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Technical aspects and access devices for preperitoneal and retroperitoneal endoscopic surgery

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Summary

The main advantages of preperitoneal and retroperitoneal endoscopic surgery over conventional laparoscopy or open surgery are the decreased risk of injury to organs and reduced postoperative adhesion formation. Exact knowledge of anatomy, as well as correct positioning of the patient, is essential for its success. While a blunt dissection technique, using either the fingers or an endoscope under pneumodissection, is preferred for preperitoneal surgery, the introduction of a balloon dissection device directly into the retroperitoneal cavity simplifies this procedure for retroperitoneoscopy. Different general surgical procedures are described for preperitoneal (hernia) and retroperitoneal (adrenalectomy, neurectomy/sympathectomy) surgery. Urological/gynaecological procedures (kidney, tumor biopsy, lymphadenectomy) are excluded from this review. In recent years, the number of possible preperitoneal and retroperitoneal surgical procedures has increased, mainly as a result of the development of commercially-available balloon trocars and balloon-tipped trocars, which create and maintain a working space.

Keywords

endoscopic surgery, retroperitoneoscopy, retroperitoneum, balloon trocar, surgery

Introduction

The endoscopic preperitoneal and retroperitoneal approach offers the following advantages over open techniques: less operative trauma with decreased pain, less risk of bowel perforation, and reduced adhesion formation. The disadvantages of the endoscopic approach are difficult access with a narrow working area, complex anatomy and the difficulty of maintaining a corresponding working space.

In conventional open surgery, the retroperitoneal space can be reached either through a transabdominal or a retroperitoneal (lumbar) approach. The same holds true for endoscopic surgery. In general surgery, conventional open preperitoneal procedures have been performed mainly for inguinal and femoral hernia repair, either through a transverse (unilateral) or midline (bilateral) incision, and by urologists to access the prostate or the bladder. This article discusses only general surgical procedures for both preperitoneal and retroperitoneal surgery. Urological/gynaecological procedures are excluded from this overview.

Whereas transabdominal laparoscopic surgery of the retroperitoneum was described by Jacobeus more than 80 years ago [1], the first gasless retroperitoneoscopy was performed by Bartel *et al.* as late as 1969 [2] for diagnosing retroperitoneal tumours and performing biopsies. At that time, the main difficulties in performing such a procedure were the access-way (open technique), the light source and the lack of instruments. Therefore, semi-open techniques, in combination with an endoscope, were used mainly by urologists to perform kidney biopsies and various stone extraction procedures [3–5].

The speed of development of preperitoneal endoscopic surgery (PES) and retroperitoneal endoscopic surgery (RES) was reduced by the difficulty of creating and maintaining a corresponding

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working space. Thus, when the technique of laparoscopic surgery using a constant pneumoperitoneum and digital visualisation was introduced into general and urological surgery, RES was popularised mainly by urologists and gynaecologists performing lymph-node or tumour biopsies [3–10]. However, closed access with the introduction of a fluoroscopically-guided Veress needle into the retroperitoneal cavity was difficult to perform and carried a high risk of injuring major vessels and parenchymateous organs; moreover, it did not allow breakage of the local fibrous string [9]. A milestone in solving this problem was the development of a balloon dissector by Gaur *et al* in 1992 [10]. This balloon trocar can be introduced under visual control directly into the retroperitoneal space, without the risk of injury to any structures. Since then, RES has gained broad acceptance for several surgical procedures [11–14] in different areas (Table 1).

The same scenario occurred with the use of PES in general surgery. The first laparoscopic transabdominal hernia repair was performed in 1989 by inner ring closure. This technique was then replaced by one involving the insertion of non-absorbable meshes, either preperitoneally (TAPP) or intra-abdominally (IPOM). However, laparoscopic hernia repair never gained the same acceptance as cholecystectomy. This was because a straightforward extraperitoneal procedure, such as the Bassini or Shouldice repair, was being replaced by a difficult intra-abdominal operation with unknown long-term results and the danger of injuring organs and causing specific complications, such as postoperative ileus, adhesion formation and bowel perforation [14]. This was the reason why PES was developed in France [15,16] using a blunt dissection technique. A balloon dissection technique, which was partially adopted from the RES-technique described by Gaur [10], was developed for PES later in the USA [17,18].

As in any surgical procedure, the precise knowledge of anatomy, as well as correct positioning of the patient, are essential for successful PES and RES.

Table 1. PES and RES procedures

General surgery	Adrenalectomy
	Pancreatic surgery
	Colonic mobilisation (left side)
	Tumour/lymph-node biopsy
	Lymph-node dissection
	Neurectomy
	Excision of mesenteric cyst
	Femoral or inguinal hernia repair (PES)
Vascular surgery	Abdominal aortic aneurysm repair
	Aortobifemoral grafting
	Sympathectomy
Urology/gynaecology	Nephrectomy/ureterectomy
	Heminephrectomy, nephropexy
	Marsupialisation/ deroofing of renal cysts
	Pyeloureterolithotomy
	Uretherolysis
	Varicocelectomy
	Retroperitoneal lymph-node dissection
	Radical prostatectomy (PES)
	Colposuspension (PES)
	Pelvic lymph-node dissection (PES)
Orthopaedics	Intervertebral spinal fusion discectomy

Anatomy

The preperitoneal and retroperitoneal cavity can be divided into three areas:

- Retropubic space.
- Iliac space.
- Lumbar space [19].

For PES, only the retropubic and iliac space are important, while for RES the lumbar (mainly) and iliac space (partially) are reached.

The retropubic space (space of Retzius for PES, see Figure 1)

The landmarks of this region are: the symphysis with both os pubis, the transversalis fascia, the epigastric vessels and the prevesical fascia. The Retzius space (RS) is located in front of the prevesical fascia of the

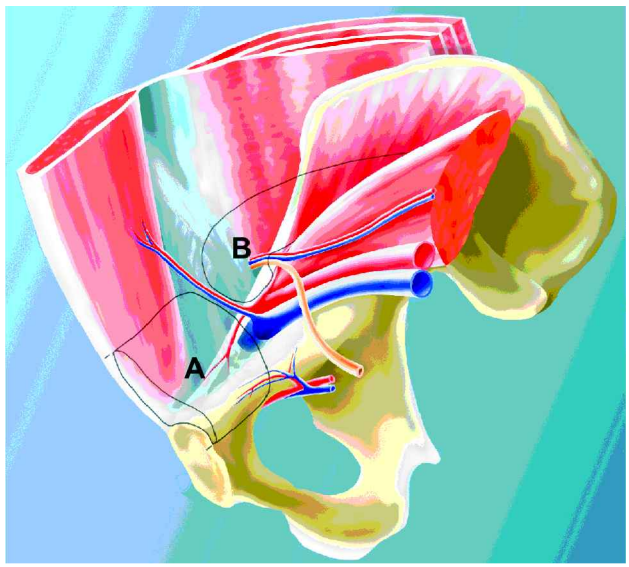

Figure 1. Schematic view of the two areas of Retzius **(A)** and Bogros **(B)** in the retropubic and iliac space needed to perform endoscopic hernia repair and PES.

bladder. Laterally, the boundaries consist of the epigastric vessels adherent with expansions of the prevesical fascia. Anteriorly, the RS is delimited by the symphysis and os pubis with, cranially to it, the fascia transversalis leading over into the posterior rectus sheath.

The iliac space (space of Bogros for PES and RES, see Figure 1)

The landmarks of this region are: the psoas muscle, the epigastric and iliac vessels and the femoral nerve. The lateral suprainguinal space of Bogros (BS) is located laterally to the RS and the epigastric vessels. To enter this space, the plane between transversalis fascia and umbilico–vesical fascia needs to be divided. The easiest way to find the right plane during endoscopy is to gently brush the tissue away from the epigastric arcade, which serves as a landmark. The plane of motion of dissection is sagittal (the same direction as the fascia and the epigastric vessels). The BS is in direct continuity with the lumbar/iliac retroperitoneum.

The lumbar space for RES (see Figure 2)

The lumbar space lies in direct continuity with the iliac space and can normally be reached through a small incision in the muscle-free triangle between the external oblique and the latissimus dorsi muscles, to open the area between the lumbodorsal aponeurosis and Gerota's fascia [10,19]. The landmarks here are in the lower part: the psoas muscle and the kidney, with ureter and gonadal vessels, as well as the lateroconal (paraconal) fascia.The latter has to be opened to gain access to the upper (more medial) part with the aorta and vena cava, pancreas and duodenum on the right side, as well as the adrenal gland.

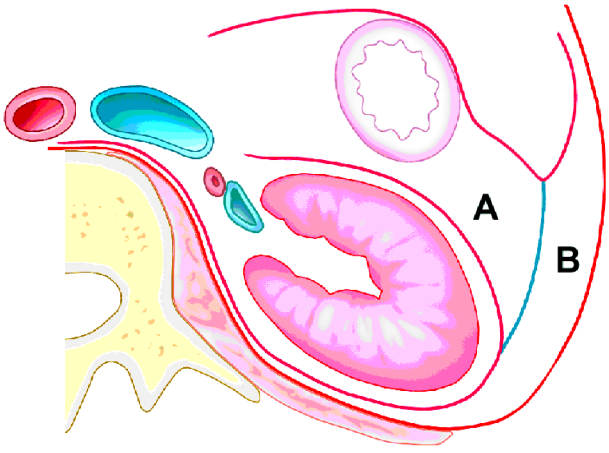

Figure 2. Transversal section of the lumbar retroperitoneal space with the kidney, ascending colon, vena cava and aorta as landmarks. The lateroconal (paraconal) fascia is indicated in blue (**A**: anterior pararenal space, **B**: posterior pararenal space). (Adapted from Ref. 20.)

Apart from the psoas muscle, the central structures of the lumbar retroperitoneal space are the kidney, with the perirenal fat, and the adrenal gland. All these structures are surrounded by the Gerota's fascia. Gerota's fascia expands laterally via the lateroconal fascia to the lateroposterior parietal peritoneum (see also Figure 2), dividing the pararenal space into an anterior and a posterior area. Distally, Gerota's fascia is open and ends abruptly. Therefore, a free connection between the anterior, posterior and the entire perirenal space, which is of major importance for RES, is always present.

Access ways to important anatomical structures in the lumbar space for RES

Accessing the iliac retroperitoneal space distal to the perirenal fascia allows direct entrance to either of the perirenal and/or pararenal space, without incising any fascial layers (see Figure 2). To enter the anterior pararenal space, the lateroconal (paraconal) fascia needs to be incised. Thus, on the right side, access to the descending part of the duodenum and the head of the pancreas is possible, whereas on the left side, the tail of the pancreas and the splenic vessels may be reached. Entering the perirenal space from the iliac retroperitoneum by the blunt introduction of a balloon trocar allows direct access to the kidney, the adrenal gland, the vena cava (on the right side) and the aorta (on the left side), without the need to incise the lateroconal (paraconal) fascia.

Cadaver studies performed by Capelouto *et al*. [21] demonstrate that the posterior axillary line is constantly located posterior to the lateral peritoneal reflection. Therefore, direct retroperitoneal access without penetrating the peritoneum can always be achieved if the first trocar is bluntly introduced behind this line (in the muscle-free triangle described above). In addition, working trocars should be placed under direct visual control to prevent injuries to the peritoneum, which needs to be gently pushed off the abdominal wall before insertion.

The authors prefer the technique described by Gaur *et al* [10]. This involves blunt introduction of a balloon device under visual control, to create a large working space in the upper or lower part of the lumbar retroperitoneum, for RES such as adrenal, pancreatic or spinal surgery, whereas for preperitoneal hernia repair (TEP), balloon dissection is usually not required. For such cases, the technique described by Begin or Dulucq [15,16] is used; a blunt trocar device is directly introduced into the preperitoneal space of Retzius to bluntly create a working access.

RES

Since 1992, due to an increasing number of performed procedures (learning curve) and development of commercial balloon devices, operative duration and conversion rates have been reduced, with all the advantages of the minimally-invasive approach. Indications for RES are summarised in Table 1, which shows that general, as well as urological and gynaecological procedures, may be performed [22–26].

General contraindications for RES include severe general and/or cardiopulmonary compromise (ASA score > IV) and manifest coagulopathy. Relative contraindications are retroperitoneal fibrosis, past history of surgery of the retroperitoneum and tumours > 7 cm in size for adrenal surgery [23], or with suspicion of malignancy due to the risk of implant metastasis[9,24].

To enter the retroperitoneal space, Gaur *et al*. [25] have proposed the blunt introduction of a balloon device under manual guidance at the level of the superior lumbar triangle without prior needle $C0_2$-insuflation. However, McDougall *et al*. [9] have suggested the lumbar triangle (Petit's triangle) as an anatomical landmark for retroperitoneoscopy to introduce a Veress needle directly into the retroperitoneal space under fluoroscopic guidance. But in obese patients identification of this triangle and the latter technique are demanding. Instead of a balloon device, a blunt trocar may be directly introduced through a small incision into the retroperitoneal space, which can then be further dissected under visual control by insufflating CO_2 (pneumodissection technique); this was described by Dulucq for PES [16] and several authors for RES [11,21,26]. The main advantage of the balloon dissection technique is direct access to create a large working space under visual control, which minimises the risk of injury or perforation of the peritoneum and other organs. As there is a risk of perforating the peritoneum, with a subsequent pneumoperitoneum leading to conversion to a transabdominal (laparoscopic) procedure, the blunt trocar technique should only be performed by experienced surgeons. Mini-incision techniques, mainly used by urologists to perform kidney biopsies and other urological procedures, have been well described [3–5], but will not be discussed in this review article, which deals with true endoscopic access techniques in general surgery.

Selected RES procedures in general surgery

Adrenalectomy

For several authors, the retroperitoneal approach to remove the adrenal glands on both sides is the method of first choice [24,27], others prefer the transabdominal approach for right-sided adrenal glands [24,28] because the vena cava and suprarenal vessels can immediately be identified. In our experience, the retroperitoneal approach is the procedure of first choice on the right side, while on the left side, the transabdominal approach, which is straightforward, is preferred because the tail of the pancreas is immediately identified and protected, and the splenic vessels are always visualised and dissected medially. Thus both the risk of injuring the tail of the pancreas and bleeding complications are minimised. For bilateral adrenalectomies the patient needs to be repositioned during RES (this is time-consuming), while this is not mandatory for the transabdominal approach.

Surgical technique

The procedure is performed under general anaesthesia. The patient is placed in the standard flank position, with the lesion side uppermost (Figure 3). The table is flexed and the kidney bridge is elevated to flatten out the lumbar region. The open technique described by Gaur *et al.* [25], which consists of inserting a balloon catheter into the retroperitoneal space under manual and visual control, is preferred to the closed technique described by Eden and McDougall [9,29].

A small 2 cm subcostal incision is created at the mid-axillary line, halfway between the costal margin and the anterior superior iliac spine. This incision is deepened through the subcutaneous fatty tissue and the three abdominal muscle layers are successively split, until the transversalis fascia can be identified. The latter is incised to enter the retroperitoneal cavity. Finger dissection of the retroperitoneum is performed in a cephalad direction. The balloon catheter is introduced (Figure 4) and distended under direct

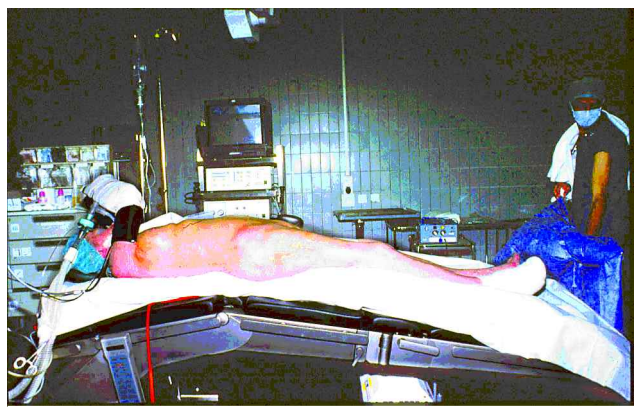

Figure 3. Position of the patient (lateral position) to perform adrenalectomy or urological procedures.

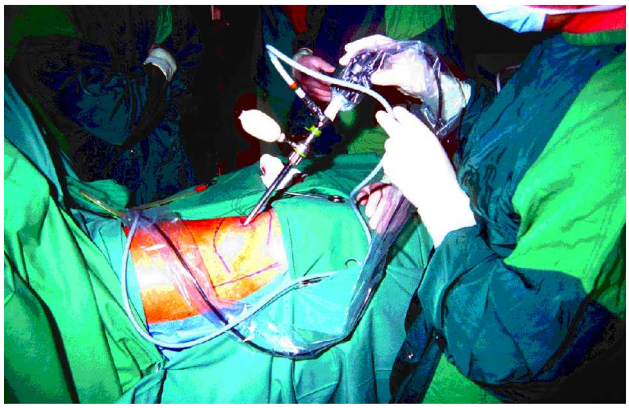

Figure 4. Insertion of a herloon balloon trocar (Aesculap, Tuttlingen, Germany) under visual control directly into the lumbar retroperitoneal space for right adrenalectomy.

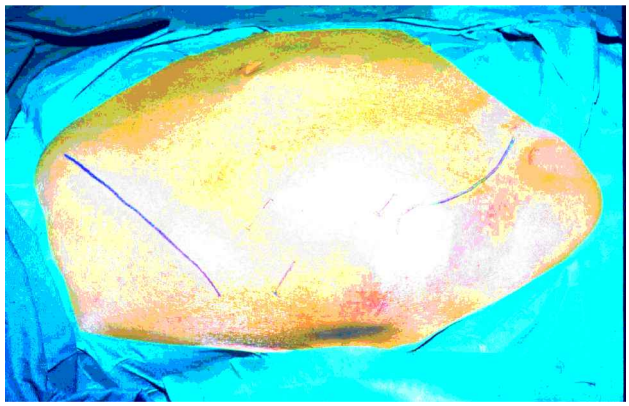

Figure 5. Lateral position with exact localisation for trocar insertion to perform neurectomy of the genitofemoral nerve or sympathectomy. The iliac crest, as well as the lower rib-margin, are marked.

endoscopic guidance (via the cannula) to see how the peritoneum is separated and the retroperitoneal space exposed. If landmarks such as psoas muscle or the kidney are visible, the surgeon can be sure of having separated the right space. The balloon dilator is then removed and a blunt 12 mm Hasson trocar is inserted as the primary port. CO_2 is insufflated with a pressure of 10–12 mmHg. A 25° endoscope is inserted and the retroperitoneal space can be visualised. Under direct vision, usually two to three secondary ports are introduced (as widely separate as possible). Blunt dissection is continued to enlarge the retroperitoneal space. The landmarks consist of the psoas muscle, paraconal fascia, peritoneal reflection, ureter and the gonadal vessels. The paraconal fascia is incised parallel and close to the psoas. The adrenal gland is found by dissecting the kidney toward the upper pole and medially across the vena cava (on the right side), or above the pancreatic tail and renal vein on the left side.

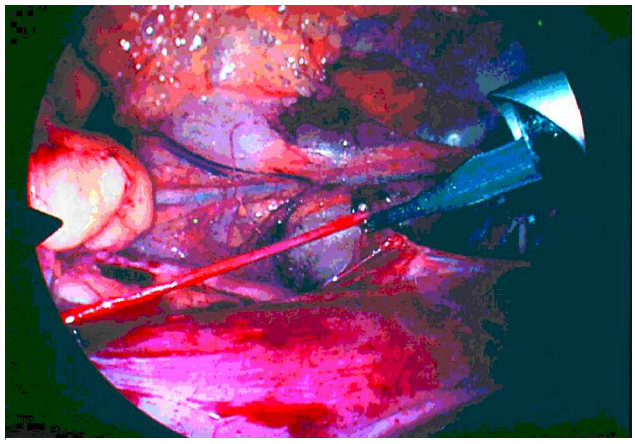

Figure 6. View into the lower lumbar retroperitoneal space with, in front, the psoas muscle and the genitofemoral nerve lifted-up with a hook device. In the back, the right ureter and the gonadal vessels are visible.

Endoscopic extraperitoneal lumbar sympathectomy/genitofemoral nerve neurectomy

This procedure is also performed under general anaesthesia. The patient is positioned in a 45° lateral position and the table broken at level L3. A small 1–2 cm incision is created and the access preformed as already described [1]. The second 10 mm port is inserted above the iliac crest. The trocar has to be inserted under visual control, to avoid perforating the peritoneum. Finally, the third 5 mm port is placed at level L3–L2 in the umbilical region (Figure 5). The genitofemoral nerve, with both branches, can then easily be found across the psoas muscle and excised (Figure 6). The sympathetic nerve, with its ganglion, has to be dissected along the vena cava on the right and the aorta on the left side, just below the medial border of the psoas muscle [30,31]. Excision is usually performed using clips and Ultracision.

PES

As for RES, preperitoneal endoscopic procedures have been popularised during the last decade as a result of the development of commercially-available balloon devices and of minimally-invasive surgery. The main indication for PES is hernia repair; it is used for bilateral and femoral hernias, as well as selected urological/gynaecological procedures, such as radical prostatectomy, pelvic lymph-node sampling and colposuspension, which will not be discussed further.

General contraindications for PES include the patient's risk factors and manifest coagulopathy or anticoagulation. Relative contraindications are previous lower abdominal surgery and large hernias.

Selected PES procedures in general surgery

Endoscopic total extraperitoneal hernia repair (TEP)

An overview of laparoscopic hernia surgery has been previously presented by our study group [14]. In brief, TEP hernias are repaired without entering the abdominal cavity. This procedure therefore prevents iatrogenic bowel injuries and postoperative adhesion formation. It was first described using a blunt dissection technique, by Begin or Dulucq [15,16] from France. In the USA, this procedure was introduced by McKernan [17] and Phillips *et al*. [18] using a balloon dissection technique.

Surgical technique

The procedure is performed under spinal or general anaesthesia. The patient is placed in a supine and Trendelenburg position of 20–30°, with both arms tucked next to the body. The surgeon stands on the opposite side from the hernia.

A 1–2 cm incision is made below the umbilicus and deepened through the subcutaneous fat layer. The anterior rectus fascia is prepared and incised. Under blunt dissection, a space behind the rectus muscle and the posterior fascia is created. A 10–12 mm blunt Hasson trocar is inserted into the preperitoneal space and CO_2 is insufflated to enlarge it under visual guidance. Then the blunt dissection of the space follows under the control of a 25–45° telescope in the direction of the space of Retzius, to expose the symphysis as the first landmark. The dissection is continued, to expose Cooper's ligament and the epigastric vessels. The next step is to enter Bogros' space, by gently brushing the tissue away from the epigastric arcade to enter the space between transversalis fascia and umbilico–vesical fascia. The plane of motion of the dissection is sagittal (the same direction as the fascia and the epigastrics). One to two further trocar sleeves (5 mm trocar in the midline above the symphysis and 10–12 mm trocar 3 cm above the anterior superior iliac spine) are inserted under direct vision, followed by the blunt reduction of the hernia sac and the insertion of a large non-absorbable mesh (Prolene; 15 x 12 cm), with all its edges cut off. The mesh is adapted to the posterior inguinal wall and has to cover the whole myopectineal orifice.

The balloon dissection technique described by McKernan *et al*. [17] and Phillips *et al*. [18] simplifies the procedure and significantly reduces operating time; however, due to increased direct costs, it is not our preferred approach. During the learning curve of this procedure this method may have a beneficial effect in reducing operating time and decreasing the incidence of perforations of the peritoneum, with subsequent conversion to a transabdominal approach [15,32].

Access devices for PES and RES

For PES and RES, the same equipment is needed as for routine laparoscopic surgery: a high resolution monitor, a rigid 25–45° endoscope with a Xenon light source, 5–12 mm trocar sleeves, a mechanical or electronic insufflator, a suction-irrigation pump, a bipolar/monopolar coagulator, surgical instruments and, in particular, a 10 mm balloon dissecting trocar. The need for an Ultracision device is not mandatory but simplifies the procedure, especially for removing the adrenal gland or the tail of the pancreas.

The authors prefer endoscopes with angles of 30° for routine RES, whereas for TEP hernia repair 45° endoscopes are preferred. Instruments are introduced through reusuable or disposable 5–12 mm trocars, the former being less cost-effective. The length of these trocars varies between 8.5 cm and 10.5 cm, depending on the body-mass index of the patient and the procedure.

To establish a preperitoneal working space during TEP, we insufflate preheated CO_2 using an electronic insufflator following blunt introduction of a 10 mm Hasson trocar directly into the preperitoneal cavity. Another possibility is the direct introduction of a Veress needle into this space, followed by blunt trocar insertion; this is not our preferred technique. A pressure in the preperitoneum of 10–12 mmHg has to be achieved and maintained; this will not influence micro- and macrocirculation and prevents hypercapnia. Then the preperitoneal structures can be dissected by blunt scope dissection, as described by Dulucq and others [15,16].

Balloon trocars offer another way of gaining access and maintaining a working space in the preperitoneum and retroperitoneum. These instruments consist of a hollow cannula with a coaxial dissection balloon at its end. The balloon has an inflation capacity of 500 to 1000 mL and can be insufflated with air or fluid. The hollow lumen allows the passage of a 10 mm endoscope. The inflated balloon remains in the cavity for dissection, which may permit visualisation of important landmarks during insufflation. The risk of this technique is that the peritoneum may be injured during balloon dissection; this complicates the further procedure (narrow working space). A large retraction device can be used to avoid this complication.

Two different commercial balloon systems are available, one from Aesculap, Tuttlingen, Germany, the

other from Tyco-Healthcare, Paris, France. The former system offers, with the herloon hernia balloon trocar, a complete system for extraperitoneal hernia repair, which may also be used for routine RES (Figure 7). An assembly principle of the balloon trocar, snapping a balloon shaft into the trocar body, demonstrates the cost-efficiency of the combination product. The transparency of the balloon in the dilated state and the dilatation properties of the highly elastic latex-free material affords an excellent view of the body structures.

The second system is the Extra View Balloon (Figure 8), a comparable but fully disposable system. Here, the balloon may also be insufflated with 500 to 1000 mL air to dilate the preperitoneal or retroperitoneal space directly under endoscopic guidance. For TEP hernia, the same company offers a bilateral balloon device, which creates a large bilateral working space. This device should not be used for routine RES. The same company offers another balloon-tipped trocar device to maintain a proper working space, this allows further surgery with a very low CO_2 pressure (< 8 mmHg) or even under completely gasless conditions. For prolonged procedures (bilateral hernias, difficult recurrent hernias, nephrectomy) this may prevent severe hypercapnia, or even allow hernia surgery under spinal anaesthesia.

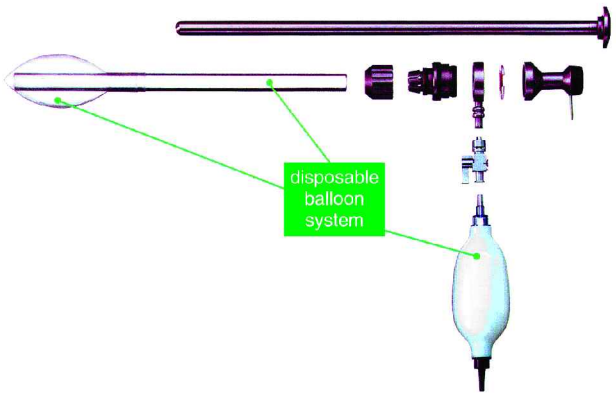

Figure 7. Complete system of the herloon hernia balloon trocar by Aesculap, Tuttlingen, Germany which is a combination product of a reusable trocar with a disposable balloon system.

Figure 8. Extra View Balloon devices by Tyco-Healthcare, Paris, France for unilateral and bilateral hernia repair as well as for RES.

Conclusion

Precise knowledge of anatomy that is relatively consistent and offers reliable landmarks, is mandatory for successful PES and RES, as in any surgical procedure. Correct positioning of the patient, as well as blunt introduction of the first blunt trocar for PES or balloon trocar for RES under endoscopic guidance and manual control, are further important steps. If the corresponding cavity is reached and insufflated, perforation of the peritoneum has to be prevented. If perforation occurs, the peritoneum has to be closed with a running suture and a Veress needle needs to be introduced into the abdominal cavity to decompress the CO_2. Incising the lateroconal fascia allows complete dissection of RES and the performance of any procedure needed.

Using Ultracision instead of a monopolar/bipolar current during dissection simplifies the procedure and prevents iatrogenic injuries to important structures (aorta, cava, pancreas). In obese patients, finding the right place and landmarks can be very difficult, which means that, especially during the learning phase of the procedure, thin patients with a BMI < 25 are preferable to prevent frustrating conversion for the surgeon.

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