Selected Applications of Balloon Dissection

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Historically, balloons have been used in surgery for a variety of applications. Over the past decades, balloons have been used by surgeons for retaining means (Foley catheter), extraction and occlusion (Fogarty catheter), tamponade (Sengstaken-Blakemore tube) as well as other uses such as dilation and calibration.[1] The pioneering efforts of Gauer[2] and Kieturakis[3] have broadened the use of balloons for a new surgical application — dissection. An important feature of balloon dissection is that it allows the surgeon to create a new operative working space in which a surgical procedure can be performed. Currently, a particularly useful working space is the region immediately outside the peritoneum, frequently termed the extraperitoneal space. A variety of procedures can be performed laparoscopically in the extraperitoneal space such as herniorrhaphy, bladder neck suspension, lymph node dissection, and varicocelectomy.

The use of balloons for dissection is still in its infancy, but is growing rapidly, particularly in the field of laparoscopy. The following is a presentation of the techniques of some of the emerging applications for balloon dissection in the field of less-invasive surgery, including general surgery, urology, and vascular surgery.

EXTRAPERITONEAL LAPAROSCOPIC HERNIA REPAIR

An extraperitoneal approach to inguinal hernia repair using prosthetic mesh is a proven technique first popularized by Stoppa and colleagues.[4] The extraperitoneal space created by the balloon dissector (Figure 1) enables the surgeon to perform this repair laparoscopically, thereby avoiding large incisions, decreasing post operative discomfort, and allowing for early return to normal activity.

Anesthesia

Because the balloon dissector creates a working space outside the peritoneal cavity, the procedure can be performed with general anesthesia, regional anesthesia, and even local anesthesia with intravenous sedation. When performing laparoscopic repair under less than general anesthesia, the introduction and insufflation of the balloon require the greatest amount of sedation. A tear in the peritoneum causes an incidental pneumoperitoneum, resulting in patient discomfort. However, such a tear is less likely as the surgeon becomes more experienced and proficient with the balloon and the procedure.

Technique

Insertion

A 1cm incision is made below the umbilicus and blunt dissection is carried out to the anterior sheath of the rectus abdominus muscle. The anterior sheath is incised longitudinally, approximately 5 mm lateral to the midline on the ipsilateral side of the hernia, so that the muscle fibers are readily visualized. These fibers are then retracted laterally in order to expose the underlying posterior sheath. When this procedure is accomplished, the balloon dissector is advanced toward the pubis such that it slides off the arcuate line, onto the peritoneum. The balloon is then inflated with 700-900 ml. of saline, depending on patient size and unilateral versus bilateral repair. Larger patients and bilateral repairs require the higher balloon fill volumes.

Operative Technique

When the balloon dissector has created the working space and the insuf-

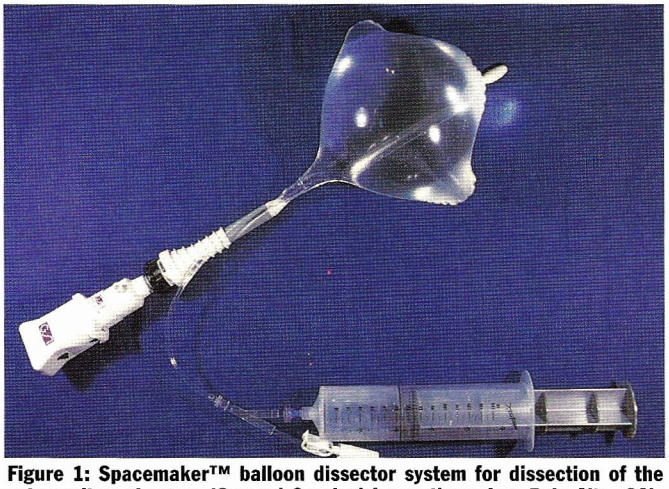


Figure 1: Spacemaker™ balloon dissector system for dissection of the extraperitoneal space (General Surgical Innovations, Inc, Palo Alto, CA). System includes dissection balloon (shown inflated with 750 ml. of saline), removable guide rod / obturator and integral trocar.

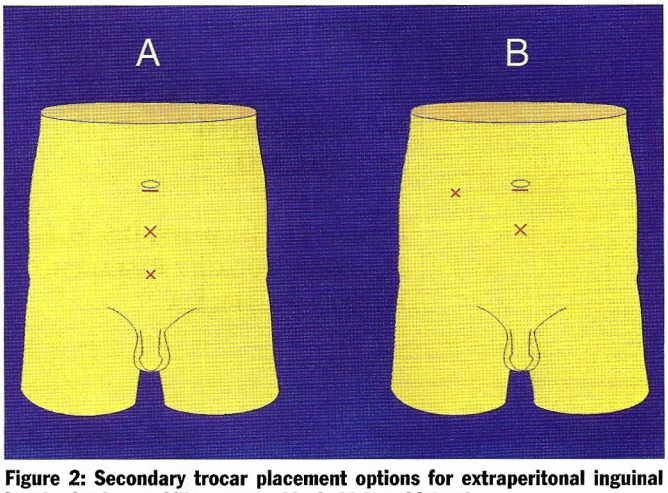


Figure 2: Secondary trocar placement options for extraperitonal inguinal herniorrhaphy a, midline suprapubic, b, high and lateral.

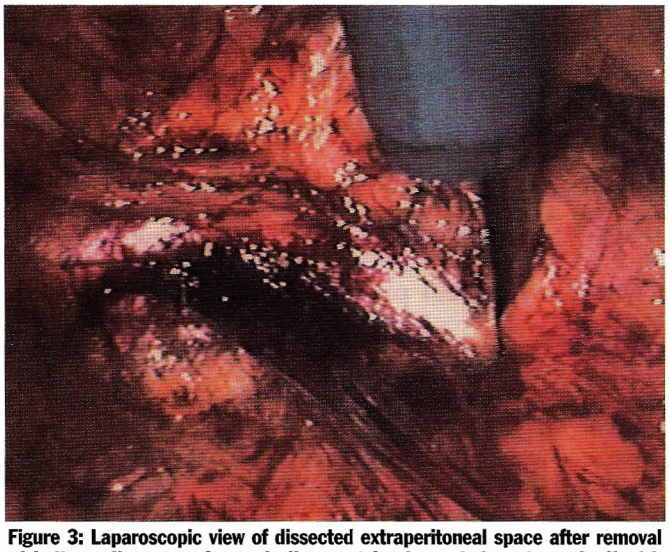


Figure 3: Laparoscopic view of dissected extraperitoneal space after removal of balloon dissector. Cooper's ligament is shown being cleaned off with grasper by way of the suprapubic port.

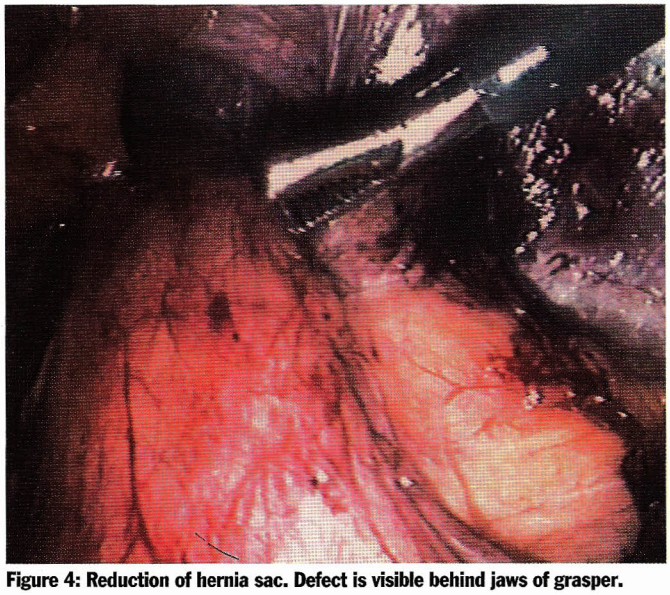


Figure 4: Reduction of hernia sac. Defect is visible behind jaws of grasper.

flating trocar is in position, low pressure insufflation with $C0_2$ gas at 8 to 10 mm Hg is used. An angled (30° to 45° degree) laparoscope is helpful in visualizing the space. Additional trocars are inserted under direct vision, starting with a 10 to 12 mm trocar placed in the midline at the level of the anterior superior iliac spine (ASIS). A second, smaller (5 mm) trocar is then placed either in the midline suprapubic area (Figure 2a) or lateral to the rectus muscle on the side of the hernia at the same level as the larger trocar (Figure 2b).

The symphysis pubis is easily identified at the midline and from this, Cooper's ligament is readily dissected (Figure 3). Laterally, along the anterior abdominal wall, the transversalis fascia is cleaned with blunt dissection. When a direct hernia is present, the sac often will be pulled away from the defect by the balloon. Any associated properitoneal fat can easily be removed from the defect as well.

At the internal ring, the hernia sac of an indirect hernia (Figure 4) is located and grasped along its lateral edge. The sac is elevated toward the anterior abdominal wall and dissected free from the canal and spermatic cord with blunt dissection, much as is done in an open repair. The overlying sac must be completely removed from the spermatic cord to posteriorize the cord structures in preparation for mesh placement. Any lipoma or properitoneal fat should also be removed from the underlying cord structures. This maneuver allows the mesh to lie directly over the posteriorized cord. The sheet of mesh (Bard Vascular, Billerica, MA) is then placed so as to cover the area from Cooper's ligament, medially, to the ASIS, laterally. The mesh will overlie the cord and extend up to the anterior abdominal wall. It is secured in place with hernia staples at Cooper's ligament (Figure 5), the rectus muscle and the transversalis fascia. Care should be taken to avoid staples in the lateral lower quandrant over the psoas muscle to prevent peripheral nerve injury. $C0_2$ gas is allowed to escape and the peritoneum, with its contents, is allowed to roll within the concavity of the mesh as the working space is deflated.

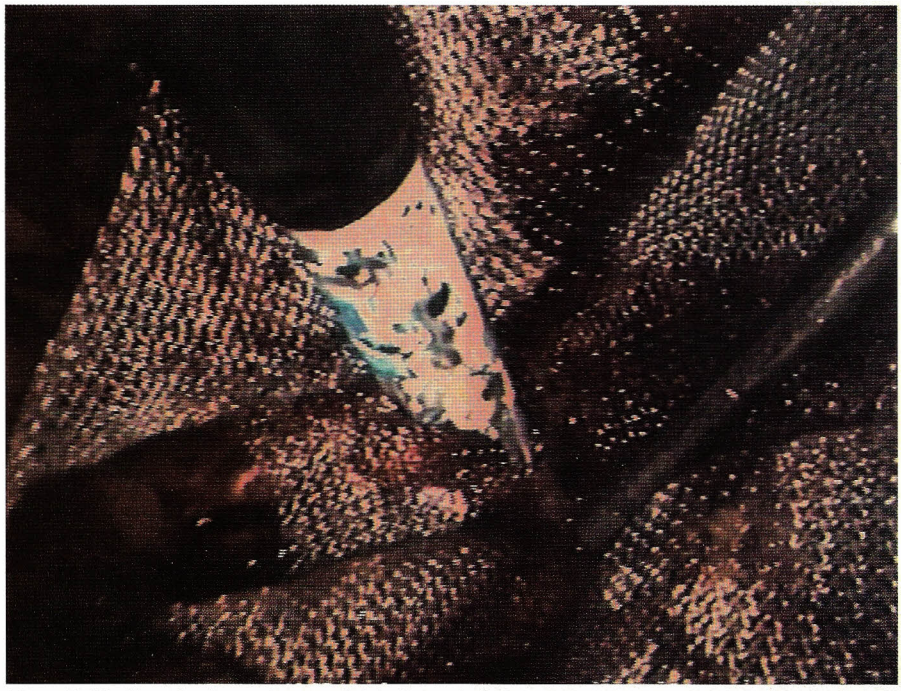


Figure 5: Stapling of polypropylene mesh into Cooper's ligament prevents postoperative migration before fibrous ingrowth.

Results

The authors have performed 60 extraperitoneal herniorrhaphies using a balloon dissector. Only one of these cases required conversion to an open repair, due to an inability to reduce the hernia contents. Eleven of these cases were performed for recurrent hernias, and nine patients had had previous abdominal surgery. In this series, there has been no early recurrence. The average time to return to full activity was 3.2 days and the average time away from work was 5.3 days.

Ventral Hernia

A defect in the abdominal wall other than at the inguinal canal can also be approached from the extraperitoneal space. This approach avoids a large incision often necessary with traditional

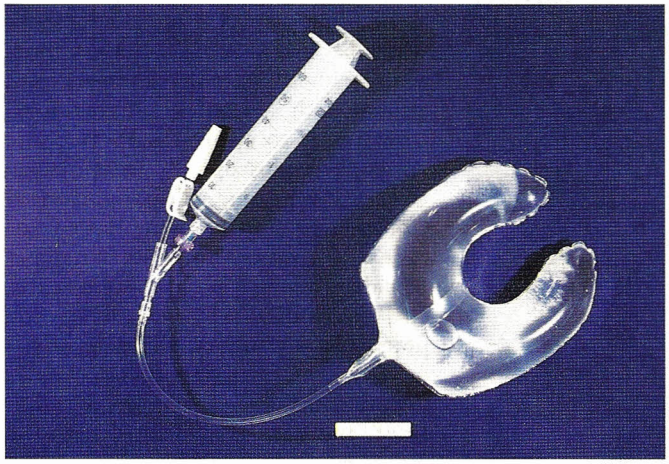


Figure 6: "U" shaped balloon dissector. The separate arms of the balloon are useful for dissecting the extraperitoneal space around either side of a ventral hernia sac.

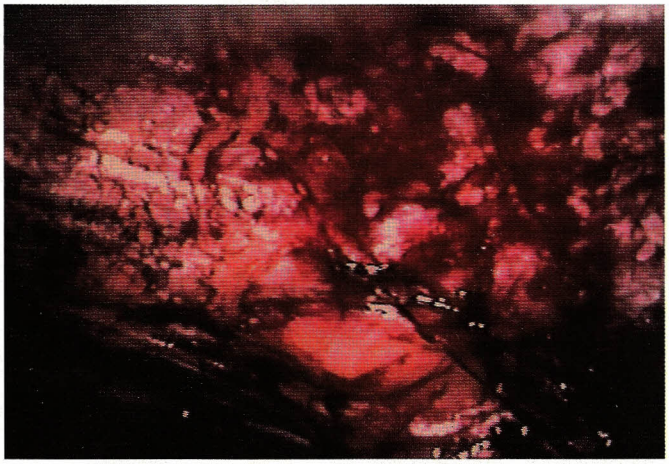


Figure 7: View of extraperitonal space dissected with a U-shaped balloon. The abdominal wall is seen above. The peritoneum is seen on the lower left and lower right. The hernia sac is seen at the lower center.

external techniques. By not entering the peritoneal cavity, any mesh placed in this space will not be exposed to intra-abdominal contents, thereby reducing the risk of adhesions.

A balloon dissector with a "U shape" configuration (Figure 6) thereby creates the working space up and around the ventral henia sac (Figure 7). Blunt dissection is then used to increase the dimensions of the space. When the sac has been isolated, it can be dissected free from the defect in the fascia (Figure 8). This is accomplished by pulling down on the sac from within, while externally lifting the abdominal wall to provide counter traction. When the sac is freed from the fascial defect, a sheet of mesh is inserted in the working space to patch the defect. The mesh is secured in position, first, with hernia staples (Figure 9) and then by bringing out pre-placed sutures from the mesh corners through small corresponding stab wounds in the skin. The sutures go through and through the layers of the abdominal wall up to the subcutaneous tissues.

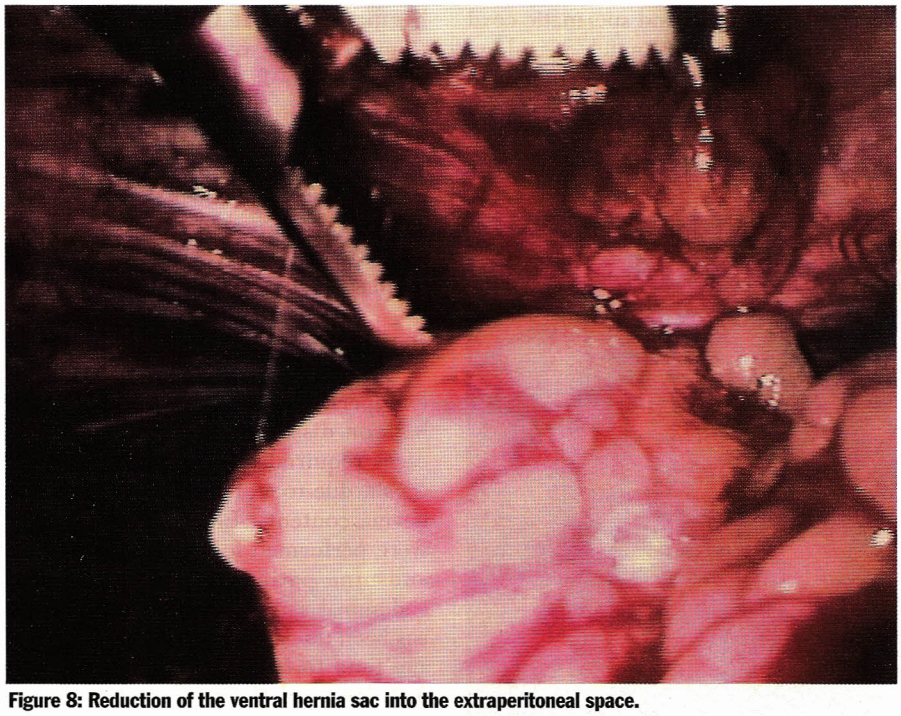


Figure 8: Reduction of the ventral hernia sac into the extraperitoneal space.

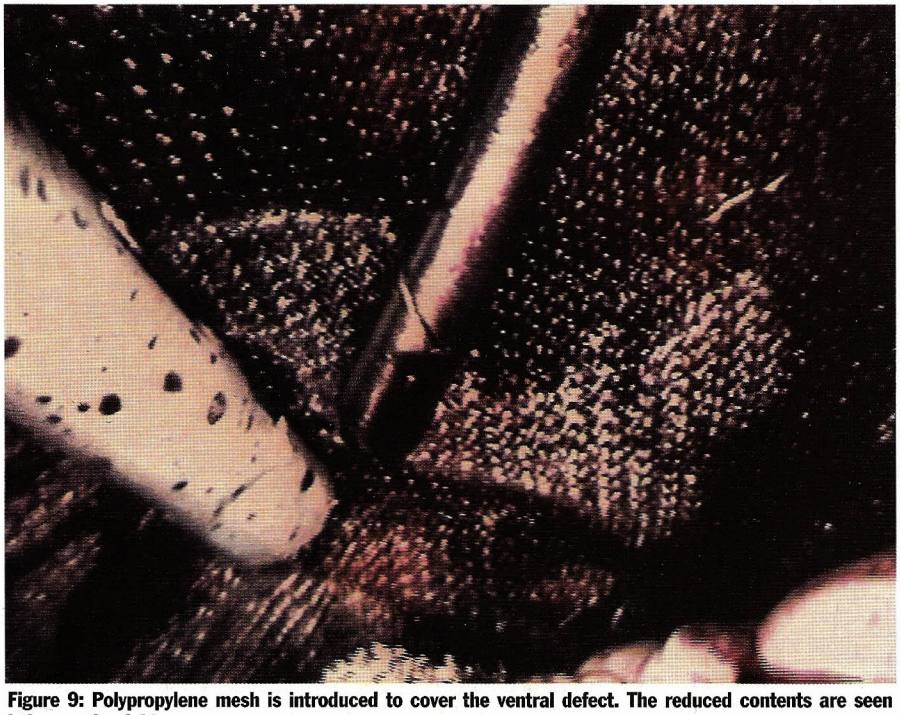


Figure 9: Polypropylene mesh is introduced to cover the ventral defect. The reduced contents are seen below on the right.

This technique has been used on patients with primary ventral hernias in the epigastric and supraumbilical area. All patients were treated on an outpatient basis, reducing the need for hospitalization when compared to open repairs. There has been no early recurrence and postoperative pain with this technique has been minimal.

Comments

We believe these initial results indicate that laparoscopic extraperitoneal hernia repair with a balloon dissector is an acceptable approach that will prove comparable to open Stoppa repair and has a place among the array of herniorrhaphy procedures.

EXTRAPERITONEAL LAPAROSCOPY IN UROLOGIC SURGERY

For years, laparoscopy has been used by gynecologists for the diagnosis and treatment of female pelvic disease. More recently, general surgeons have expanded the field of laparoscopy to include cholecystectomy, appendectomy, herniorrhaphy, and the treatment of other gastrointestinal disorders. This revolution is also expanding in urology. Although still in its infancy, a variety of urologic procedures including pelvic lymph node dissection for both prostate as well as bladder cancer, varicocelectomy, bladder neck suspension, and vasectomy have been described, all transperitoneally. Conventional open urologic surgery, however, has been performed through an extraperitoneal approach, which has the advantage of direct organ access without disturbing intraperitoneal structures. It seems logical, therefore, to attempt to approach these same structures endoscopically from outside the peritoneum. Extraperitoneal laparoscopy (EPL) retains the advantages of conventional laparoscopy including minimal pain, convalescence, and morbidity while avoiding the potentially serious complications of viscus and vessel injury, hypercarbia, hypothermia, ileus, peritonitis, adhesions, and hernias associated with the intraperitoneal approach.

First described by Danish surgeons, Hald and Rasmussen, over a decade ago,[5]

the technique of extraperitoneal laparoscopy or pelviscopy was relatively unnoticed until Gauer in 1992 published his experience with the use of a dissecting balloon to create a workable space for extraperitoneal laparoscopy.[2] Initially fashioned from either sterile surgical gloves or other latex products, the early balloons demonstrated the relative ease of retroperitoneal balloon dissection, but were limited by the deformability of these balloons. Now the Spacemaker™ balloon dissector (General Surgical Innovations, Palo Alto, CA) duplicates the ease of insufflation and dissection of the early balloons, but by maintaining its unique "manta ray" configuration provides predictable dissection without distortion. The wings of the balloon expand out laterally toward the pelvic sidewalls for the access needed for pelvic urologic surgery.

Pelvic Lymph Node Dissection

The balloon dissector is inserted through an infraumbilical, 10mm incision and is insufflated with saline to 900 - 1000 ml manually with largebore syringes. The dissection is maintained for several minutes, the balloon is then evacuated, removed, and a 10 mm blunt trocar is introduced. Under direct vision, a 10 mm suprapubic port is introduced 1cm above the pubic symphysis and the two lateral 5 mm working ports are placed. The extraperitoneum is then distended with CO_2 and insufflation is maintained at 8 to 10 mm Hg and the node dissection is commenced (Figure 10). The pubic symphysis, Cooper's ligament, epigastric vessels, and iliac vessels are readily identified. The limits of dissection are similar to that of the conventional intraperitoneal dissection, with meticulous control of small vessels and lymphatics using electrocautery. When the dissection is complete and the specimens have been removed (Figures 11 and 12), the pelvis is irrigated with antibiotic solution. Dilute Marcaine solution is instilled and the ports are closed with staples.

All these procedures have been performed in an outpatient setting and other than superficial skin bruising and ecchymosis, no significant complications have occurred. Full preoperative activity has been resumed in 48 hours.

Modified Burch Urethropexy

The patient, under either general or spinal anesthetic, is positioned in a modified lithotomy position using the Allyn stirrups. The vagina as well as the abdomen and perineum are thoroughly prepped with Betadine. The bladder is initially drained with a urethral catheter, after which a Foley balloon is inflated to 30 ml whereupon 30 to 40 ml of dilute Methylene Blue solution is retained in the bladder as the catheter is then clamped. The balloon dissector is inserted through the infraumbilical incision and the balloon is expanded with

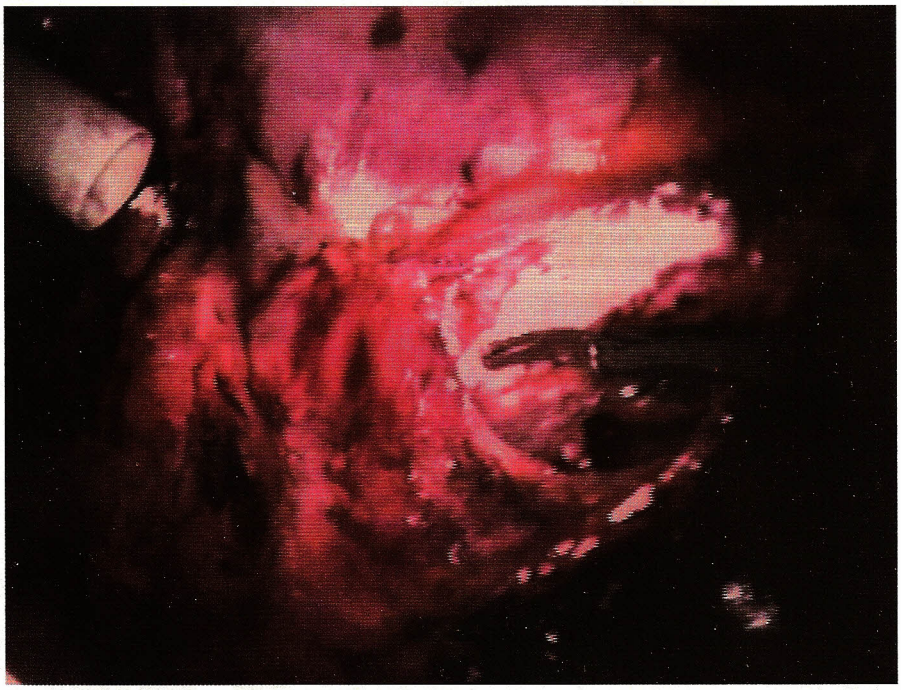


Figure 10: Laparoscopic view of balloon-dissected extraperitoneal space. Cooper's ligament is seen being cleared by the graspers. The region below and to the left will be dissected manually to expose and remove the lymph node chain along the left iliac vein.

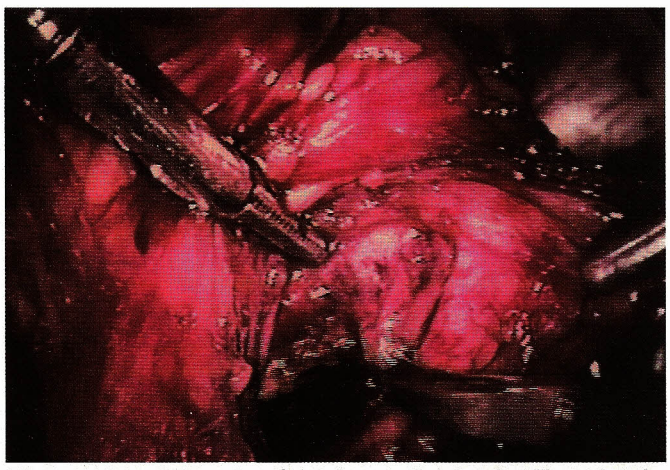
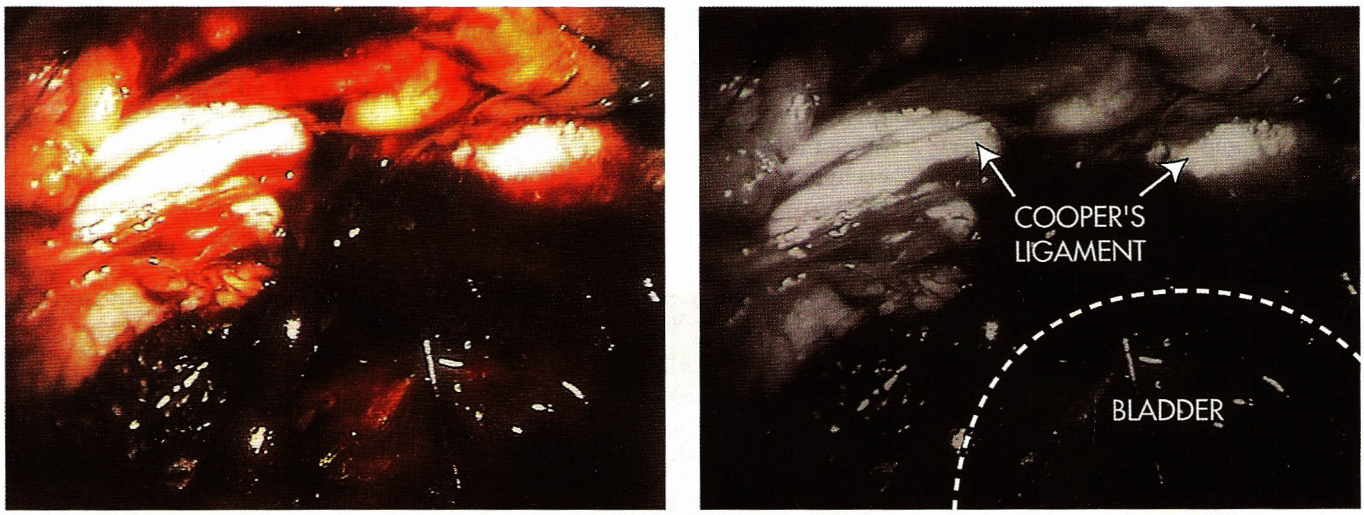


Figure 11: Manual dissection of the obturator lymph nodes. The tool at the left is retracting the left iliac vein laterally. The right grasper is applying traction on the lymph node capsule as the scissors (foreground) separate connective tissue.

Figure 12: The lymph node is about to be grasped for removal.

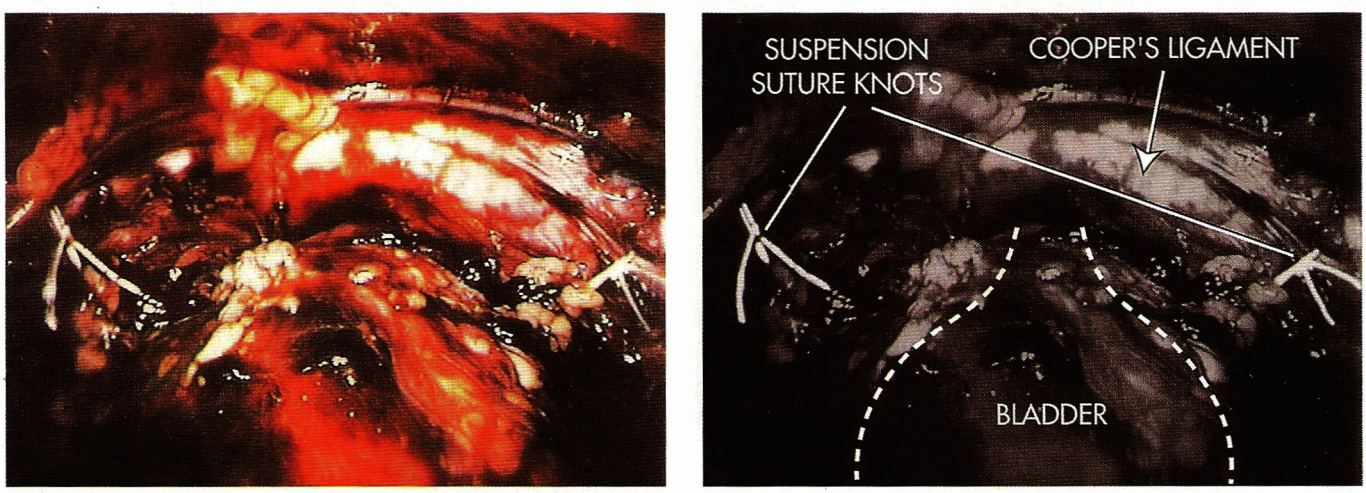
saline. It is important to position the distal tip of the balloon dissector below the superior ramus of the pubic symphysis. The balloon is then evacuated, removed and the laparoscope is introduced (Figures 13a,b). A 5mm suprapubic and two lateral 10 mm ports are introduced.

The surgeon's left hand is introduced vaginally and with mild countertraction on the Foley catheter, the periurethral tissues are dissected, exposing the periurethral fascia at the level of the bladder neck. A figure-eight 2-0 Gore-Tex® suture (W.L. Gore Corporation, Flagstaff, AZ) is passed through the full thickness of the periurethral fascia and the needle is then placed through the



Figures 13a,b: Laparoscopic view of balloon-dissected space of Retzius. Bladder with indwelling Foley lies below (dark) with Cooper's ligament (white) seen above [courtesy: General Surgical Innovations].

Figures 14a,b: Right knot of Gore-tex® suture is tightened after passage through Cooper's ligament and perivaginal tissue. Knot-tying device is seen on left, grasper on right. [courtesy: General Surgical Innovations].



Figures 15a,b: Elevation of the bladder neck toward Cooper's ligament by way of the two Gore-tex® sutures signifies the suspension is complete [courtesy: General Surgical Inovations].

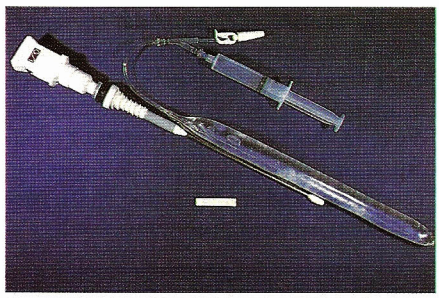


Figure 16: Tunneling balloon for extraluminal dissection along the greater saphenous vein. Balloon is shown completely everted and filled with saline (with 20ml. syringe).

medial aspect of Cooper's ligament (Figures 14a,b). A similar stitch is then placed at the contralateral bladder neck (Figures 15a,b). The sutures are tied either intra- or extra-corporeally. The pelvis is extensively irrigated; Methylene Blue extravasation is indicative of bladder laceration or perforation. Indigo Carmine is given intravenously and the integrity of the ureters is checked cystoscopically before closure. The Foley catheter is replaced.

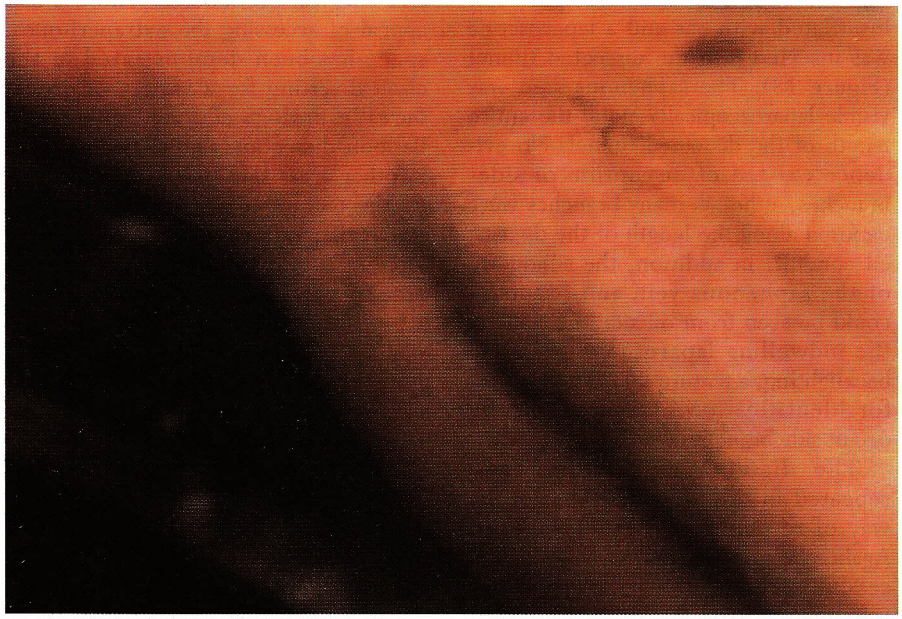


Figure 17: External view of dissecting balloon propagating subcutaneously along the greater saphenous vein.

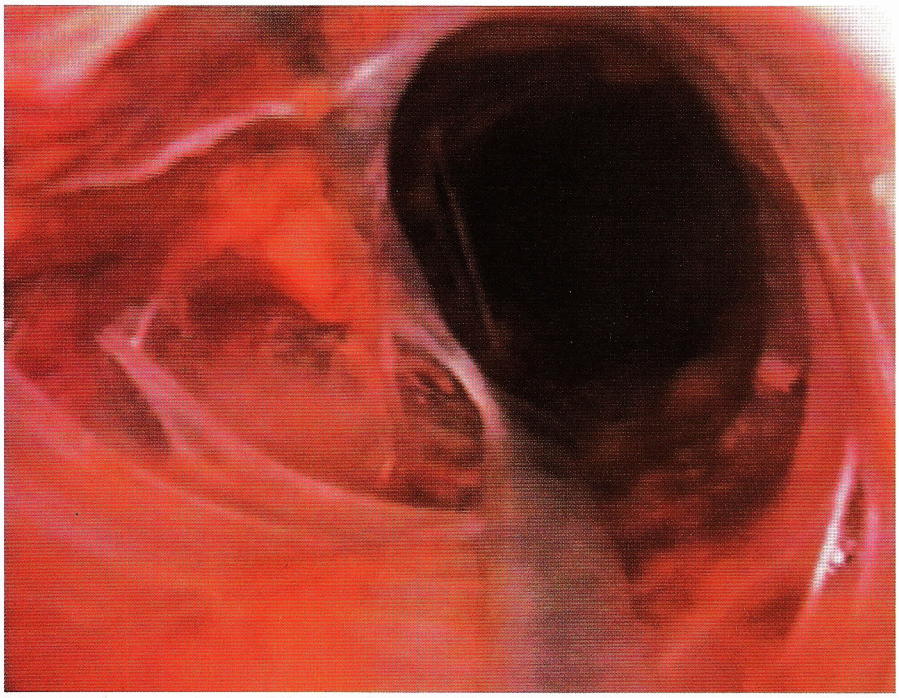


Figure 18: Laparoscopic view of the dissected space. The saphenous vein can be seen coursing along the wall of the balloon-dissected tunnel at approximately the 6 o'clock position.

Varicocoele Repair

The surgical approach to the varicocoele is similar to that for pelvic lymph node dissection or hernia repair. In patients with bilateral varices, trocar placement is identical. In patients with unilateral varicocoele, one of the lateral 5mm ports can be avoided. It is important to free up the peritoneal reflection laterally out to the pelvic sidewall. The internal ring is identified lateral to the epigastric vessels just anterior to the iliac vessels. The vas deferens is identified and retracted medially and the spermatic vessels are then mobilized and secured with a vessel loop. At this level, in most patients, the spermatic vein has two major trunks; about 15% of the patients will have a third major branch. We make every effort to identify and preserve the spermatic artery. The pulsation of the artery is apparent as the vessels are skeletonized. When the artery has been identified and isolated, the venous trunks are ligated using titanium clips. Bovie cauterization is avoided in the area for fear of thermal injury to the artery. Lateral dissection is limited to prevent injury to the genitofemoral nerve. The pelvis is inspected, irrigated, and when satisfied that the field is dry, the trocars are removed and closed in the usual fashion.

Comments

Our early experience with the extraperitoneal approach to pelvic laparoscopy has been encouraging. The technique is easy to adopt for laparoendoscopic surgeons with basic skills and does not require additional training or instrumentation. The availability of a large dissecting balloon allows for rapid, hemostatic dissection of the space of Retzius, creating a large space and easy access for most urologic procedures. The major complications associated with laparoscopy are avoided as the peritoneal cavity and its contents are avoided. We feel that for patients requiring pelvic laparoscopy for urologic problems, the extraperitoneal approach is the procedure of choice and we encourage our colleagues to consider this surgical option.

OTHER APPLICATIONS

Retroperitoneal

Urologic and vascular procedures such as nephrectomy, adrenalectomy, and lumbar sympathectomy have also been performed with the aid of balloon

dissection. For these procedures, instead of placing the balloon anterior to the peritoneum, the balloon is placed more laterally and upon inflation, the balloon dissects the retroperitoneal space.

Extraluminal Vascular

In addition to the extraperitoneal space, perhaps the most promising vascular application for balloon dissection is extraluminal dissection. We define extraluminal dissection as the process of tracking a dissection balloon along an existing anatomic conduit such as a vein or artery. This dissection technique holds promise for dissection along an artery for graft placement and also dissection along a vein such as the greater saphenous for side branch ligation or vein harvesting. The minimally invasive nature of balloon dissection may enable less-invasive techniques for peripheral vascular reconstruction (eg, femoropopliteal bypass) and saphenous vein harvesting (eg, for coronary artery bypass grafting).

Materials and Methods

To examine the feasibility of extraluminal dissection for these applications, a specially designed balloon dissector (Figure 16) was used in a cadaver model. The greater saphenous vein was identified by direct observation through the skin at the mid-thigh level. An incision was made over the vein approximately 10cm above the knee. The vein was isolated and a finger was passed posteriorly to the vein and directed along the vein in a superior direction to dissect a small region along the posterior portion of the vein. The balloon dissector was inserted into this small dissected space and advanced along the vein superiorly. When in position, the balloon cover was removed and the balloon was inflated. Upon inflation, the balloon filled out and unrolled along the vein, propagating the initial finger-dissected region. The advancing balloon is visible through the skin (Figure 17) and can be directed with manual palpation to keep the balloon on course. After complete inflation, the balloon was deflated and removed out of the incision and a trocar was advanced into the dissected space through the initial skin incision. The dissected space was insufflated with gas and a laparoscope was inserted into the dissected tunnel (Figure 18). The saphenous vein was visible laparoscopically along the entire length of the dissected tunnel. No evidence existed of disruption of side-branches, although many branches were exposed along the length of the dissected conduit. In addition, the silhouette of the saphenous vein and branches could be seen from outside the skin, as the indwelling laparoscope provided backlighting, a feature that can be useful for identification of endoscopically occult side branches.

The dissection procedure was repeated in the inferior direction by way of the same mid-thigh incision. Again, the entire length of balloon successfully tracked along the saphenous vein as it crossed the knee and terminated above the ankle.

Comment

The simplicity of the balloon dissection procedure, combined with the ability of the balloon to successfully expose the vein and side branches with no evidence of disruption, makes this a promising technique that could enable a totally endoscopic approach to saphenous vein harvesting or other procedures where venous side branch ligation is necessary (eg, Linton procedure, *in-situ* bypass). Early clinical application of balloon dissection in accessing, visualizing, and manipulating the saphenous vein has been promising as well.

CLOSING COMMENTS

Balloon dissection techniques hold promise for a variety of minimally invasive surgical procedures. The use and appeal of accessing the extraperitoneal space has been demonstrated in the clinical setting for a variety of procedures in urology and general surgery. Balloon dissection also shows promise in other areas such as vascular surgery. As the technique and instrumentation are further refined, it is likely that balloon dissection will have use in an even broader range of procedures and surgical specialties. **STI**

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