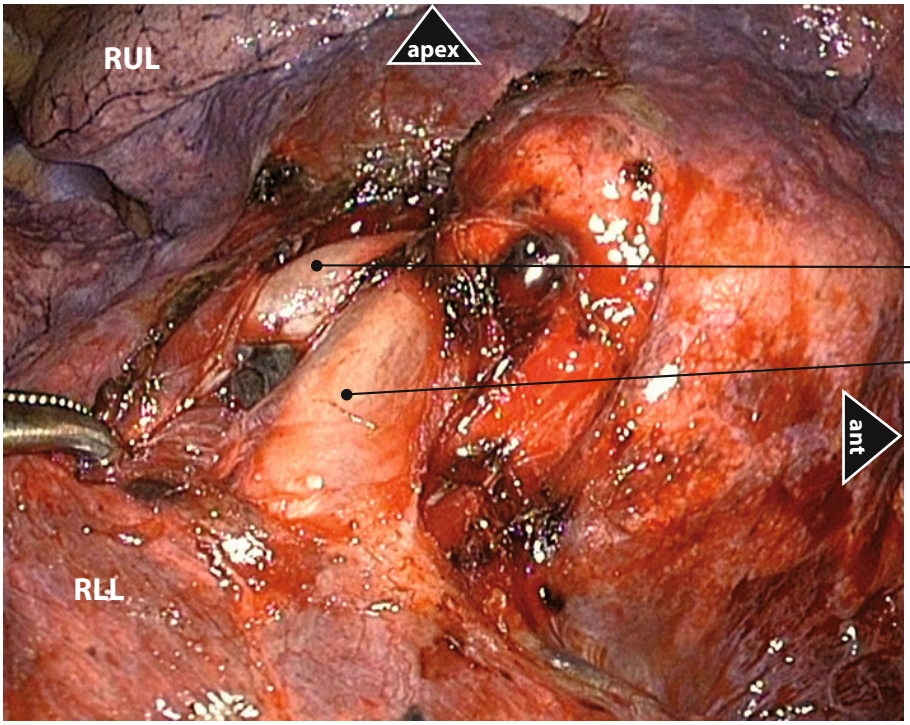


Fig. 3 – Identification of the basal arterial trunk.

2. Bronchus

Division of the basilar trunk gives access to the basal bronchus, which is cleared and divided, with avoidance of impingement on the segmental superior bronchus. If any doubt, a reventilation test can be helpful (**Fig. 4**).

In case of difficult dissection of the basal bronchus, the veins can be controlled first.

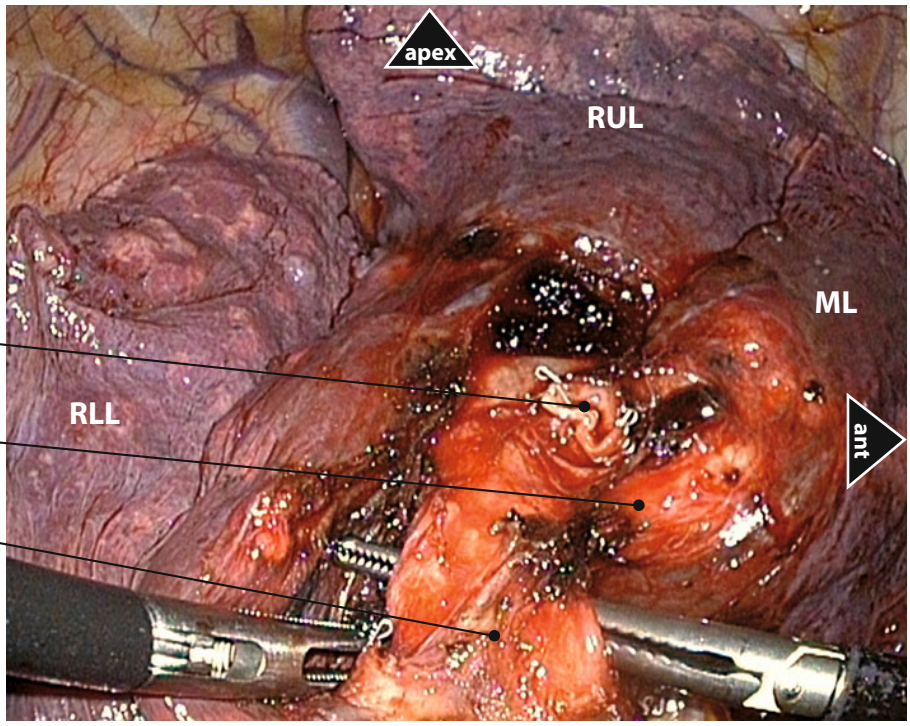


Fig. 4 – Dissection of the basal bronchi.

3. Vein

The pulmonary ligament is incised up to the lower vein using both diathermy and gentle traction on the lower lobe (**Fig. 5**).

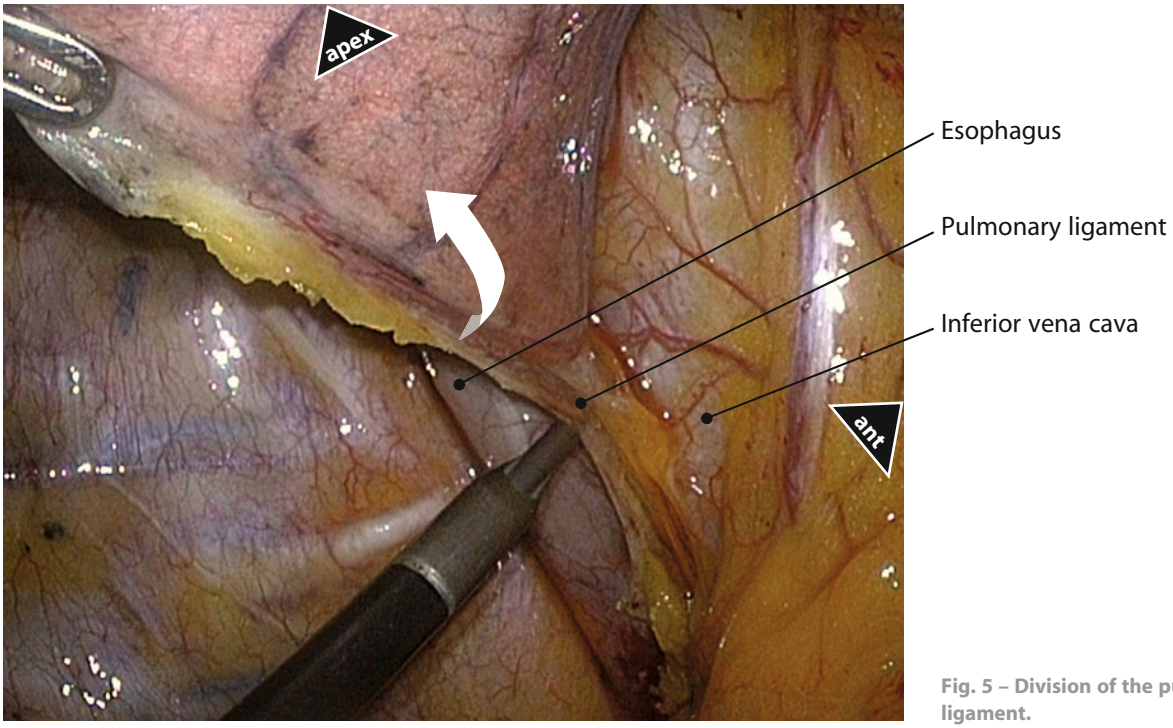


Fig. 5 – Division of the pulmonary ligament.

The inferior pulmonary vein is cleared from the surrounding tissues, and its basal branches are dissected. They can join the inferior pulmonary vein either via multiple segmental branches or via two trunks. Demonstration of the segmental veins is achieved by using a combination of gentle traction of the lobe and blunt dissection with an endopeanut.
All branches are isolated and clipped, taking care to preserve the superior segmental vein (**Fig. 6**).

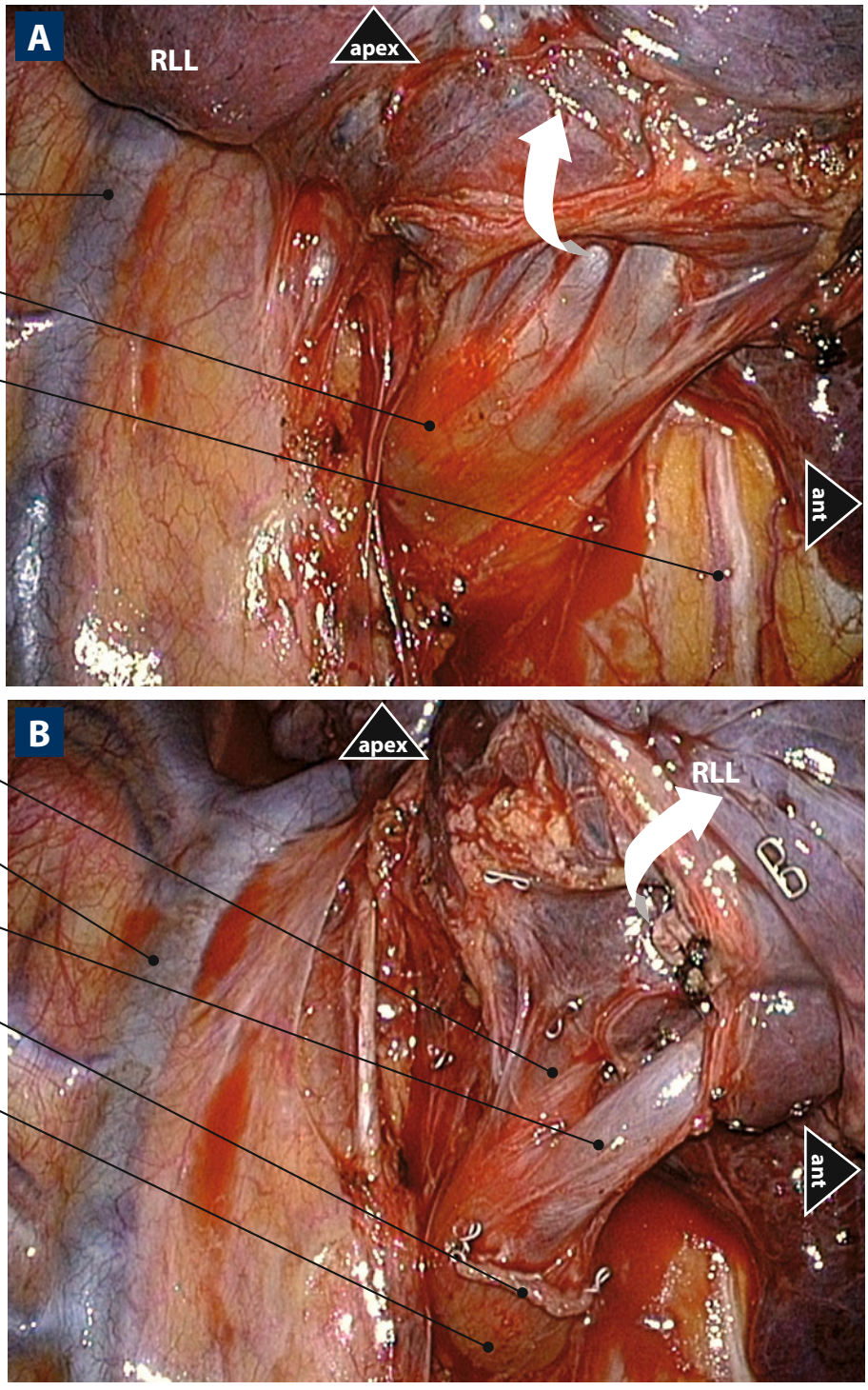


Fig. 6 – Control of the segmental venous branches.
(a) Venous pattern with multiple branches.
(b) Venous pattern with two main trunks (in this case, the lowermost tributary has been divided).

4. Division of the parenchyma

A long clamp is applied on the parenchyma. A reventilation test allows to delineate the intersegmental plane. The parenchyma is compressed by the clamp to ease stapler application.

During stapling, the bronchial and arterial stumps should be pushed away, so that they stay on the specimen side and remote from the stapler jaws. A constant watch should be kept on the superior segmental vein (**Fig. 7**).

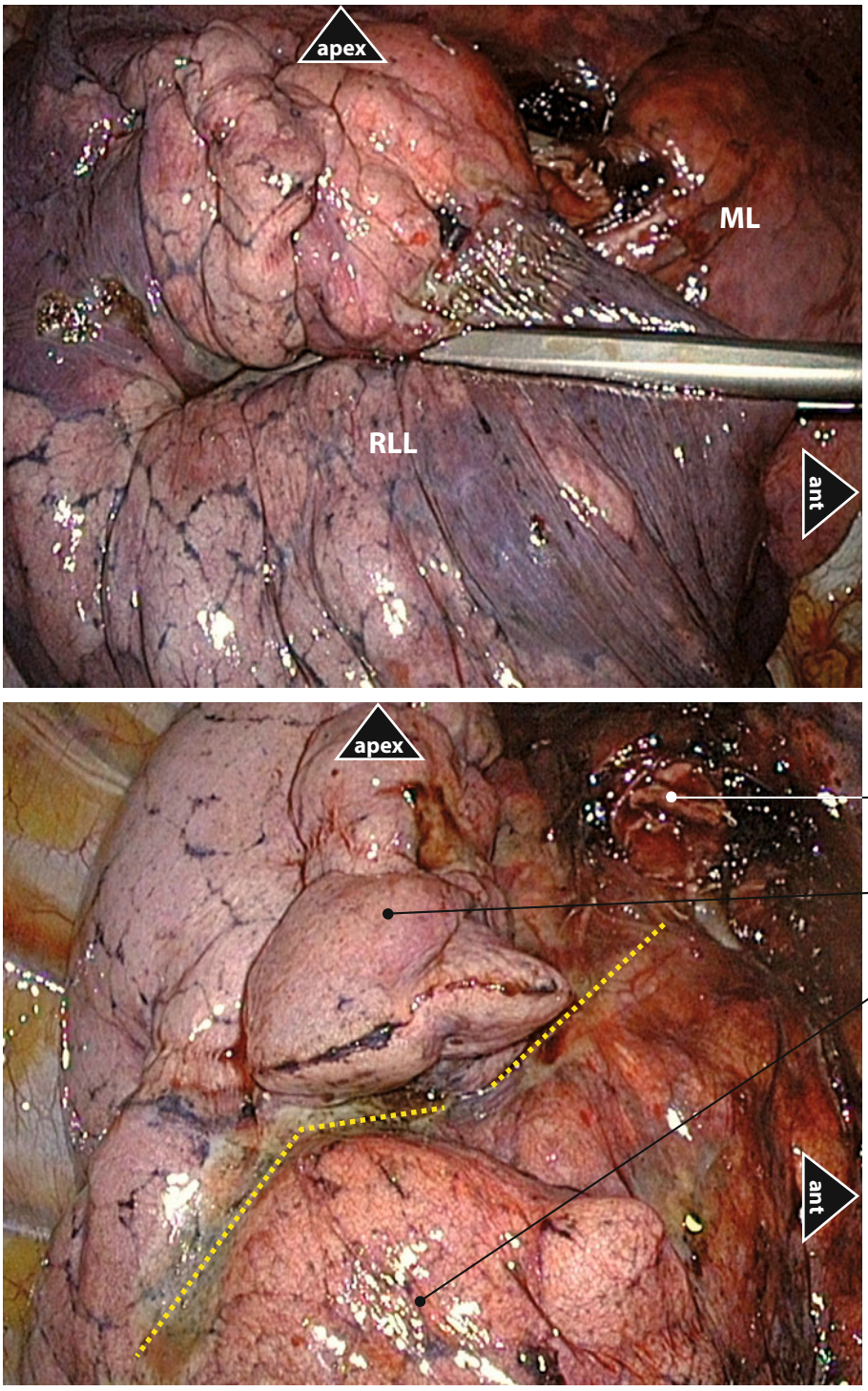


Fig. 7 – Intersegmental plane.
(a) Compression before stapling.
(b) Marking the intersegmental plane with dots.

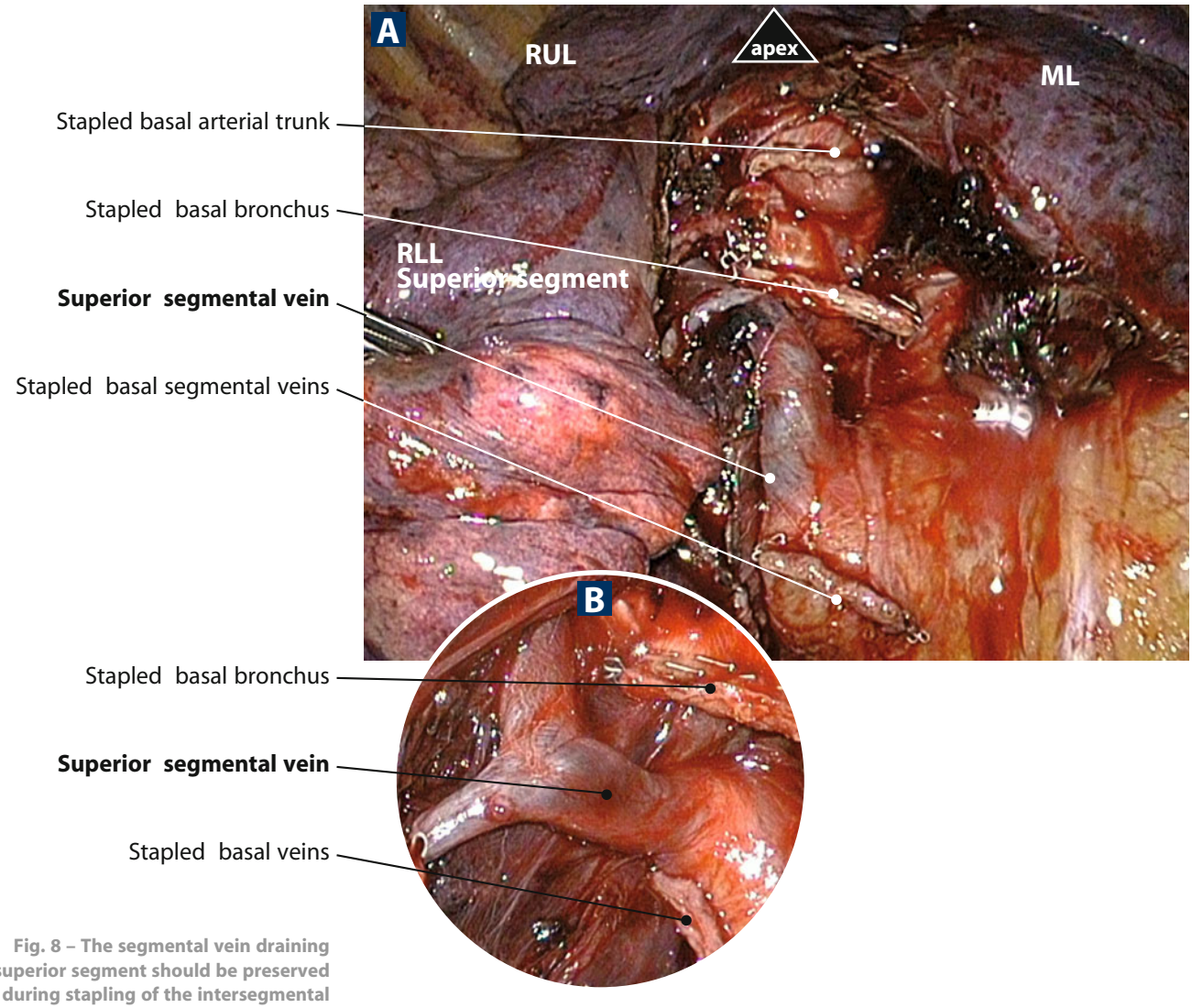


Fig. 8 – The segmental vein draining the superior segment should be preserved during stapling of the intersegmental plane. (b) Close-up view of the superior segmental vein after basilar resection.

The remaining superior segmental vein is thin and fragile. Care should be taken not to injure it during stapling of the intersegmental plane (Fig. 8).

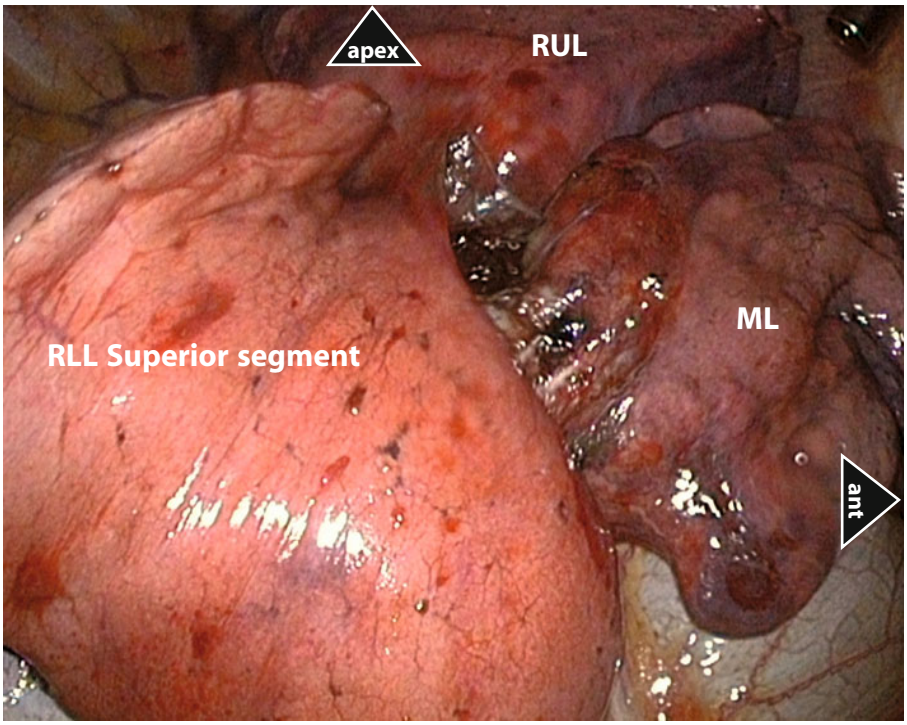


Fig. 9 – Final aspect after specimen retrieval and reventilation.

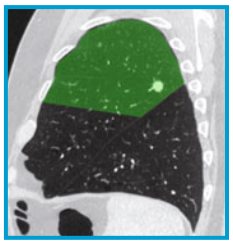
The specimen is excised and retrieved in the usual fashion (**Fig. 9**).

: The video of this technique can be consulted on weBSurg at the following address: http://www.websurg.com/ref/doi-vd01en2523.htm

Chapter XI

Left upper lobe: superior segments

Chapter XI Left upper lobe: superior segments



Segmental resections involving the left upper lobe are the following: upper division (S1+2 and S3) (lingular sparing lobectomy), apicoposterior segmentectomy (S1+2), and lingulectomy (S4 + S5), which will be described in the next chapter.

Anatomical landmarks (Fig. 1)

- **Bronchi**: The segmental bronchi are concealed by arteries that must be divided first. The upper lobe bronchus splits immediately into the lingular bronchus and a common stem that separates into an anterior bronchus and an apicoposterior bronchus. All these segmental bronchi have a short course that can make their dissection and identification difficult.

- **Arteries**: There are two different supplies to the left upper lobe: the truncus anterior and the posterior arteries. The truncus anterior is often broad and short. It supplies the apicoposterior and anterior segments. In some patients, an additional branch supplies the lingula. The posterior segmental arteries originate in the fissure and distribute themselves over the curve of the pulmonary artery. Their number varies from one to five, but most often from two to three. All but the lingular artery must be divided.

- **Veins**: The superior pulmonary vein has usually three major tributaries. The superior branch drains the apicoposterior segments and frequently blocks the access to the apicoposterior arteries. The middle branch drains the anterior segment, and the lowermost branch drains the lingula. The latter must be preserved.

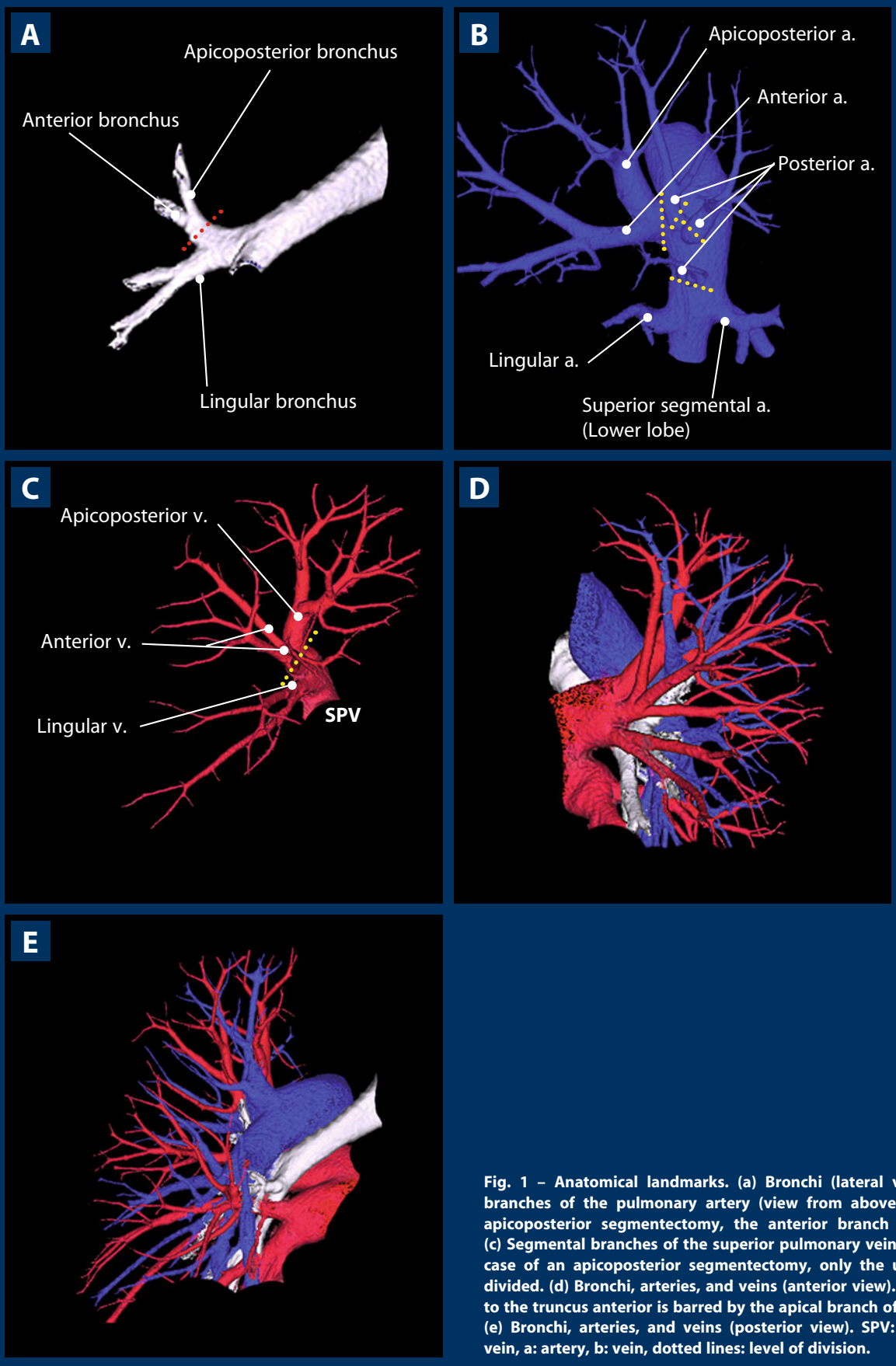


Fig. 1 – Anatomical landmarks. (a) Bronchi (lateral view). (b) Segmental branches of the pulmonary artery (view from above). In the case of an apicoposterior segmentectomy, the anterior branch must be preserved. (c) Segmental branches of the superior pulmonary vein (lateral view). In the case of an apicoposterior segmentectomy, only the uppermost branch is divided. (d) Bronchi, arteries, and veins (anterior view). Note that the access to the truncus anterior is barred by the apical branch of the pulmonary vein. (e) Bronchi, arteries, and veins (posterior view). SPV: superior pulmonary vein, a: artery, b: vein, dotted lines: level of division.

Technique

a. Upper division

The procedure is similar to a left upper lobectomy apart from the lingular vessels, which are preserved, and the anterior portion of the fissure, which does not require splitting. As for an upper lobectomy, part of the dissection can be carried out from behind.

1. Veins

The superior branches of the superior pulmonary vein partly hide the truncus anterior and should be divided first.

The upper lobe is pulled backward. The mediastinal pleura is incised posterior to the phrenic nerve. Dissection of the vein is achieved by a combination of bipolar diathermy and gentle sweeping motion with an endopeanut. The lowermost tributary that drains the lingula is preserved. Only the two superior branches are divided using a stapler or clips or a vessel sealing device, depending on their diameter (**Fig. 2**).

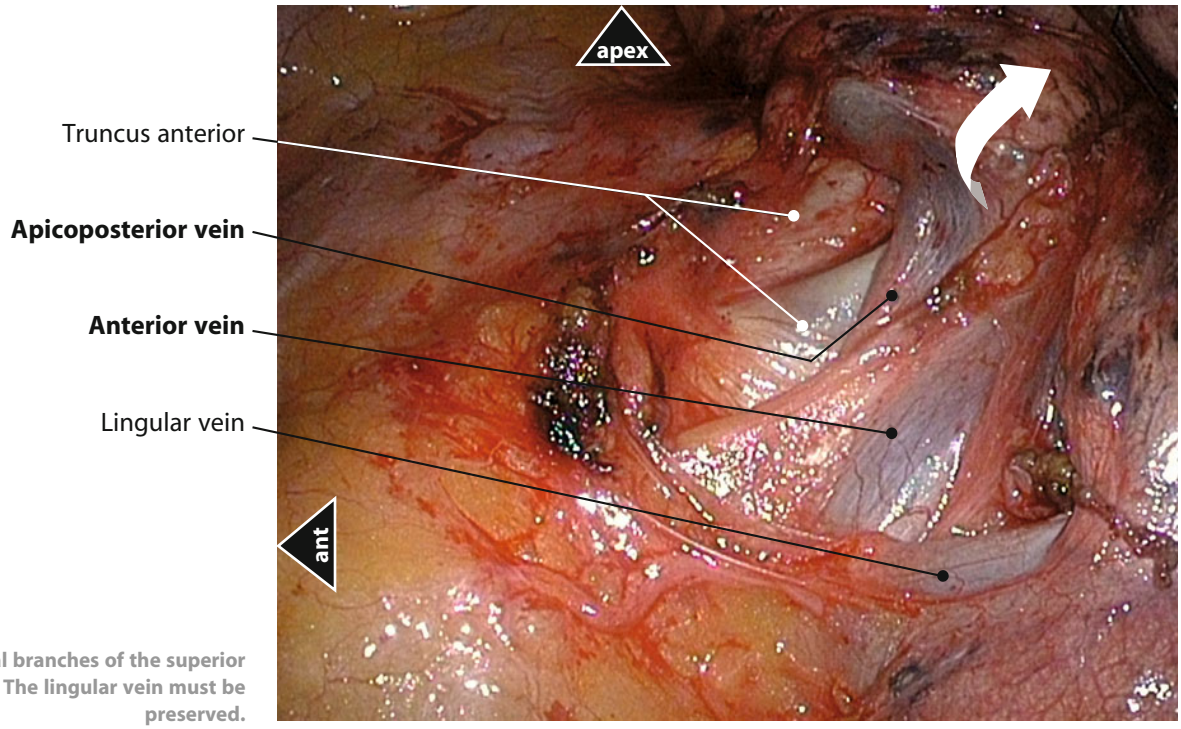


Fig. 2 – Segmental branches of the superior pulmonary vein. The lingular vein must be preserved.

2. Truncus anterior

Division of the veins gives access to the anterior surface of the apicoposterior and anterior branches of the truncus anterior. Clearing of their posterior and superior surfaces require a posterior dissection that is achieved by retracting the upper lobe downward and forward. The apicoposterior and anterior branches are stapled (**Fig. 3**).

An inferior branch of the truncus anterior is present in one-quarter of patients. It is usually impossible to predict whether this branch supplies the anterior segment or the lingula or both. When in doubt, it is advisable to preserve it.

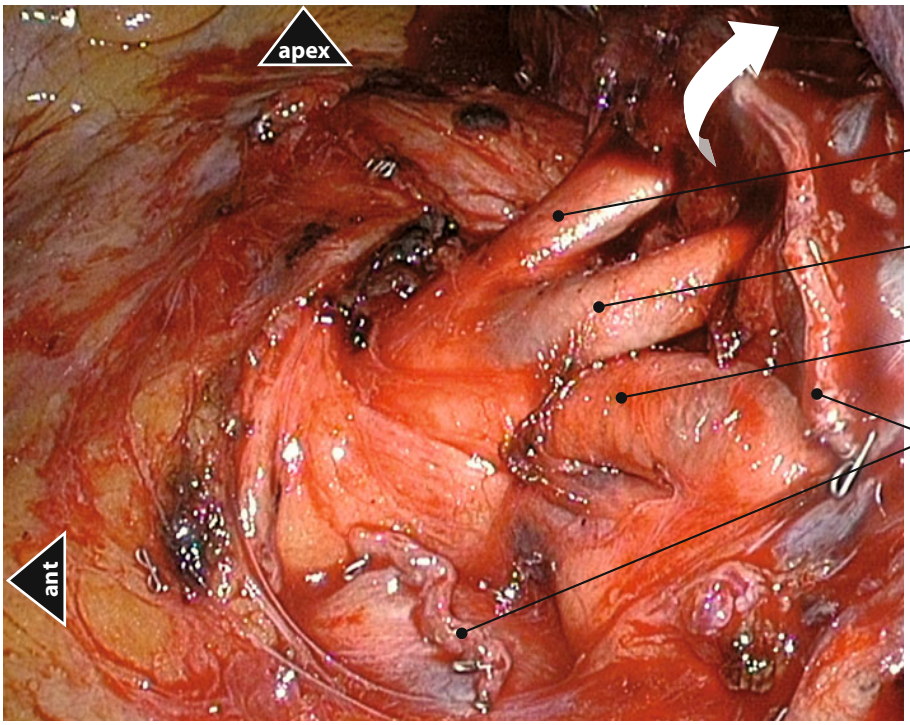


Fig. 3 – Apicoposterior and anterior arteries after division of the venous branches. The lowermost artery supplies either the anterior segment or the lingula or both, and must be preserved.

3. Fissure and posterior arteries

Both lobes are spread apart to expose the middle portion of the fissure. The pulmonary artery may be visible or hidden if the fissure is fused (**Fig. 4**).

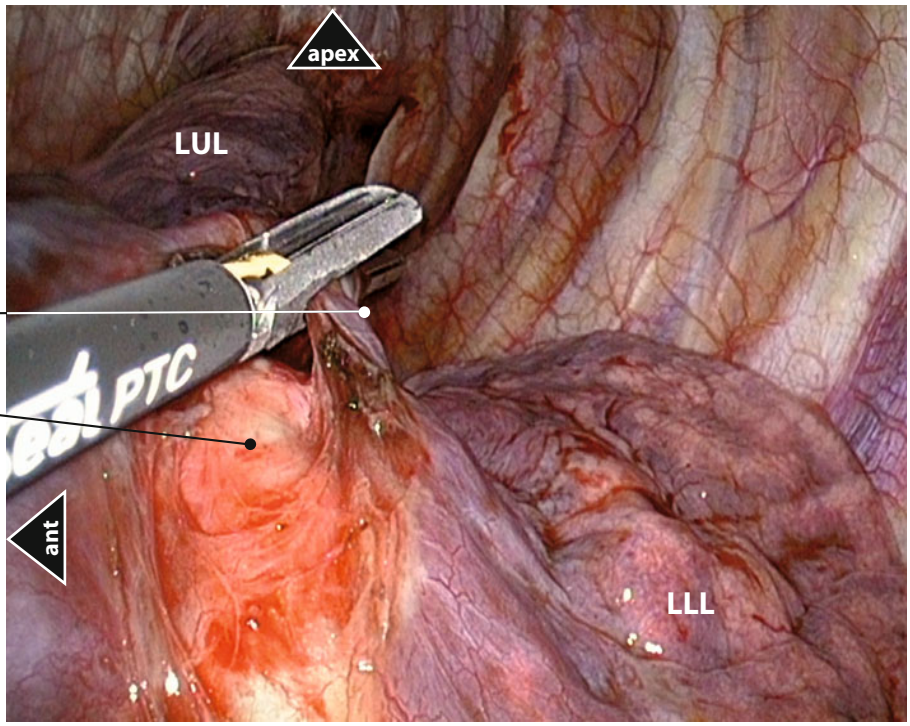


Fig. 4 – Division of the posterior part of the fissure.

The upper lobe is gently pulled forward, avoiding any undue traction that could lead to injury to the vessels. Dissection is conducted cephalad, and all encountered posterior arteries are divided by turn. Traction helps exposing the first segmental artery whose dissection is usually easy. It is controlled by clipping or with a vessel sealing device or with a combination of both (**Fig. 5**).

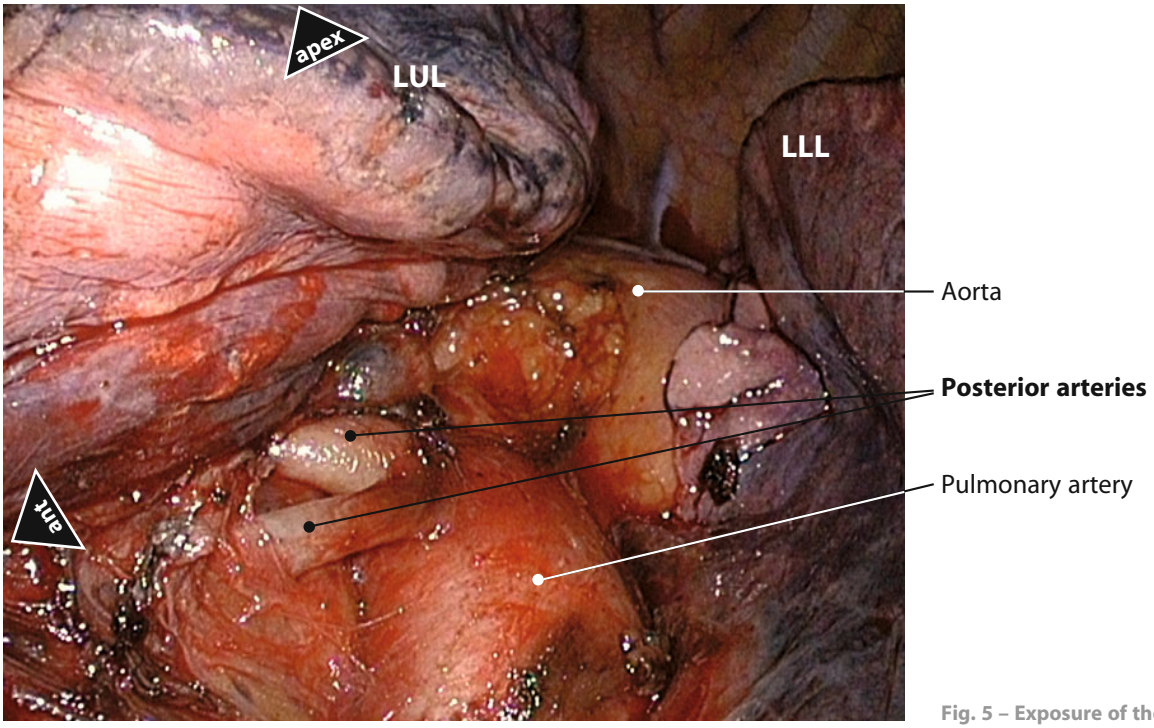


Fig. 5 – Exposure of the posterior arteries.

As the posterior segmental arteries are gradually divided, the upper lobe unfolds and uncovers the posterior aspect of the truncus anterior, which can be approached posteriorly. It is then also dissected from above and from the front, using various visions, thanks to the deflectable scope. Gentle blunt dissection is used to clear the origin of the trunk. If the trunk bifurcates into large branches, these are dissected with caution and stapled independently.

4. Bronchi

Once the arteries and veins have been divided, traction on the parenchyma helps exposing the segmental bronchi. The origin of the lingular bronchus is visualized, and the upper trunk – which separates into an anterior bronchus and an apicoposterior bronchus – is exposed, cleared using a blunt tip dissector, and stapled as a stem (**Fig. 6**).

The apical artery lies just behind the bronchus and must therefore be controlled first before dissecting the segmental bronchi.

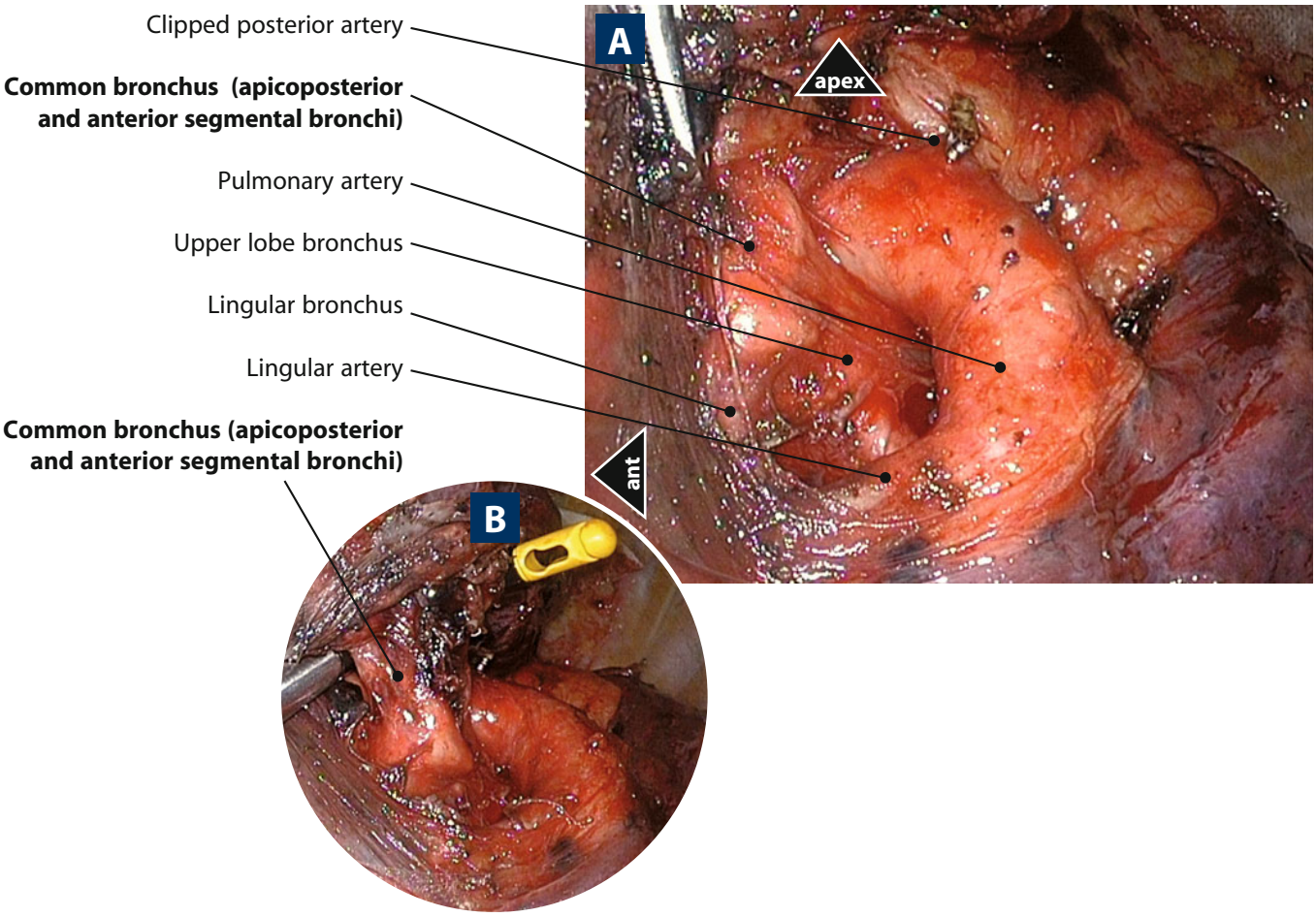


Fig. 6 – Exposure of the bifurcation between the lingular bronchus and the common bronchus to the anterior and apicoposterior segments: (a) global view and (b) close-up view of dissection.

5. Parenchyma

The parenchyma must be stapled between the lingula and the upper division. A clamp is applied on the parenchyma, the lung is reventilated to identify the intersegmental plane, and the parenchymal division is then performed using 4.8-mm staples (**Fig. 7**).

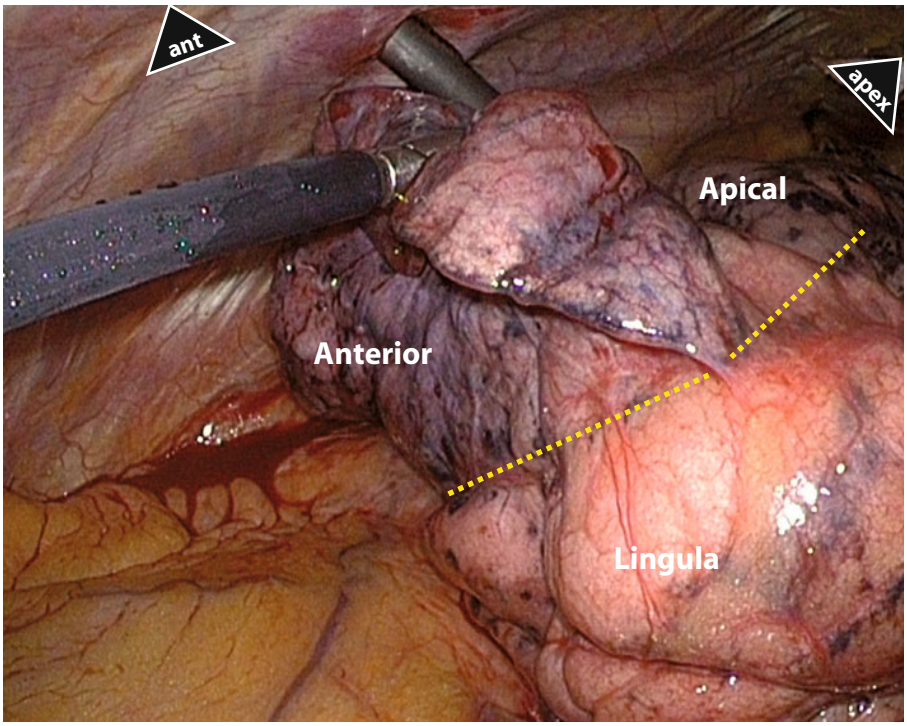


Fig. 7 – Intersegmental plane, after reventilation.

The specimen is removed in the usual fashion, and the inferior pulmonary ligament is divided (**Fig. 8**).

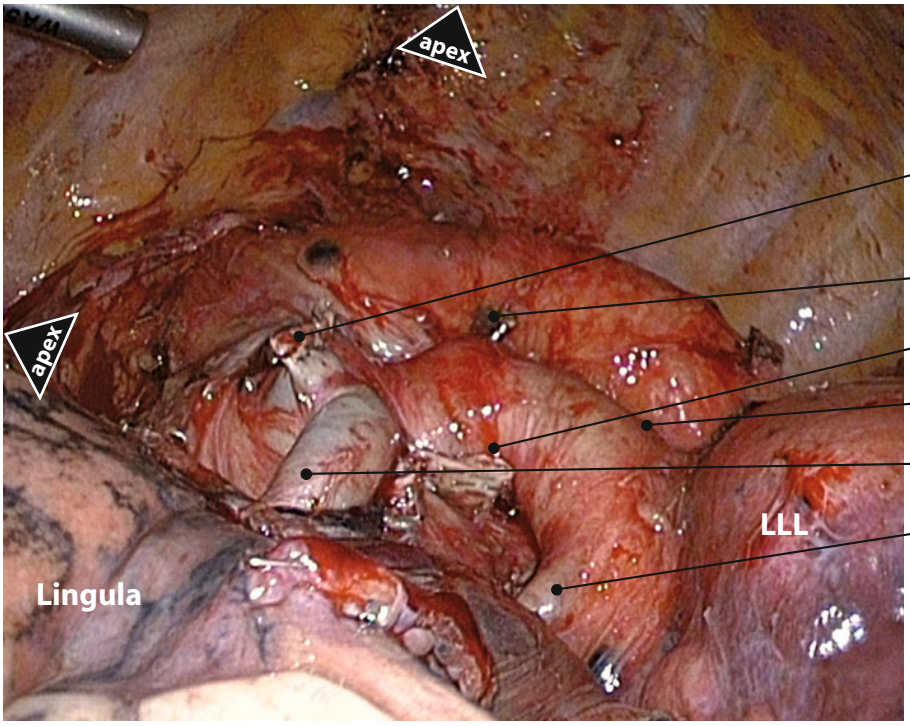


Fig. 8 – Final aspect after specimen retrieval. Note the accessory lingular artery arising from the truncus anterior.

b. Apicoposterior segmentectomy

From the vascular aspect, the procedure is simpler since only the apical and posterior arteries are divided, and this can be done from behind by stretching the upper lobe anteriorly. But, from the bronchial aspect, the dissection of the segmental bifurcation can be difficult, especially in case of peribronchial nodes, because of the shortness of the segmental bronchi.

1. Fissure and arteries

This step is similar to the posterior control of arteries during a lingular sparing upper lobectomy. The only difference is that only the uppermost branch of the truncus anterior requires division. This can be achieved through a total posterior approach or partially through an anterior dissection of the hilum for the control of the apical artery.

2. Vein

When the superior pulmonary vein receives multiple radiating branches, making the venous pattern difficult to grasp, only the uppermost vein should be divided, thus making sure to preserve the middle branch, which drains the anterior segment (**Fig. 9**).

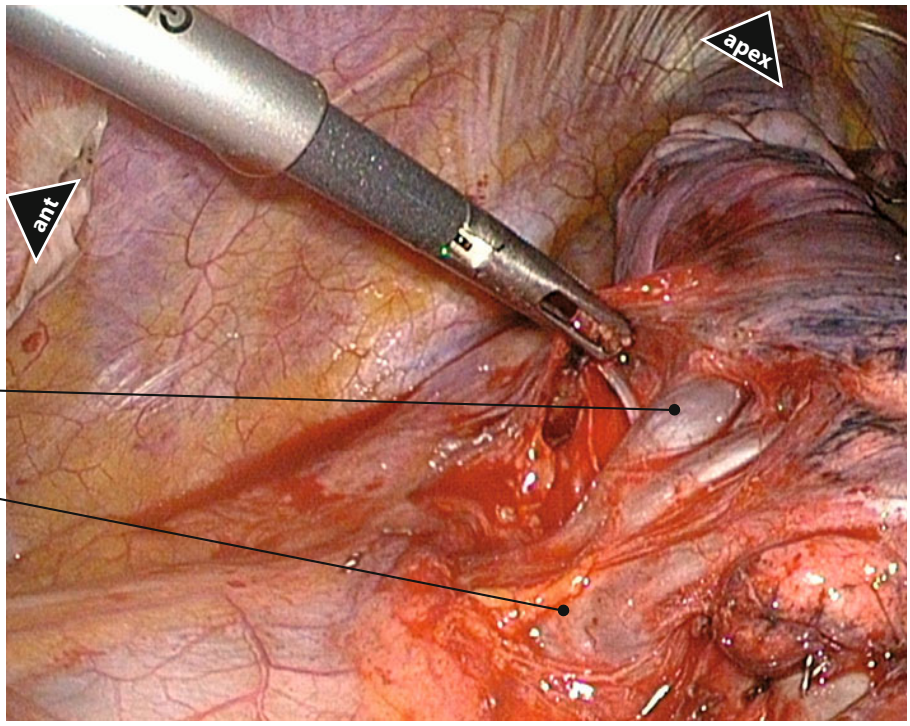


Fig. 9 – Only the uppermost venous branch is divided.

3. Bronchi

As mentioned earlier, the segmental bronchi are concealed by arteries that should always be divided before dissection of the segmental bronchi. Once the posterior segmental arteries have been divided, the posterior surface of the bronchi appears. Gentle retraction of the upper lobe and blunt dissection with an endopeanut progressively expose the segmental trifurcation: the anterior segmental bronchus (the lowermost and the most anterior one), which will be preserved, and the apicoposterior trunk. Although the arteries have already been divided, it is advisable to keep flush with the bronchi as the dissection of their anterior surface is pursued. Since these bronchi are short, a guide for the stapler can be helpful (**Fig. 10**).

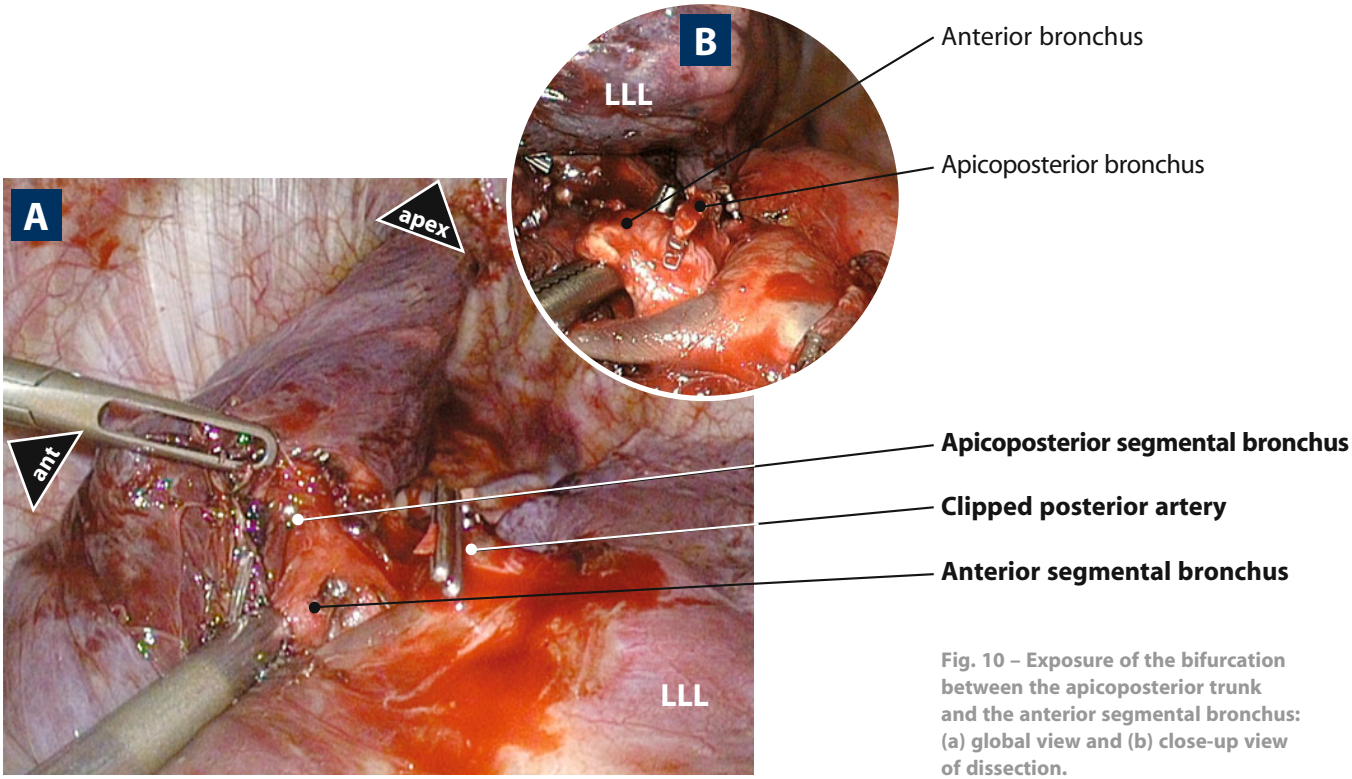


Fig. 10 – Exposure of the bifurcation between the apicoposterior trunk and the anterior segmental bronchus: (a) global view and (b) close-up view of dissection.

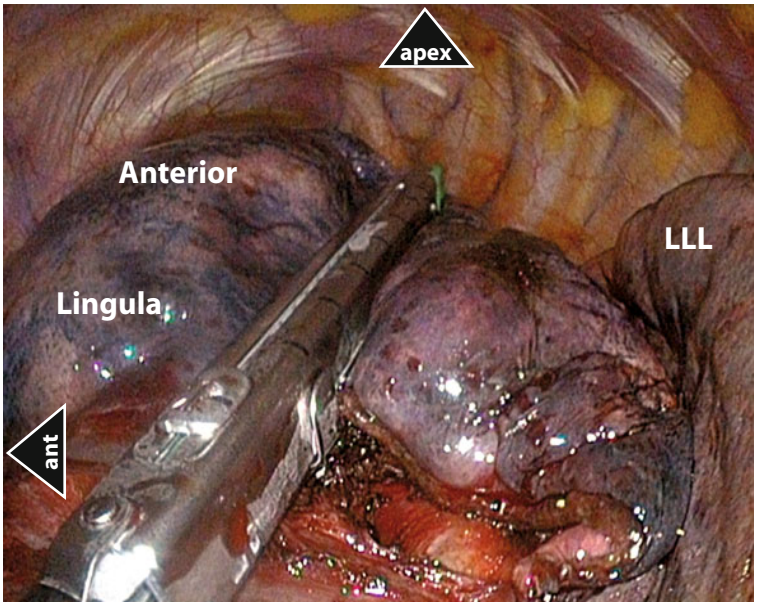
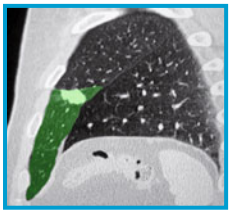


Fig. 11 – Division of parenchyma.

Chapter XII

Left upper lobe: lingula

Chapter XII Left upper lobe: lingula



Although a lingulectomy (S4 + S5) is equivalent to a middle lobectomy with respect to pulmonary function and anatomy, it is actually technically more difficult because of the variable anatomical relationships.

Anatomical landmarks (Fig. 1)

- **Bronchus:** The lingular bronchus originates from the bifurcation of the upper lobe bronchus and has a short course before it enters the parenchyma.

- **Arteries:** The main supply of the lingula comes from the lingular trunk, which is the most anterior branch of the posterior segmental arteries. It originates from the anterior aspect of the pulmonary artery within the fissure and splits into two segmental branches. In some patients, an additional lingular artery arises from the truncus anterior.

- **Veins:** The lingular vein is the lowermost tributary of the superior pulmonary vein. It is easily recognizable when the superior pulmonary vein has three major roots (apicoposterior, anterior, and lingular). However, in some patients, there are actually multiple radiating venous branches. In these cases, it is safer to divide only the lowermost branch. Once the lingula becomes mobile, thanks to the arterial and bronchial division, the venous drainage will become more apparent.

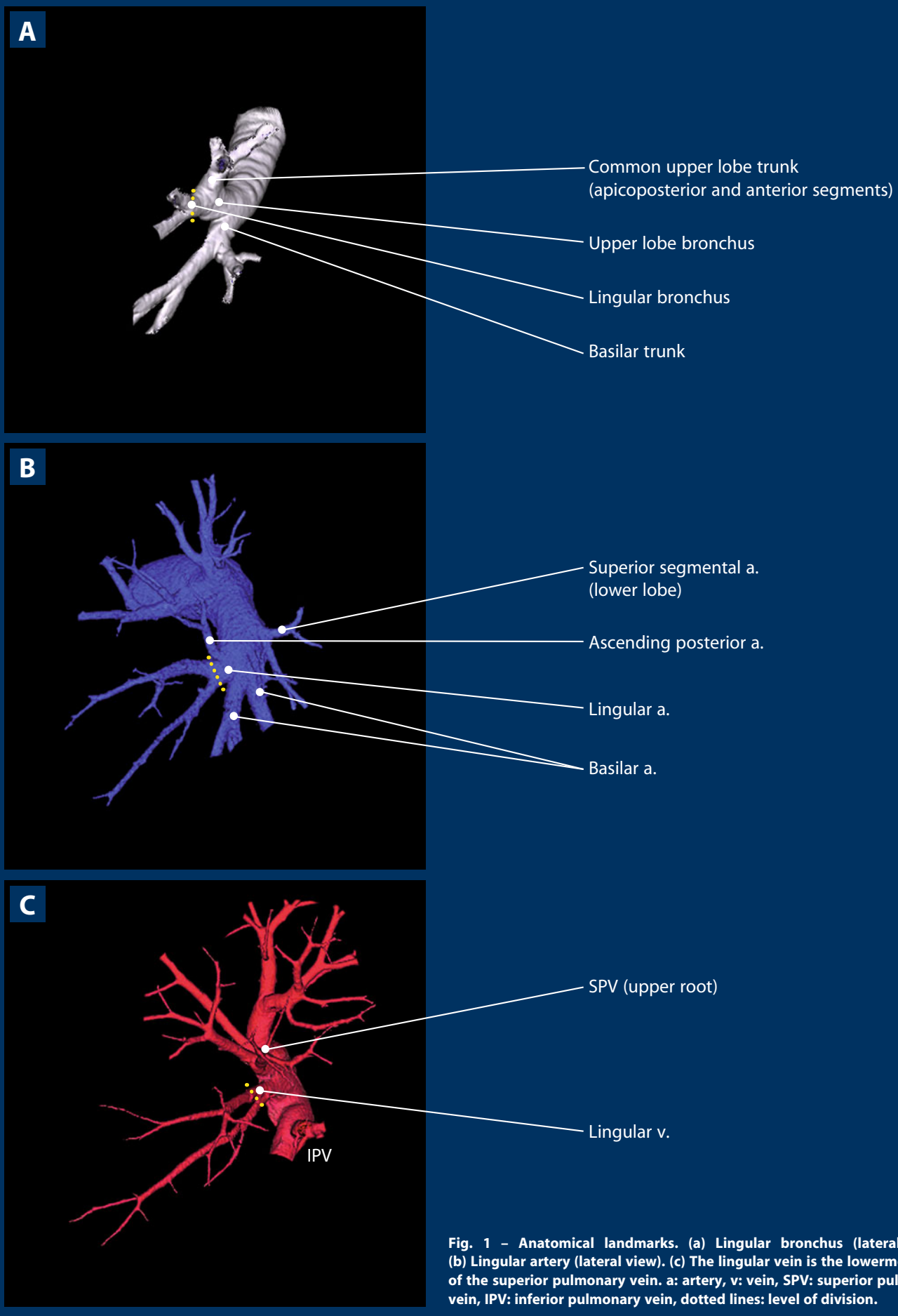


Fig. 1 – Anatomical landmarks. (a) Lingular bronchus (lateral view). (b) Lingular artery (lateral view). (c) The lingular vein is the lowermost root of the superior pulmonary vein. a: artery, v: vein, SPV: superior pulmonary vein, IPV: inferior pulmonary vein, dotted lines: level of division.

Technique

1. Fissure and artery

The anterior portion of the oblique fissure is open from the periphery to the hilum. The peripheral portion is usually thin so that the division can be initiated with either ultrasonic shears or a bipolar sealing device. When the fissure is thick and large, it is preferable to first staple its peripheral portion, always keeping an eye on the pulmonary artery (**Fig. 2**) (see page 73).

The hilar portion of the fissure must not be divided until the origin of the lingular artery has been identified.

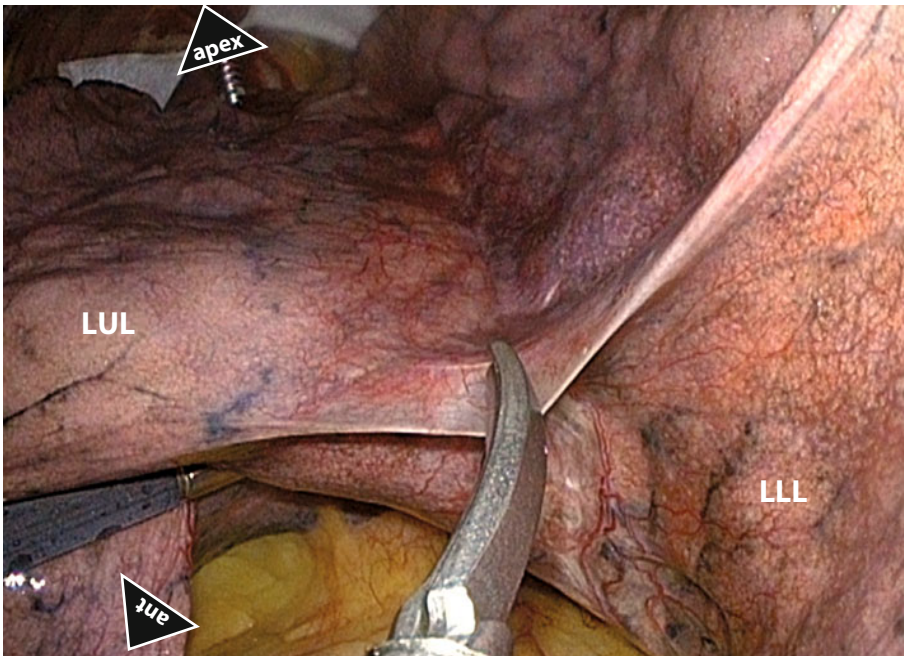
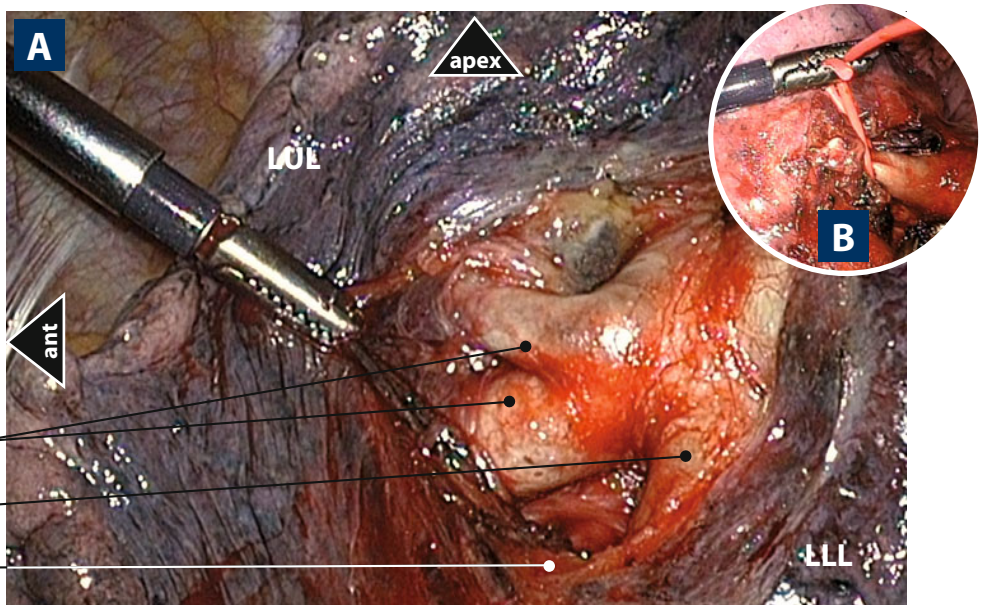


Fig. 2 – Opening of the anterior portion of the oblique fissure (the white gauze at the apex is a lens cleaning system (EndoClear™).

The anterior aspect of the pulmonary artery is approached and its sheath is opened. The lingular artery – its trunk or the two segmental branches – is divided after clipping or stapling, depending on its diameter (**Fig. 3**).

Fig. 3 – Control of the lingular artery. (a) General view. (b) Retraction of the lingular artery to ease stapling.

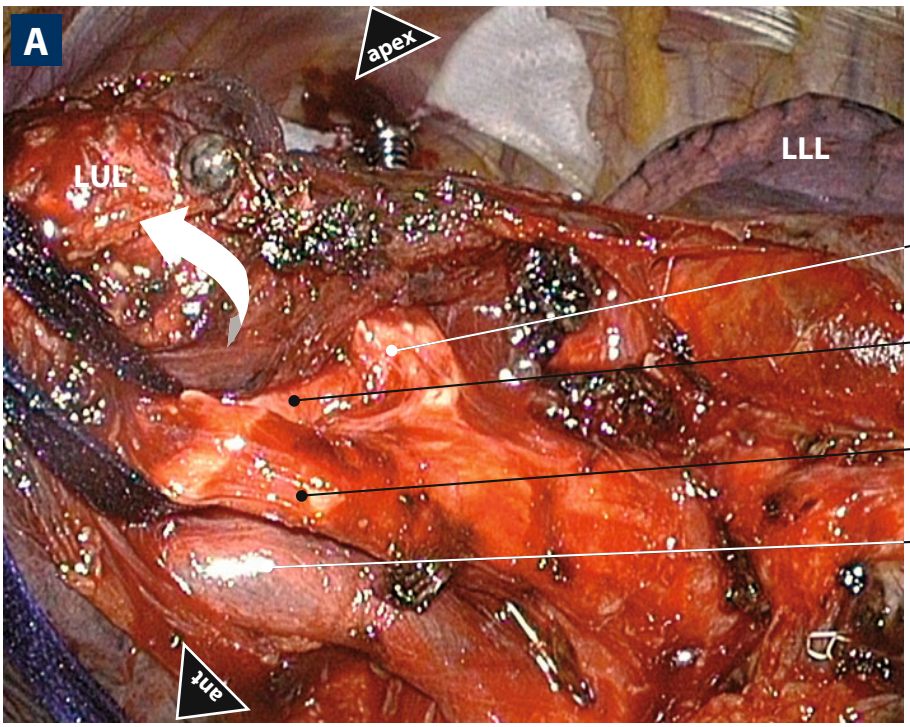


2. Bronchus

The division of the lingular artery allows identification of the upper lobe bronchus and the lingular bronchus, which is its lowest and most anterior branch. It is dissected, taking care to the artery of the anterior segment, which runs behind the bronchus (**Fig. 4a**).
The lingular bronchus has a short course, and the peribronchial space is very narrow, so that a guide can be helpful for passing the stapler anvil smoothly (**Fig. 4b**).

In case of very short lingular bronchus, which makes it impossible to staple, cutting the bronchus and closing it with stitches – as done during open surgery – is possible provided the surgeon masters endoscopic suturing.

Tip



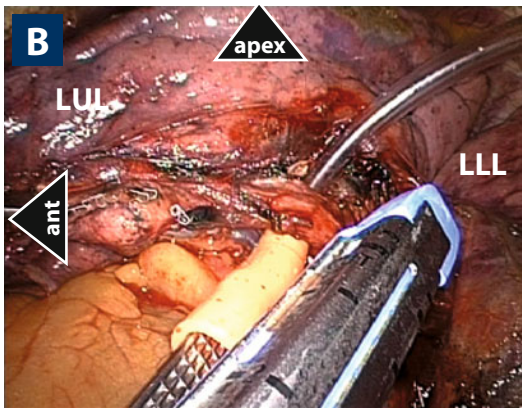


Fig. 4 – Control of the lingular bronchus.
(a) Dissection and retraction of the lingular bronchus.
(b) Using a guide for the endostapler.

3. Vein

The lowest tributary of the superior pulmonary vein is transected. It can be difficult asserting that the adjacent venous branch drains the lingula. When in doubt, this branch must not be divided until the lingula has been fully mobilized and the intersegmental plane has been initiated (**Figs. 5 and 6**).

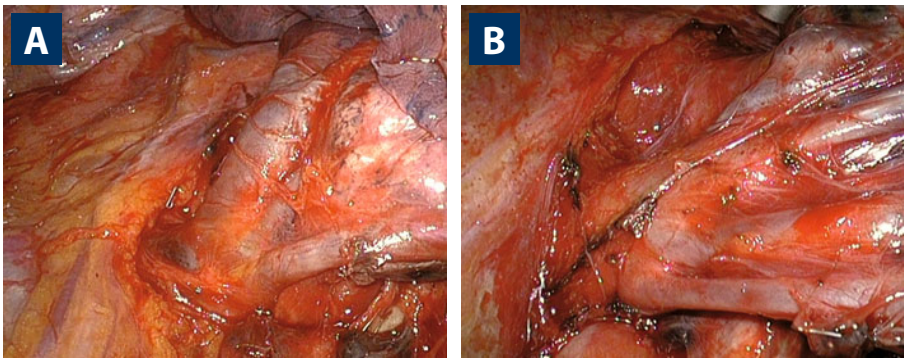


Fig. 5 – Various venous drainage of the lingula.
(a) Usual pattern with an independent lingular vein.
(b) Multiple branches (only the lowermost vein must be divided).

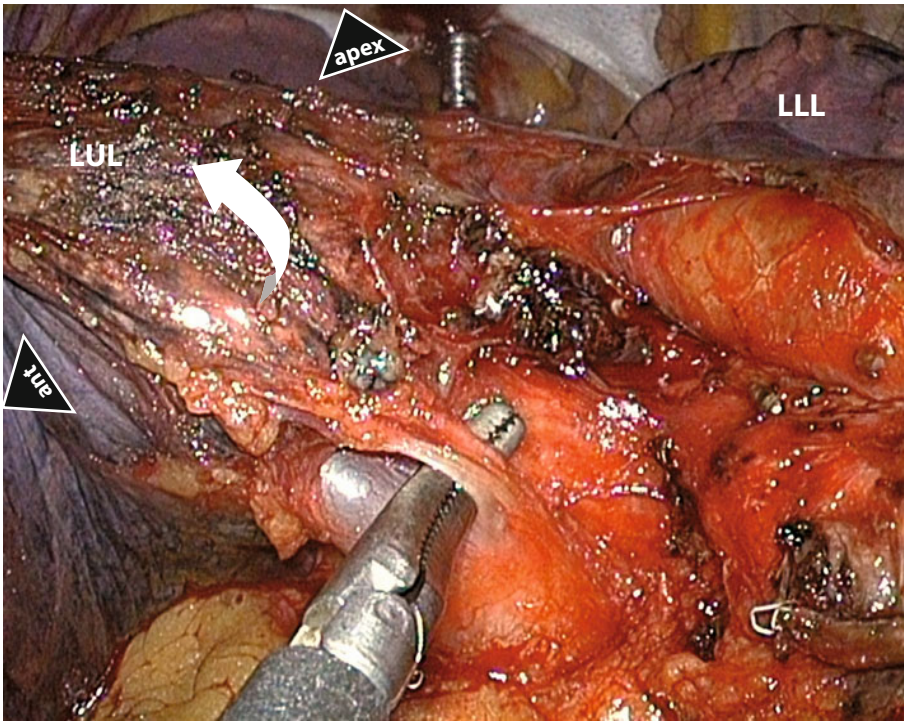


Fig. 6 – Dissection of the lingular vein.

4. Division of the parenchyma

A clamp is applied on the parenchyma, the lung is reventilated to identify the intersegmental plane, and the parenchymal division is then performed using 4.8-mm staples. The bronchial stump (specimen end) must sometimes be retracted anteriorly to permit adequate positioning of the anvil. The specimen is removed in the usual fashion (**Fig. 7**).

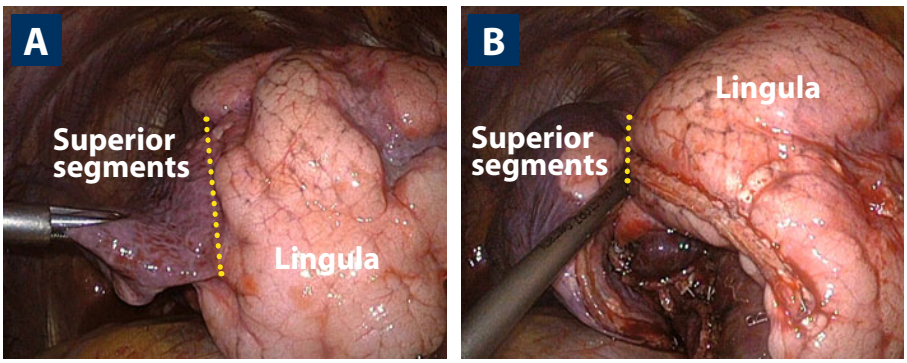


Fig. 7 – Delineation of the intersegmental plan after selective reventilation of the lingula.

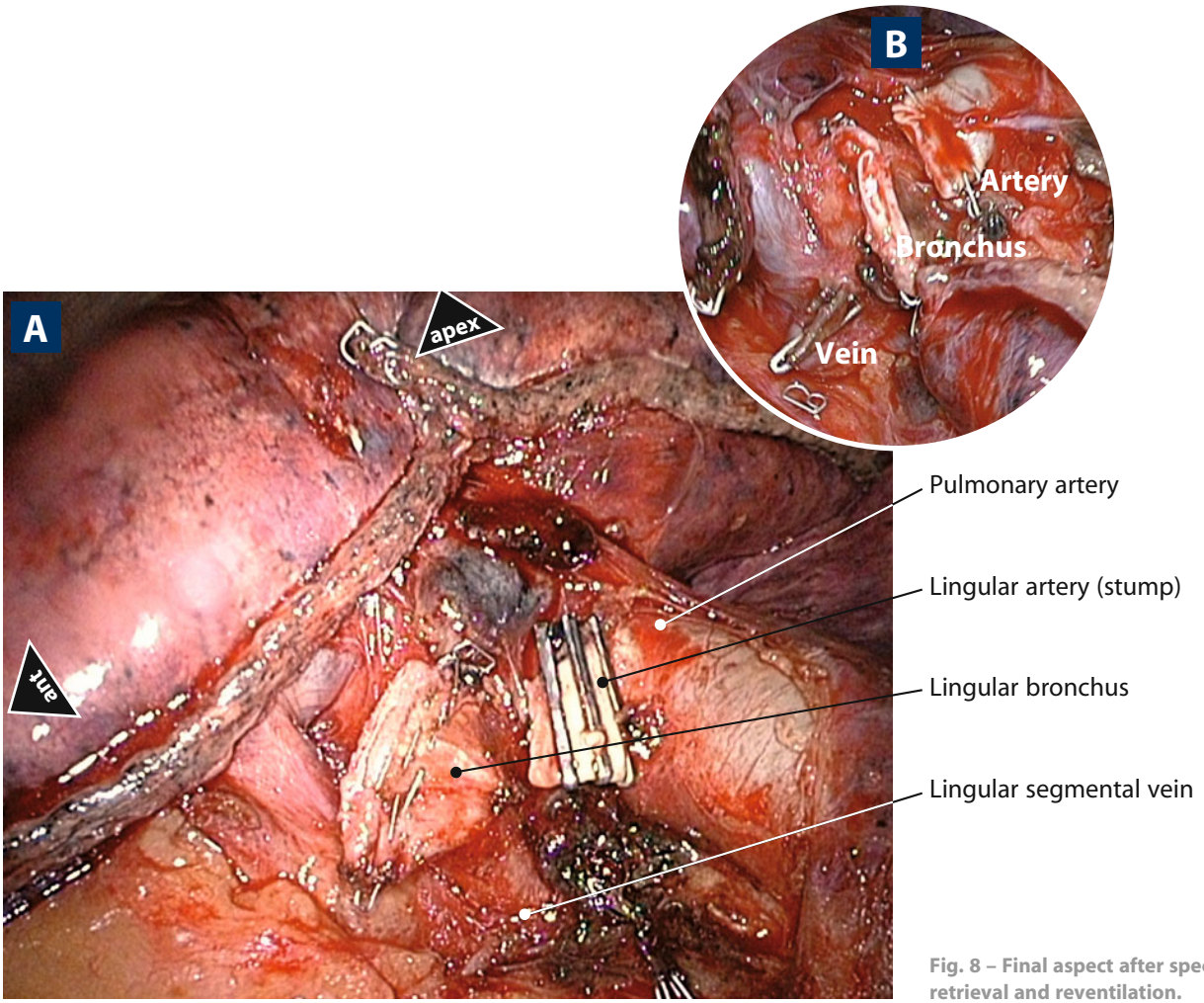


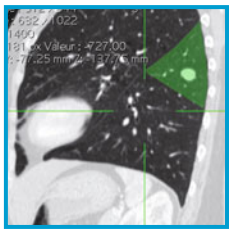
Fig. 8 – Final aspect after specimen retrieval and reventilation.

: The video of this technique can be consulted on WEBSURG at the following address: http://www.websurg.com/ref/doi-vd01en2266.htm

Chapter XIII

Left lower lobe: superior segment

Chapter XIII Left lower lobe: superior segment



Resection of the superior segment (S6) of the left lower lobe is more or less similar to the resection of the superior segment of the right lower lobe, but even simpler because the segmental artery is usually readily identified in the fissure.

Anatomical landmarks (Fig. 1)

- **Bronchus**: The superior segmental bronchus is the first branch of the lower lobe bronchus. It arises laterally and posteriorly and lies posterior to the segmental artery.

- **Arteries**: The superior segment of the left lower lobe is supplied by a single artery that originates from the posterior surface of the pulmonary artery in the posterior portion of the fissure. It runs anterior to the segmental bronchus. Rarely, this artery is double. It can provide a branch to the upper lobe.

- **Vein**: The superior segment is drained by the superior segmental branch of the inferior pulmonary vein. Its identification requires the dissection of the whole inferior vein.

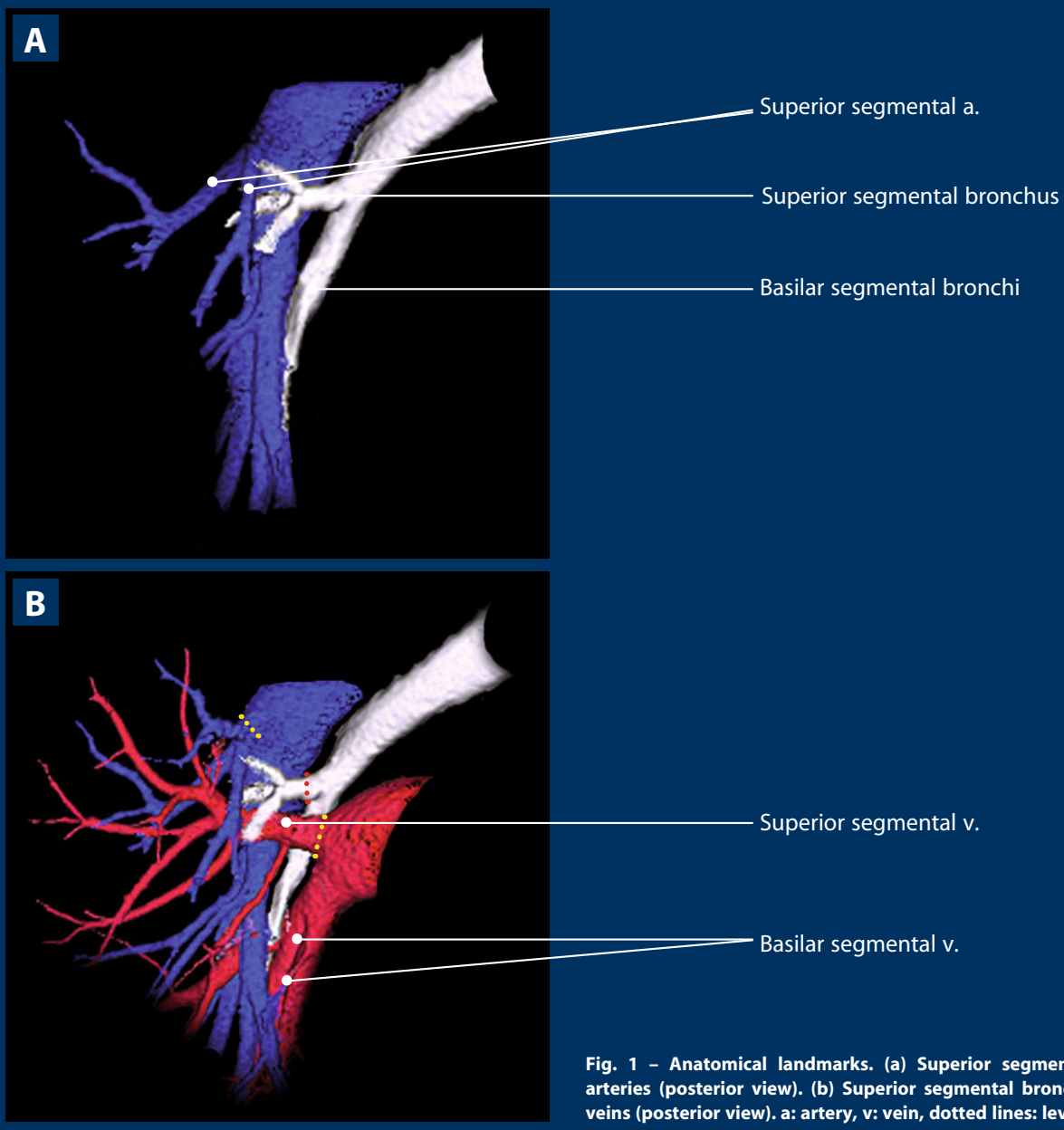


Fig. 1 – Anatomical landmarks. (a) Superior segmental bronchus and arteries (posterior view). (b) Superior segmental bronchus, arteries, and veins (posterior view). a: artery, v: vein, dotted lines: level of division.

Technique

1. Fissure and artery

This step is similar to the dissection of the fissure during a left lower lobectomy (see page 92). If the lung is deflated, the fissure can be approached without the help of retractors. Otherwise, both lobes should be spread apart to expose the middle portion of the fissure. The pulmonary artery may be visible or hidden if the fissure is fused (**Fig. 2**).

Tip

There is no need to display the whole trunk of the pulmonary artery. Only its posterolateral surface must be clearly displayed.

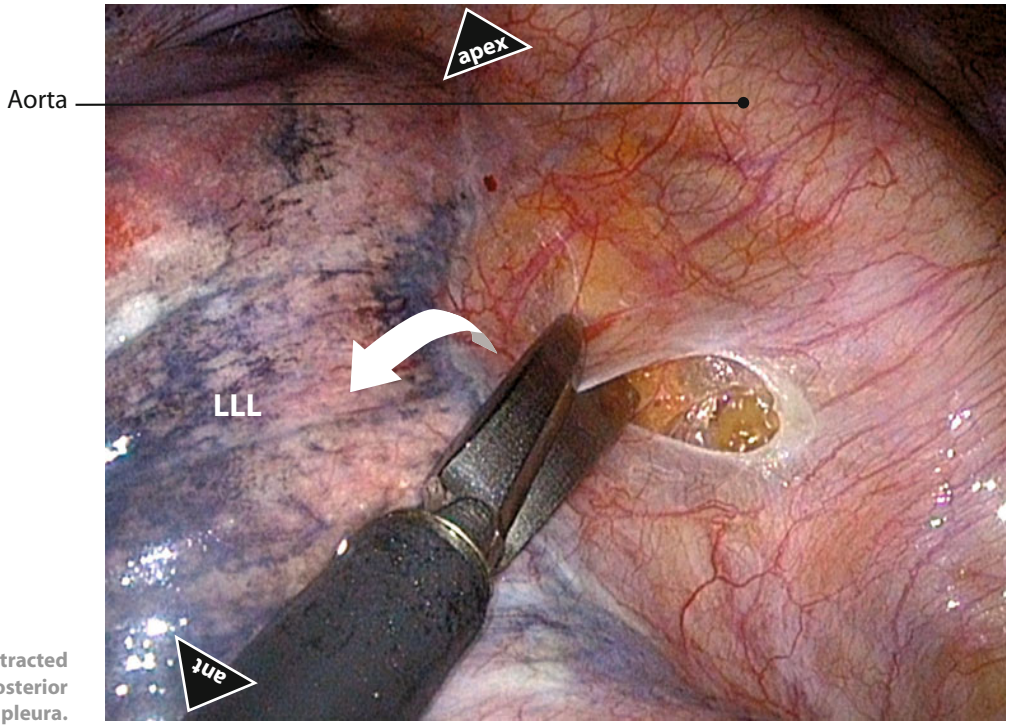


Fig. 2 – The lower lobe is retracted anteriorly to access the posterior mediastinal pleura.

The posterior fissure is opened by inserting the tip of a dissecting forceps from the posterior aspect of the pulmonary artery to the posterior mediastinum. This may require retracting the lobes forward in order to expose the posterior mediastinal pleura. An oblique-viewing endoscope or a deflectable scope is helpful to control this maneuver. The posterior fissure is then stapled (**Fig. 3**).

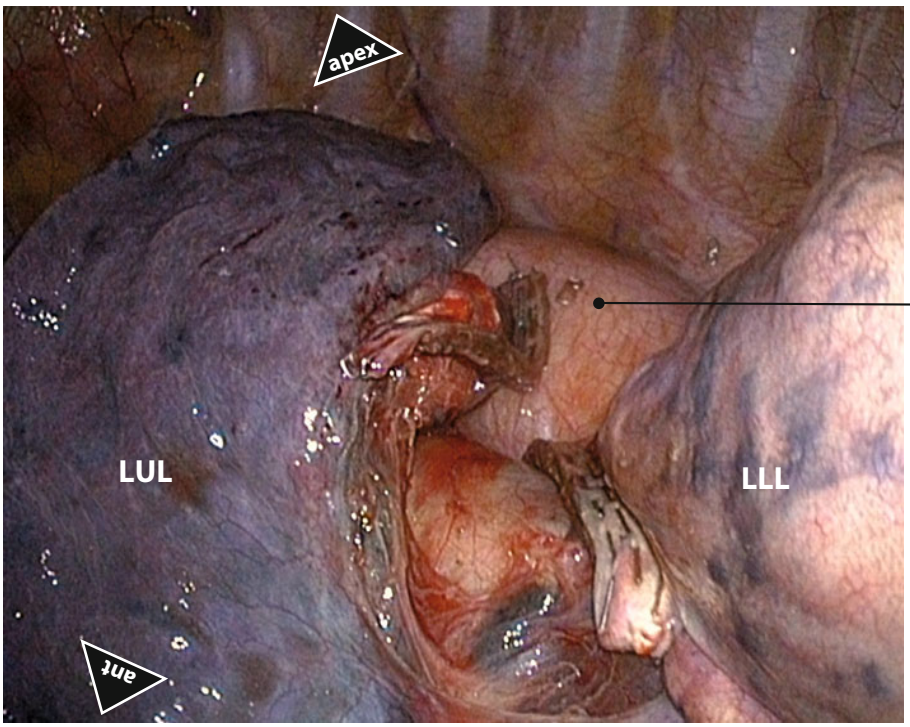


Fig. 3 – Division of the posterior part of the fissure.

The superior segmental artery, which runs anteriorly to the segmental bronchus, is usually single, sometimes double. It is dissected and clipped (**Fig. 4**).

The superior segmental artery must be dissected on a sufficient length to make sure it does not provide an accessory ascending branch to the upper lobe.

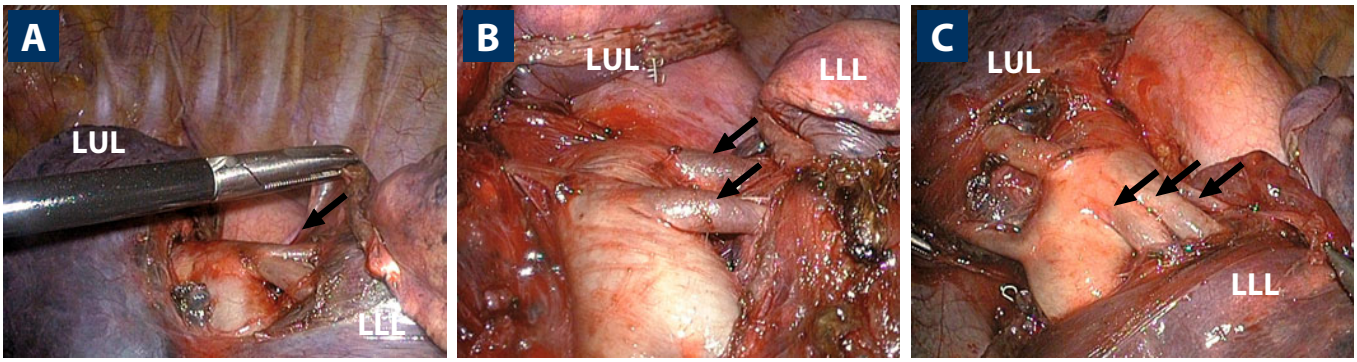


Fig. 4 – The superior segmental artery (*arrow*) can be single (a), double (b) or even triple (c).

2. Bronchus

Division of the segmental artery gives access to the segmental bronchus, which is cleared and divided, with the avoidance of impingement on the basilar bronchus. If any doubt, a reventilation test can be helpful (**Fig. 5**).

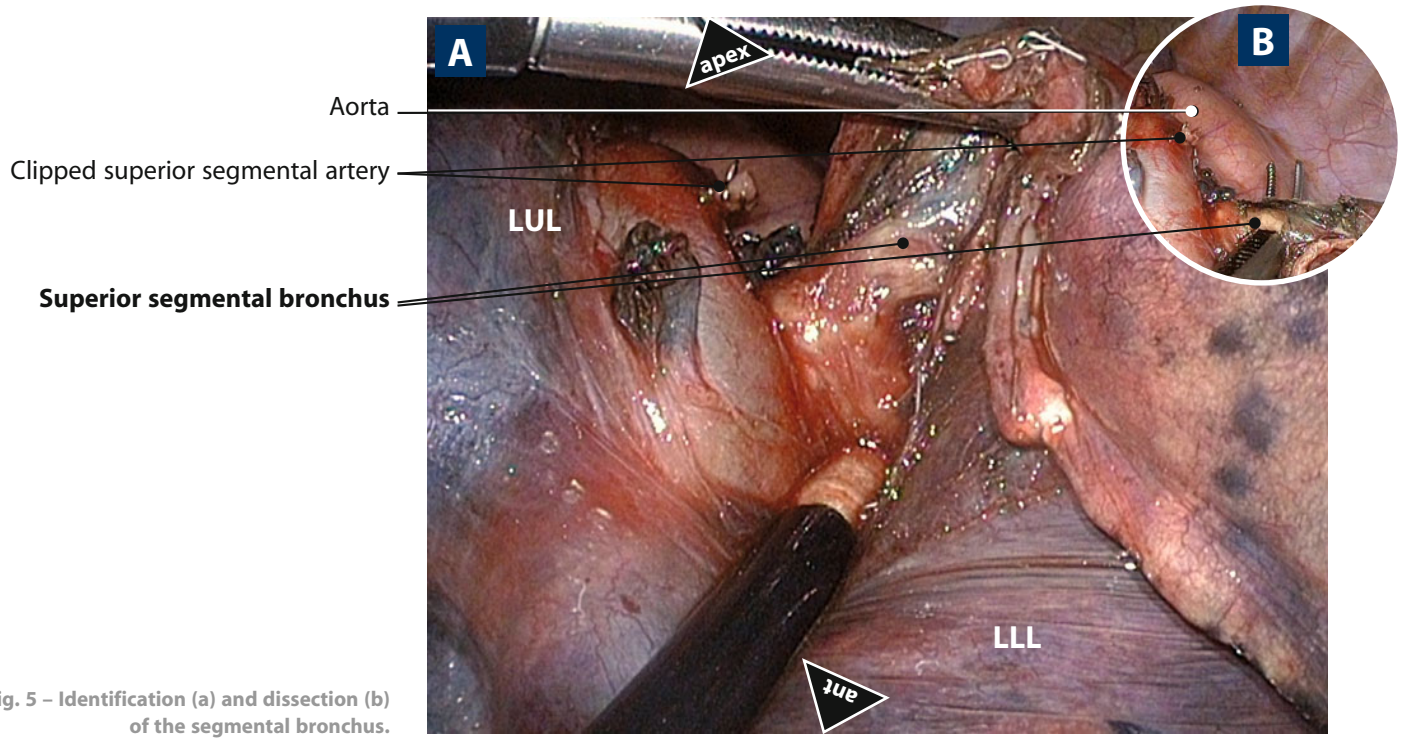


Fig. 5 – Identification (a) and dissection (b) of the segmental bronchus.

3. Vein

The pulmonary ligament is incised up to the lower vein using both diathermy and gentle traction on the lower lobe (**Fig. 6**).

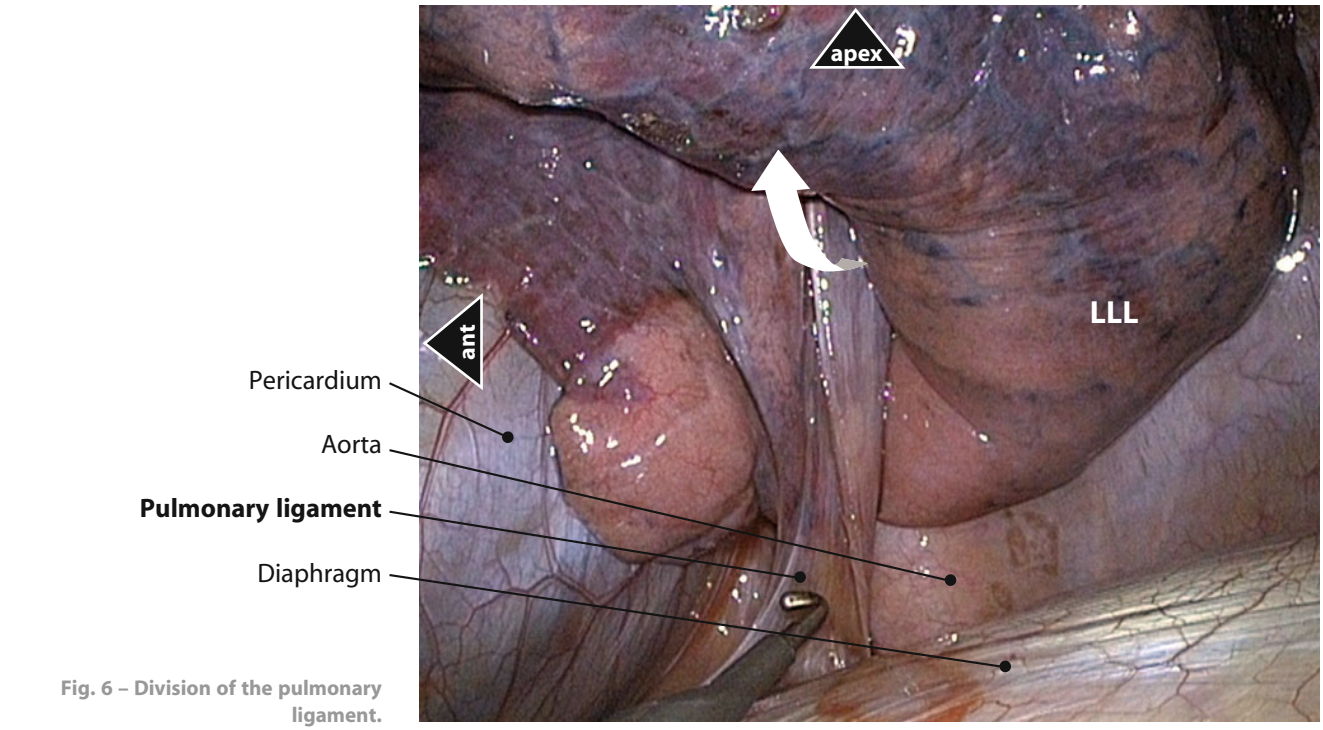


Fig. 6 – Division of the pulmonary ligament.

The inferior vein is cleared from the surrounding tissues until its uppermost tributary is identified. It lies usually inferior to the bronchus. It can be clipped or divided with a vessel sealing device (**Fig. 7**).

These two later steps can be inverted.

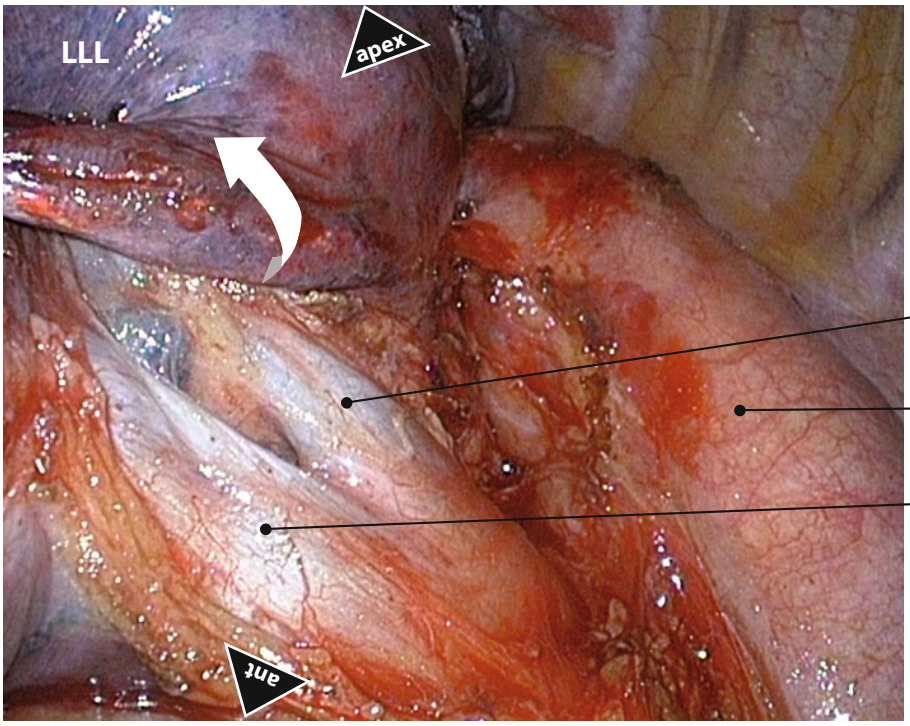


Fig. 7 – Identification of the upper branch of the inferior pulmonary vein.

4. Parenchymal division

Division of the vein helps lifting up the superior segment. A long clamp is applied on the parenchyma, checking that the bronchial stump stay remote and will not get stuck within the stapler jaws. A reventilation test allows to identify the intersegmental plane. The parenchyma is compressed by the clamp to ease stapler application (**Fig. 8**).

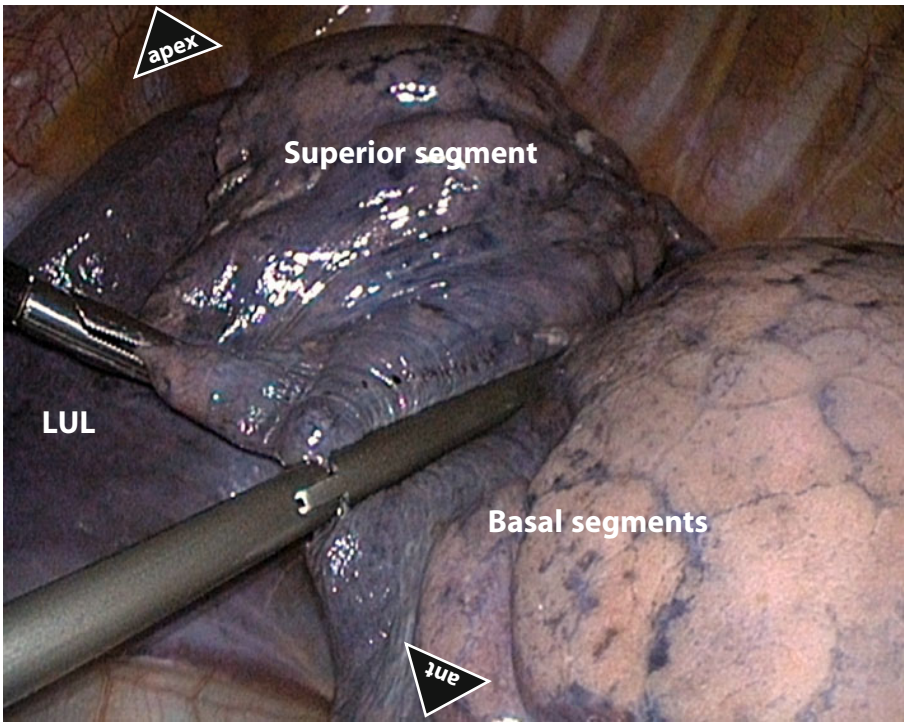


Fig. 8 – Reventilation helps delineating the plane between the superior and basal segments.

The specimen is retrieved in the usual fashion. A small size (10-mm-diameter) bag is sufficient (**Fig. 9**).

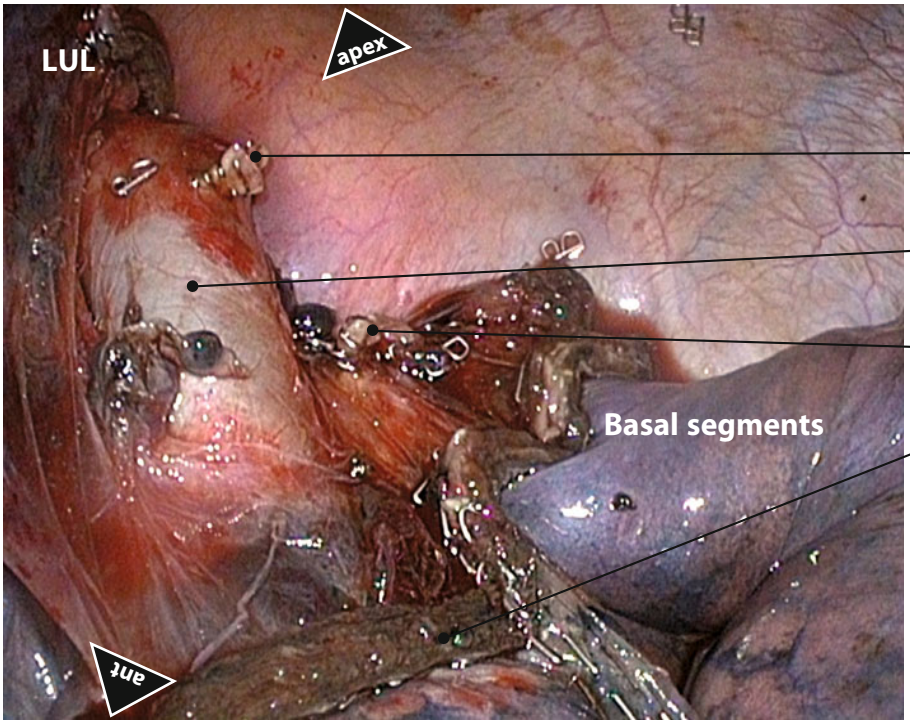


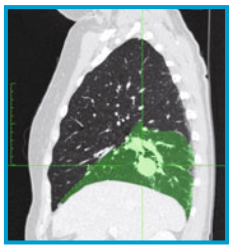
Fig. 9 – Final aspect after retrieval of the specimen.

: The video of this technique can be consulted on WEBSURG at the following address: http://www.websurg.com/ref/doi-vd01en2921.htm

Chapter XIV

Left lower lobe: basal segments

Chapter XIV Left lower lobe: basal segments



In addition to the superior segment (S6), the lower lobe comprises four basal segments: anterior (S7), medial (S8), lateral (S9), and posterior (S10). Although the medial and anterior (S7+8) and the posterior and lateral (S9+10) segments can sometimes be individualized, it is usual to remove all basal segments together. The procedure is similar to a left lower lobectomy. Only the demonstration of the basilar vein and the recognition of the intersegmental plane may be difficult.

Anatomical landmarks (Fig. 1)

- **Bronchus**: The origin of the common basal trunk is found in the fissure 1–2 cm beyond the origin of the superior segmental bronchus.

- **Arteries**: The arterial supply of the basal segments is the termination of the pulmonary artery after the takeoff of the lingular artery and the superior segmental artery. It runs anterior to the segmental bronchus and usually divides into two main trunks: one for the anteromedial segment and one for the posterior and lateral segments. It can also separate into three or four segmental branches (see page 87).

- **Veins**: The basal segments are drained by a large basal venous trunk that is the lowest tributary of the inferior pulmonary vein. In some patients, the branching is made from multiple segmental veins, as on the right side.

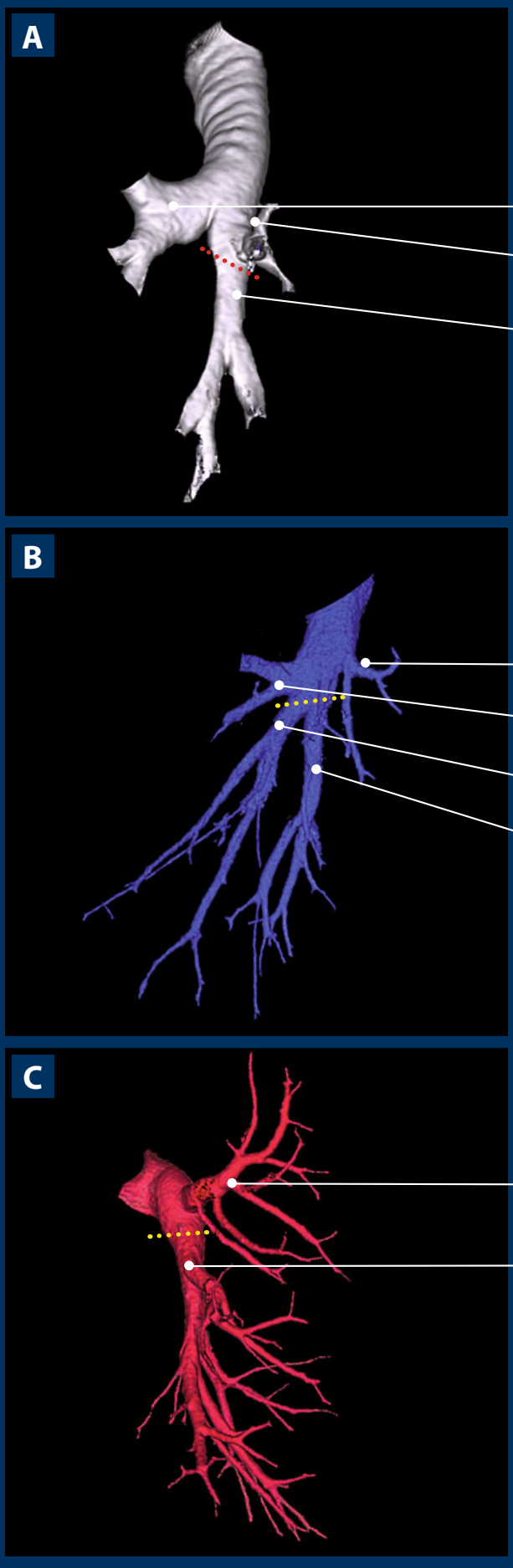


Fig. 1 – Anatomical landmarks. (a) Common basal trunk (lateral view). (b) Basal segmental arteries (in this case, split in two main trunks) (lateral view). (c) Basal segmental veins (lateral view). a: artery, v: vein, dotted lines: level of division.

Technique

1. Fissure and artery

The dissection starts as for a lower lobectomy (see page 88) (**Fig. 2**).

In case of a fused and long fissure, it is advisable to first divide the anterior portion of the fissure in order to facilitate mobilization and exposure of the arteries.

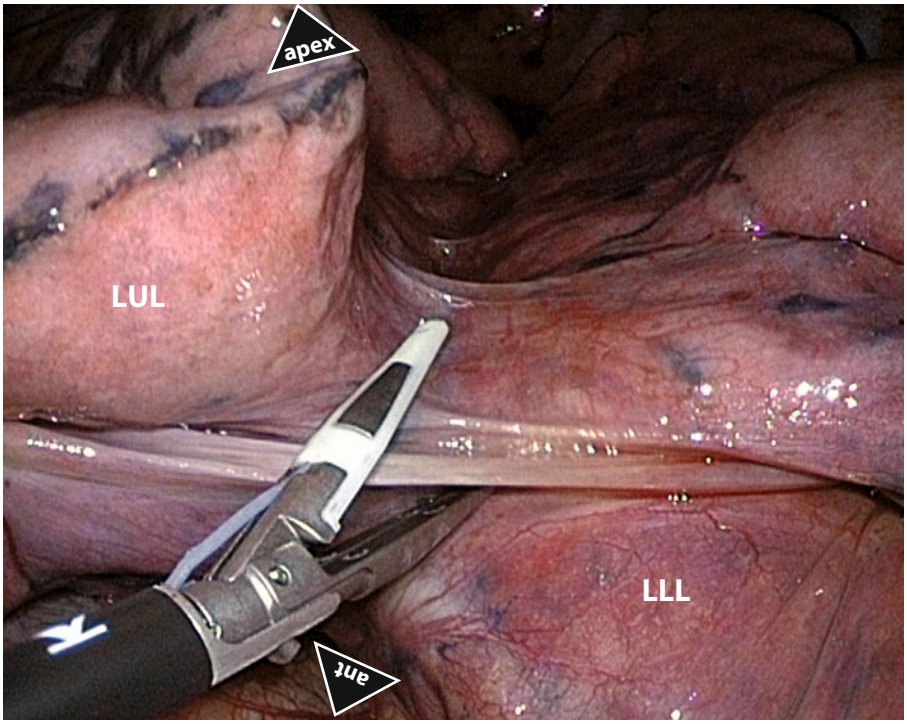


Fig. 2 – Division of the anterior part of the fissure using bipolar sealing.

Once the peripheral portion of the fissure has been divided, it becomes easier to display the reflection of the mediastinal pleura between the two pulmonary veins. The pleura is opened with electrocautery, and a right-angle dissector can then be passed toward the pulmonary artery. This allows completing the division of the anterior fissure.

Completion of the anterior fissure division helps exposing the pulmonary artery whose sheath is opened. The basilar trunk is dissected. There is no need to isolate the superior segmental artery, but the latter must be identified before stapling the basilar artery, which can present as a common trunk or with multiple branches (**Fig. 3**).
The posterior part of the fissure does not need to be stapled.

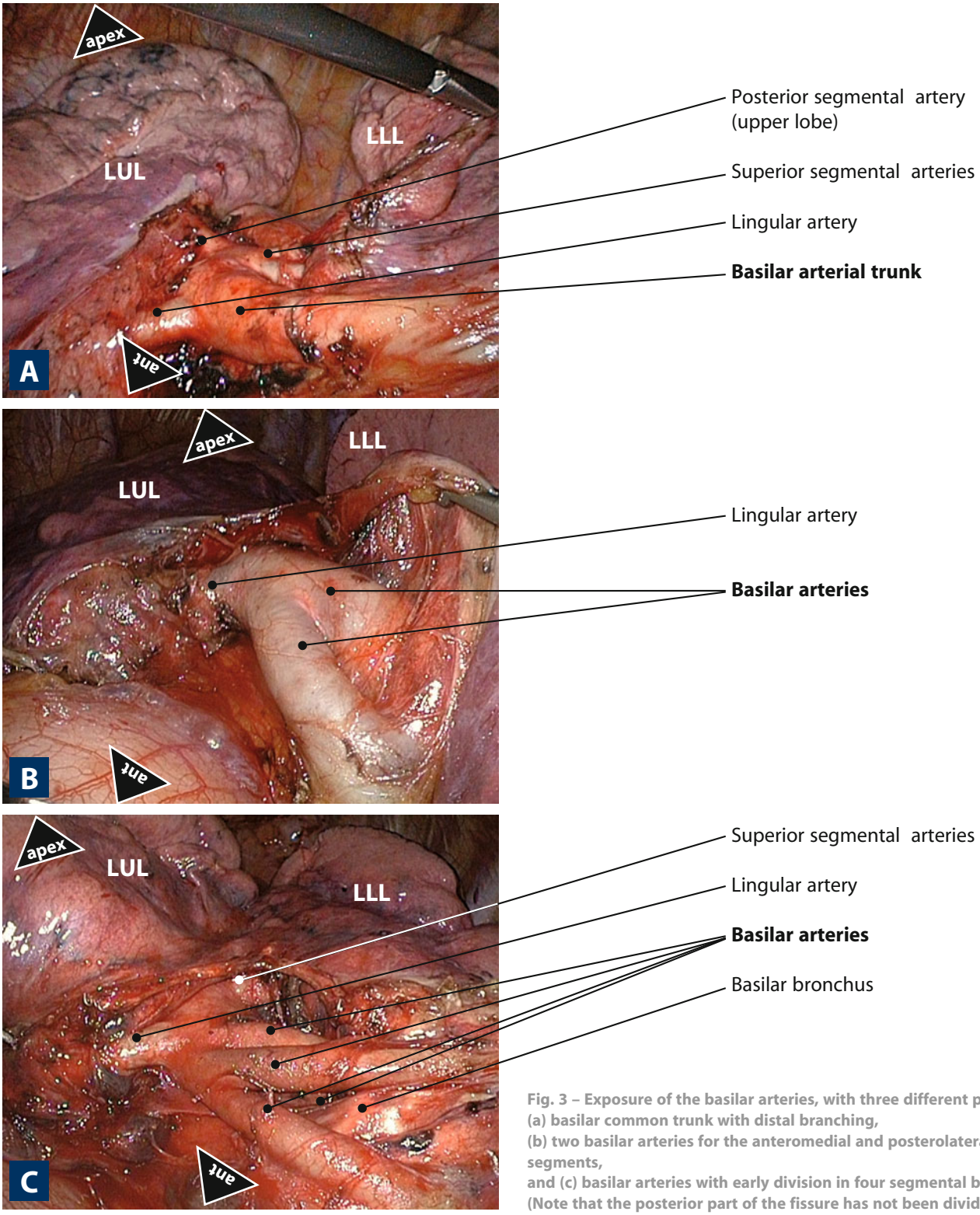


Fig. 3 – Exposure of the basilar arteries, with three different patterns: (a) basilar common trunk with distal branching, (b) two basilar arteries for the anteromedial and posterolateral segments, and (c) basilar arteries with early division in four segmental branches. (Note that the posterior part of the fissure has not been divided.)

2. Bronchus

Division of the basilar trunk gives access to the basal bronchus, which is cleared and divided, with the avoidance of impingement on the segmental superior bronchus. If any doubt, a reventilation test can be helpful (**Fig. 4**).

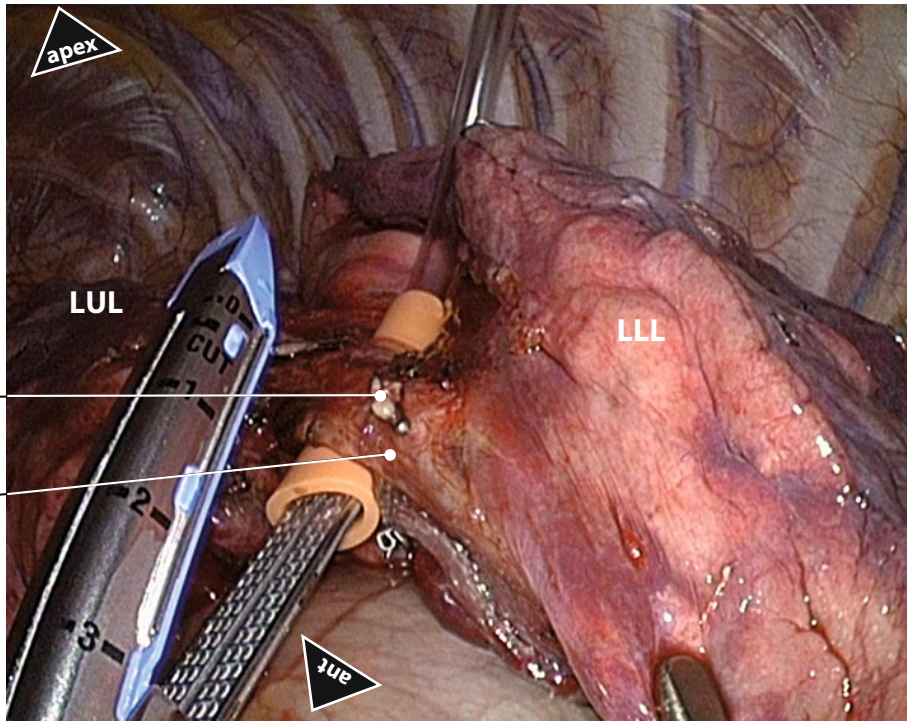


Fig. 4 – Use of a 16-Fr suction tube as a guide for passing the endostapler anvil around the basal bronchial trunk.

3. Vein

The pulmonary ligament is incised up to the lower vein using both diathermy and gentle traction on the lower lobe. Demonstration of the segmental vein is achieved by using a combination of gentle traction of the lobe and blunt dissection with an endopeanut. The vein is cleared from the surrounding tissues, and its inferior root is dissected, isolated, and clipped, with care taken to preserve the superior segmental vein (**Figs. 5 and 6**).

In some patients, it can be easier to divide the segmental vein before the bronchus (**Fig. 5c**).

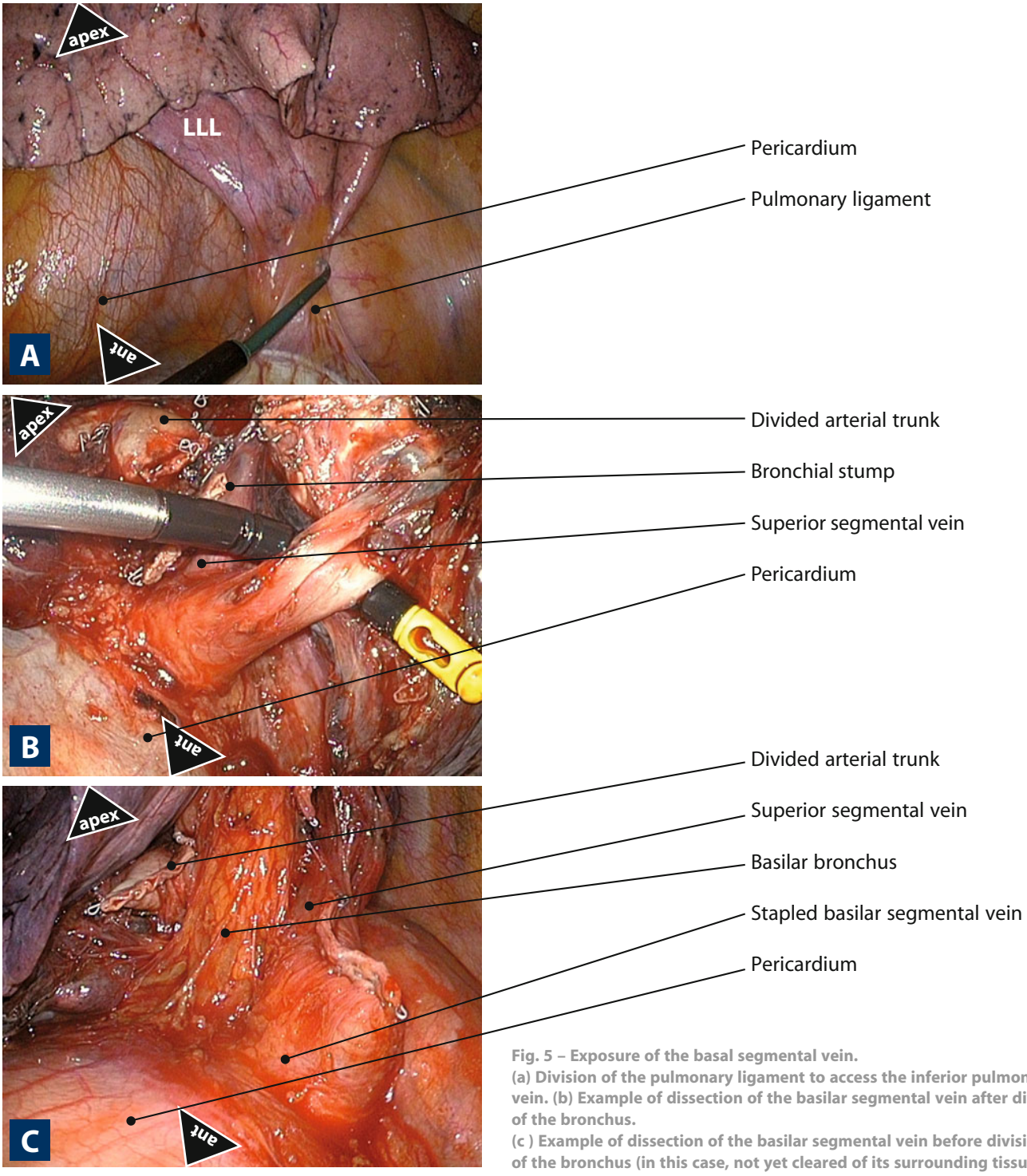


Fig. 5 – Exposure of the basal segmental vein.
(a) Division of the pulmonary ligament to access the inferior pulmonary vein. (b) Example of dissection of the basilar segmental vein after division of the bronchus.
(c) Example of dissection of the basilar segmental vein before division of the bronchus (in this case, not yet cleared of its surrounding tissues).

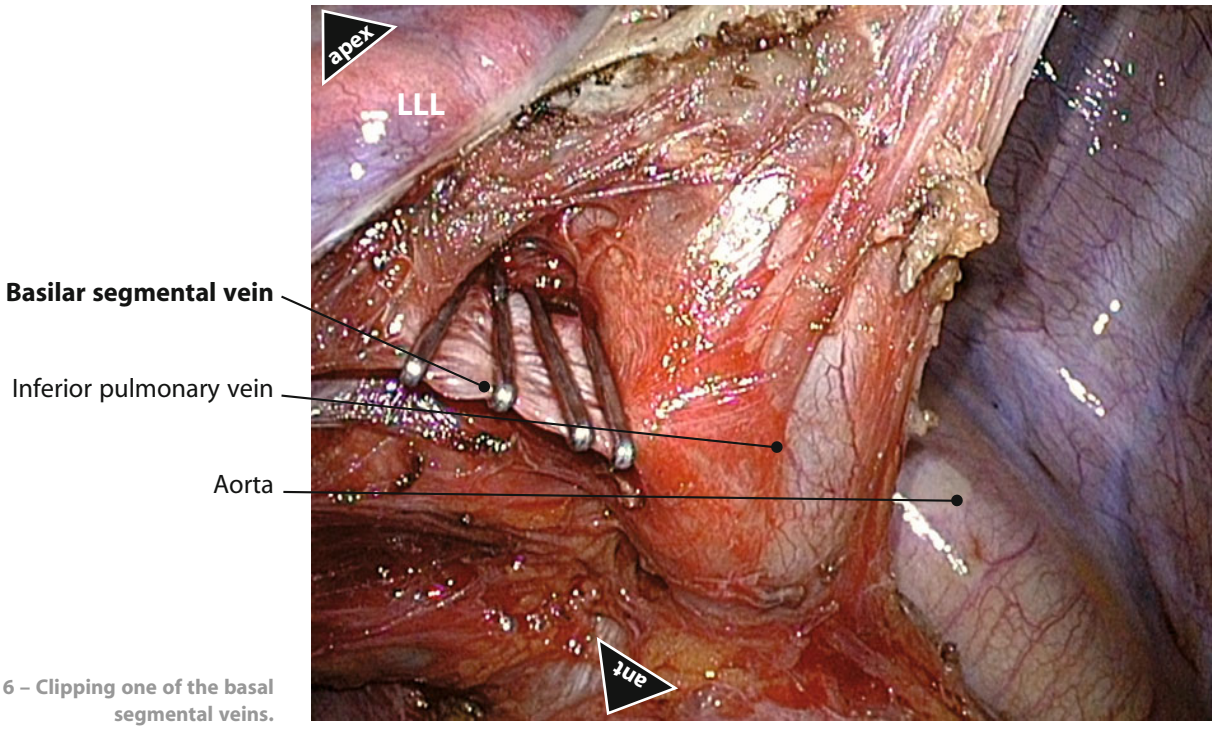


Fig. 6 – Clipping one of the basal segmental veins.

4. Division of the parenchyma

A long clamp is applied on the parenchyma. A reventilation test allows to identify the intersegmental plane. The parenchyma is compressed by the clamp to ease stapler application.
The specimen is retrieved in the usual fashion (**Figs. 7 and 8**).

During stapling, care should be taken to keep the bronchial stump away from the stapler.

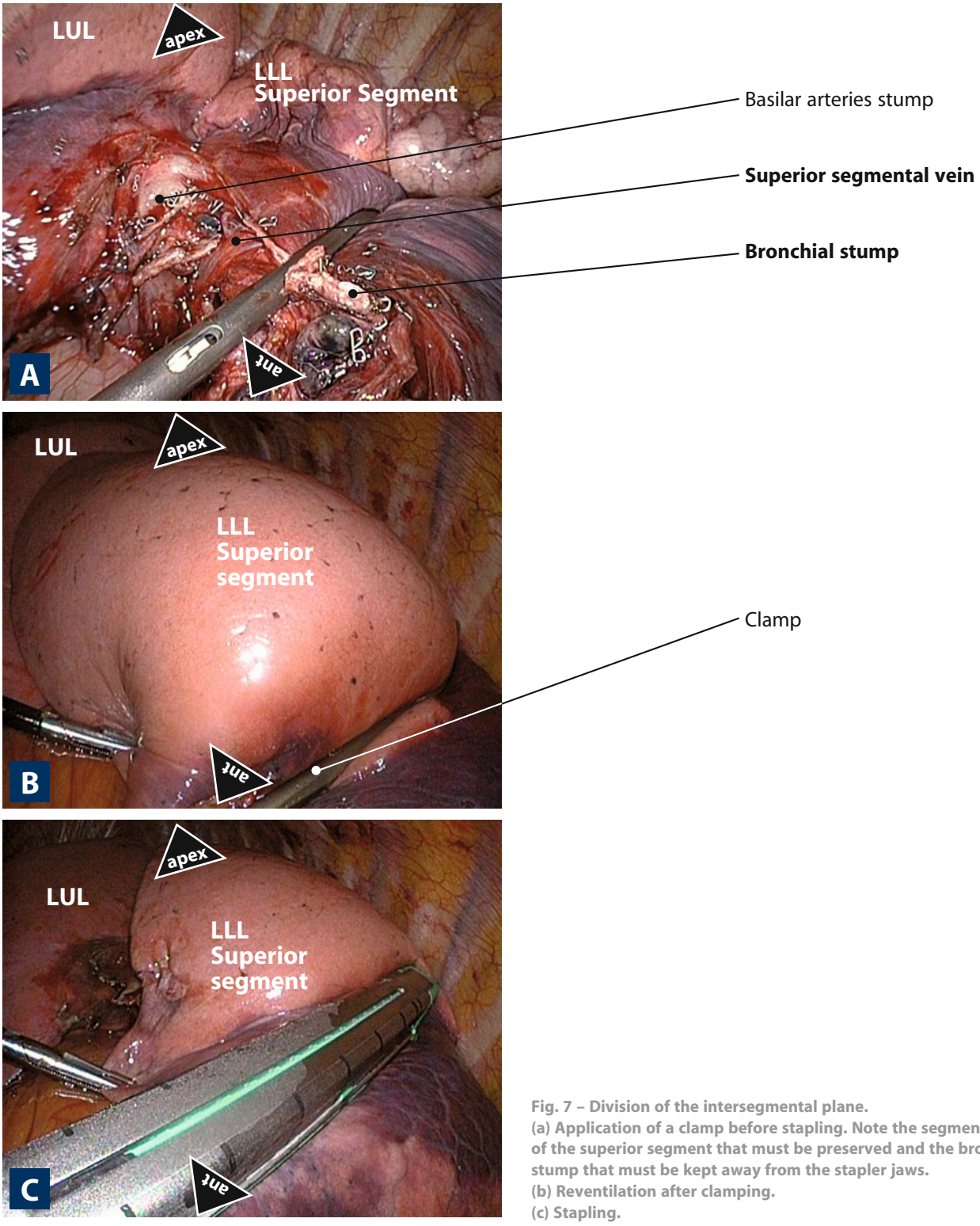


Fig. 7 – Division of the intersegmental plane.
(a) Application of a clamp before stapling. Note the segmental vein of the superior segment that must be preserved and the bronchial stump that must be kept away from the stapler jaws.
(b) Reventilation after clamping.
(c) Stapling.

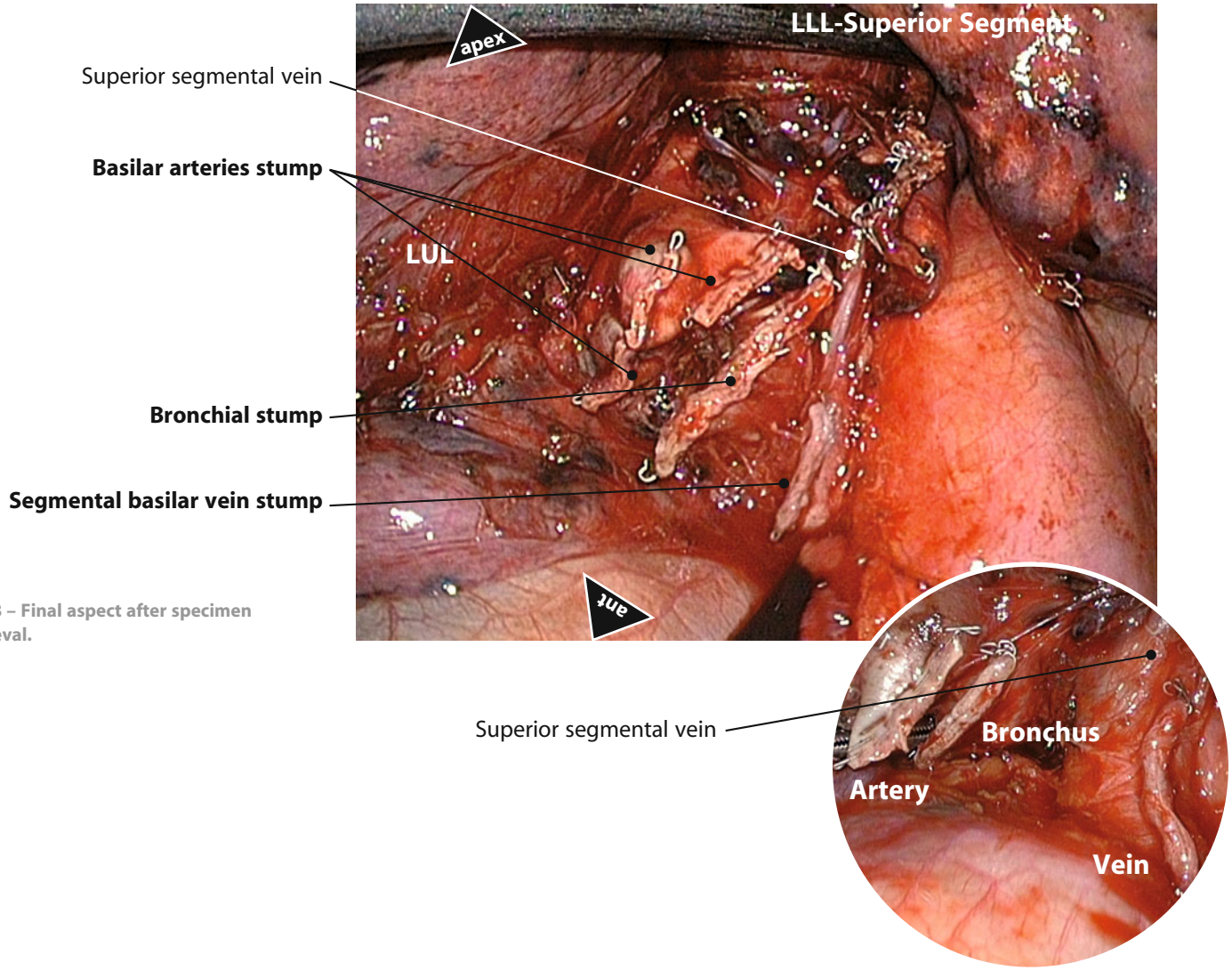


Fig. 8 – Final aspect after specimen retrieval.

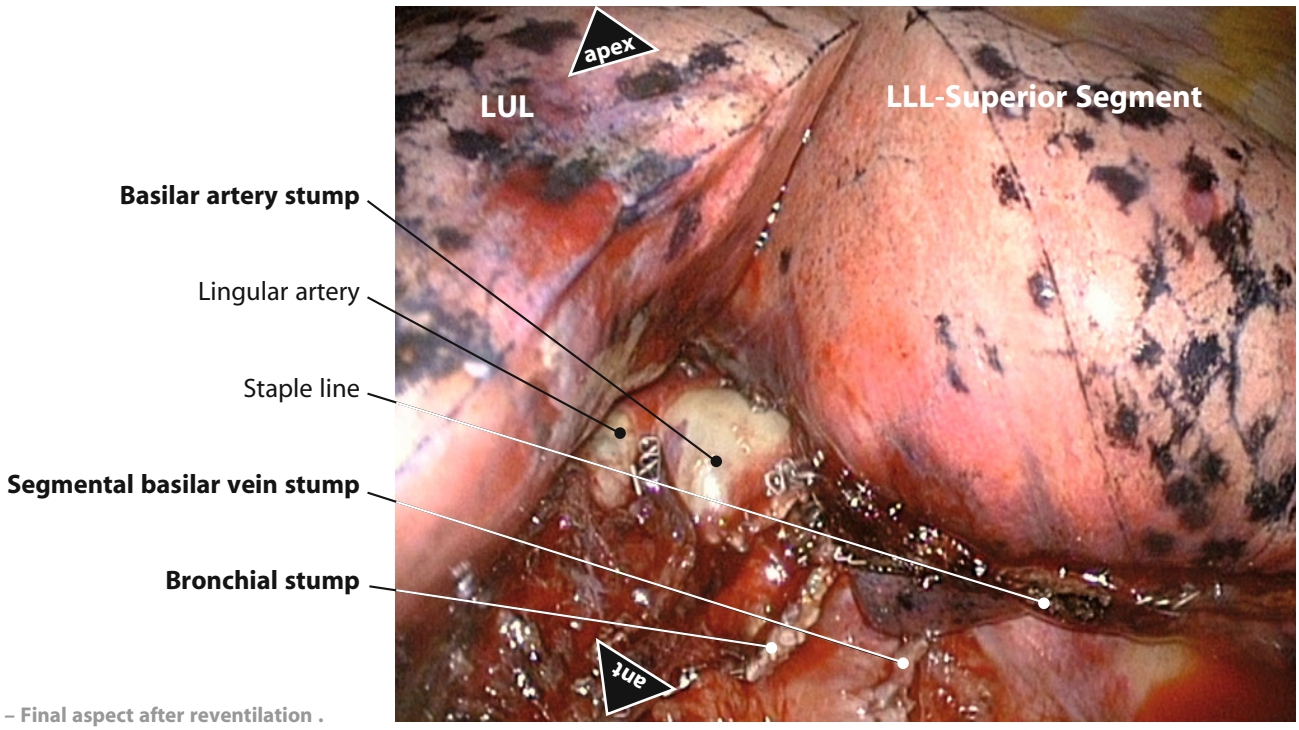


Fig. 9 – Final aspect after reventilation .