J Gastrointest Surg (2010) 14:175–185
DOI 10.1007/s11605-009-0981-9

HOW I DO IT

Repair of Abdominal Wall Hernias with Restoration of Abdominal Wall Function

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Received: 25 June 2009 / Accepted: 21 July 2009 / Published online: 5 August 2009

Keywords Incisional hernia · Ventral hernia · Prosthetic material · Herniorrhaphy · Laparoscopic herniorrhaphy · Rives-Stoppa herniorrhaphy

Our operative approach to the repair of abdominal wall hernias has changed tremendously over the last two decades based on our ongoing insight into the etiopathogenesis of their development. For instance, 20 years ago, use of alloplastic prosthetic material in the repair of direct inguinal hernias was rare, but currently, the accepted standard of care involves routine use of prosthetic material to "repair" the defective inguinal floor.

Repair of incisional hernias of the anterior abdominal wall is undergoing a similar transition with our appreciation of recurrence rates of >50% in long-term follow-up studies of autogenous tissue repairs.[1–4] Moreover, research into the inherent metabolic abnormalities in wound healing in the majority of patients developing incisional hernias in the absence of technical errors or tissue loss had led to evidence-based support for the use of prosthetic material in the repair of incisional hernias.[5–6] Indeed, most herniologists today believe that prosthetic material to repair or reinforce the repair of incisional hernias is imperative in these patients to assure the best results. In addition, interest in the biomechanics of the abdominal wall and its musculature has altered the operative approaches as well. For instance, the technique of components separation offers restoration of medialization of the rectus muscles, *but* this repair is an autologous repair despite the concept of it being a "tension-free" repair.

With these considerations in mind, this technique-based manuscript will describe the open and laparoscopic techniques we utilize for repair of incisional hernia. While we have our own parochial beliefs, we believe strongly that the literature supports the concepts of (1) a sublay repair (versus an onlay or inlay repair), (2) wide lateral overlap of prosthesis to maximize surface ingrowth and/or sublay support, and (3) restoration of reapproximation of the rectus musculature whenever possible. With these approaches and employing the above concepts, recurrence rates should be about 5%.[7]

Preoperative Evaluation

Determination of the width and rostral/caudal extent of the hernia defect is important as well as determining other associated defects (Swiss cheese defects) or lateral defects where, for instance, a stoma had been located. Abdominal computed tomography, although not imperative, may help in recognizing associated defects and in delineating the status of the remnant abdominal wall musculature.

Two other concerns require discussion. First, can/should the operation be performed laparoscopically or via an open approach? Factors supporting a laparoscopic approach include smaller defects, lack of severe adhesions, a history of previous prosthetic infection, and lack of need for restoration of muscular reapproximation (e.g., the elderly patient). Factors supporting an open approach include known severe adhesions, defects extending up to the bony

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confines of the abdomen (pubis, costal margin), and the need for complete restoration of muscular reapproximation because of the occupation of the patient (e.g., younger patients and laborers). Second is the presence of obesity. With a BMI>35 kg/m^2 (or even >30), the primary discussion with the patient should not be directed at the hernia but rather at their obesity; strong consideration should be given to obligating substantive weight loss or an initial bariatric operation *before* any definitive operative repair of the abdominal wall hernia.

Open Ventral Hernia Repair

Concepts of Repair

Our approach involves a modification of the original, prosthetic-based, Rives-Stoppa repair. The guiding principles involve a repair that is (a) largely extraperitoneal, (b) a sublay with wide 5- to 10-cm overlap of the prosthesis laterally, and, whenever possible, with intramural placement of the prosthetic material posterior to the rectus muscles and anterior to the posterior rectus fascia, (c) use of a meshed, alloplastic prosthetic to allow tissue transgrowth as the form of permanent fixation, (d) coverage of the anterior surface of the prosthetic material with autogenous, musculofascial tissues which restores muscular reapproximation, and (e) fixation transabdominally to a solid anterior fascia rather than limited fixation using a short tacker.

Creation of Retrorectus Plane

An incision is made directly over the defect usually excising the previous incision (Fig. 1a, b). Skin and subcutaneous scar should be excised back to healthy tissue

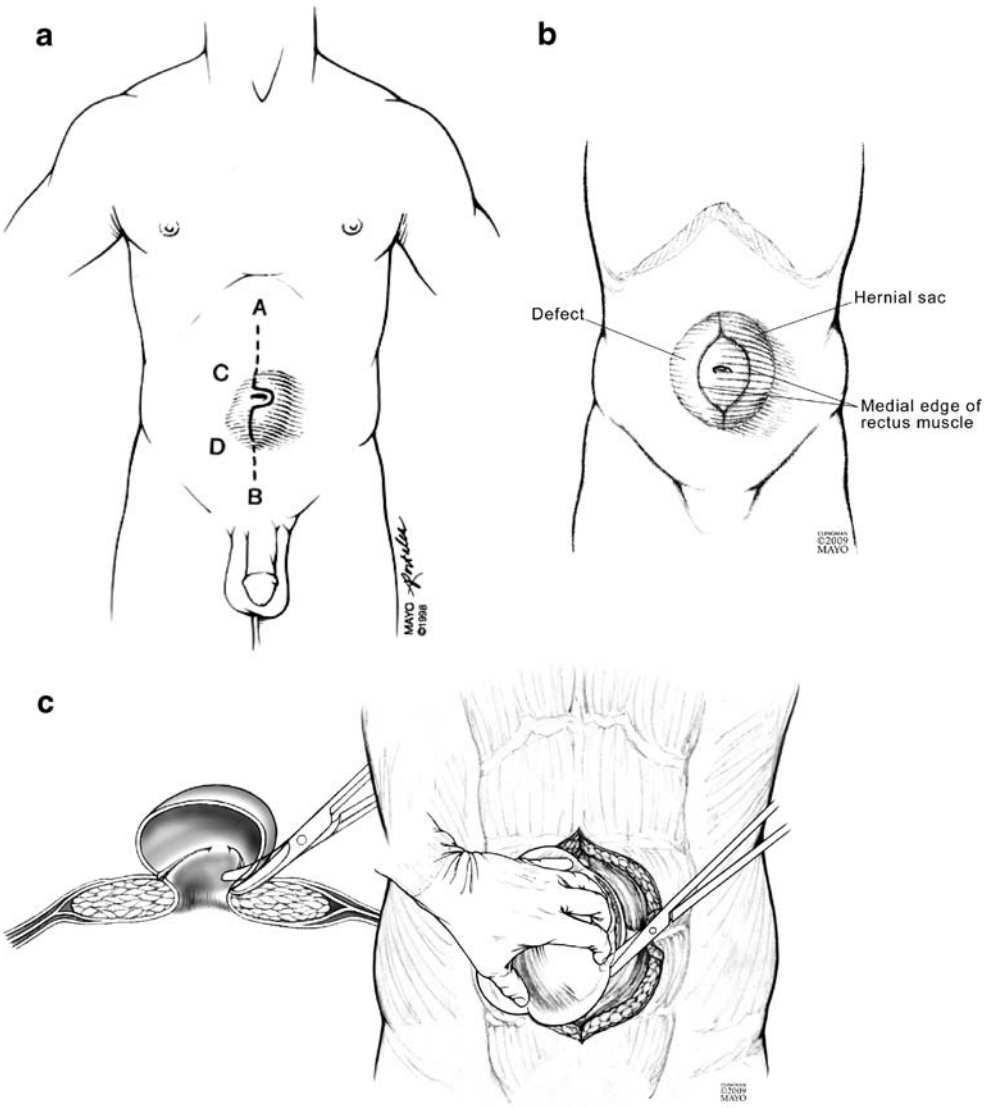

Figure 1 The incision **a** usually lies directly over the defect excising the previous scar. **b**, **c** The sac is dissected from the subcutaneous tissue back to the fascial edge of the defect. Copyrighted and reproduced with permission of Mayo Foundation for Medical Education and Research.

whenever possible. The length of the incision should be long enough to develop the appropriate planes and take down any adhesions safely but most often does not require reopening of the entire incision. The initial maneuver involves freeing the hernia sac entirely both laterally and rostrocaudally down to the edges of the fascial defect (Fig. 1c). *But* this peritoneal sac is *not* excised but rather is bunched up, if necessary, and is positioned posterior to the prosthetic material to serve as autogenous tissue between the intraperitoneal viscera and the prosthetic material in an attempt to prevent complications related to adherence of intraperitoneal viscera to the prosthesis (adhesions, fistulas) (Fig. 2a).

Next, an anterior fasciotomy is made at the medial-most edge of the anterior rectus fascia (Fig. 2a), the rectus muscle is identified, and a plane is developed posterior to the muscle (Fig. 2b) but anterior to the posterior rectus fascia (rostral to the semicircular line) and anterior to the peritoneum (caudal to the semicircular line) in the preperitoneal plane (Fig. 2c). This essentially avascular plane is freed up bluntly, being careful to preserve the superior epigastric vessels rostrally and the inferior epigastric vessels caudally. The plane is developed to the lateral extent of the rectus muscles, often up to and over the costal margin rostrally (the rectus muscles do not insert on the costal margin but rather about 5 cm rostral to the costal margin; Fig. 3a) and down to the pubis and Coopers ligament (if necessary) caudally. This plane should be developed 5–10 cm beyond the edges of the fascial defect for eventual placement of the prosthesis (Fig. 3b) at the same time being careful to look for smaller "Swiss cheese" defects in any other part of the fascia that was incised previously and also to look for an associated umbilical hernia. Be careful to look for a potential knuckle of bowel that may potentially herniate through *only* the posterior rectus fascia at the site of any prior transrectus stoma (e.g., ileostomy, colostomy).

Xiphoid Many/most upper midline hernias extend up to or near the xiphoid. It is important to develop the plane rostral and posterior to the xiphoid. This maneuver requires dissection anterior to the triangular fat pad (which can be excised) but posterior to the xiphoid/lower sternum (Fig. 4a). And, when placing the prosthesis, it will be necessary to disconnect the insertion of the posterior rectus fascia rostrally near the xiphoid to allow a smooth transition

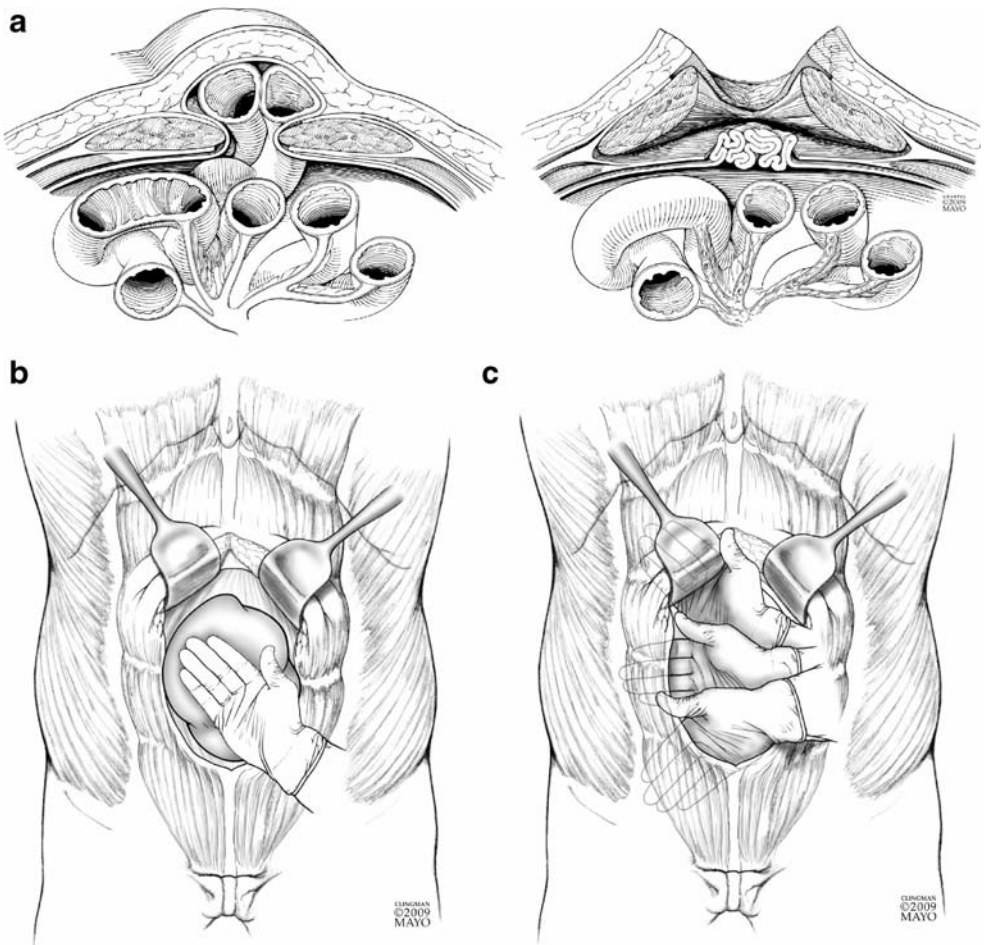

Figure 2 Development of retrorectus plan. **a** Transverse depiction of retrorectus plane; **b** preserving the hernia sac, the retrorectus plane is developed bluntly; **c** note the extent of rectorectus plane to 5–7 cm lateral, rostral, and caudal to the fascial defect. Copyrighted and reproduced with permission of Mayo Foundation for Medical Education and Research.

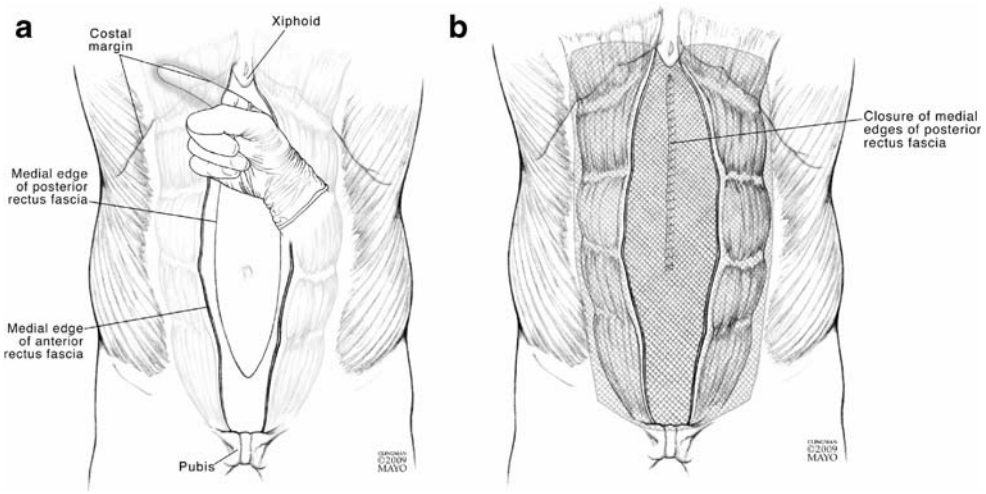

Figure 3 Placement of prosthesis. **a** Note rostral extent of retrorectus space anterior and rostral to costal margin; **b** the posterior rectus fascia is approximated posterior to the prosthesis; caudally, the posterior rectus sheath ends at the semicircular line. Copyrighted and reproduced with permission of Mayo Foundation for Medical Education and Research.

of the prosthesis from behind the xiphoid and into the retrorectus plane laterally (Fig. 4b). A similar disconnection is necessary caudal to the extent of the defect to allow the rectorectus planes bilaterally to communicate posterior to the otherwise intact lower midline fascia. At this point, prior to placing the prosthesis, the surgeon should try to reapproximate the medial edges of the posterior rectus fascia if at all possible (Fig. 3b). This maneuver will not only add another barrier of autogenous tissue between the intraperitoneal viscera and the prosthesis but will also help to reapproximate the rectus muscle in the midline.

Insertion/Fixation of Prosthesis

A large sheet of prosthesis is then positioned in this rectorectus plane. We prefer to use the large-pore, low-weight polypropylene mesh prosthesis (e.g., Ultrapro, Ethicon, Inc., Somerville, NJ, USA), but we will also use Prolene® mesh (Ethicon, Inc.) or Parietex Tet (Covidien). We usually do not use expanded polytetrafluorethylene (ePTFE) or some of the mesh prostheses with the one-sided non-adhesive barriers because we want to promote tissue transgrowth both anteriorly and posteriorly.

Fixation of the prosthesis to the anterior fascia is performed by making a small stab wound in the anterior abdominal wall like the numbers of a clock at the lateral-most extent of the retrorectus plane (Fig. 5a). We use the more blunt-tipped laparoscopic suture passer (Endoclose, Covidien, Norwalk, CT, USA) that facilitates this maneuver markedly. The suture is passed through the anterior rectus fascia and full thickness of the rectus muscle at its lateral extent, through the prosthetic mesh, and then back out through the muscle and fascia. We use an absorbable #1 polydioxanone for the initial fixation; we are consciously

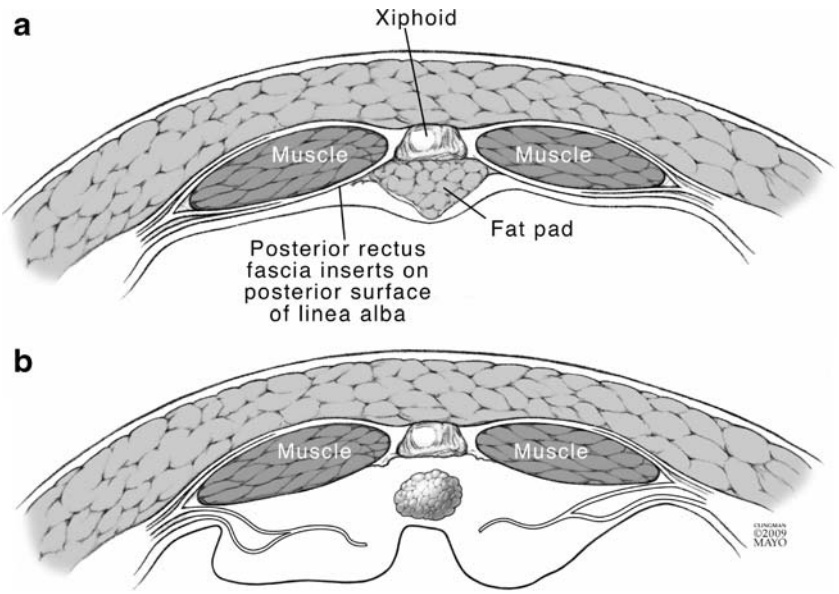

Figure 4 (**a**) Rostral dissection; when the fascial defect extends near the xiphoid, the retrorectus plane should extend rostral and posterior to the xiphoid. This dissection requires mobilization of the retrorectus fat pad and transection of the insertion of the posterior rectus fascia from its anterior insertion medially (**b**). Copyrighted and reproduced with permission of Mayo Foundation for Medical Education and Research.

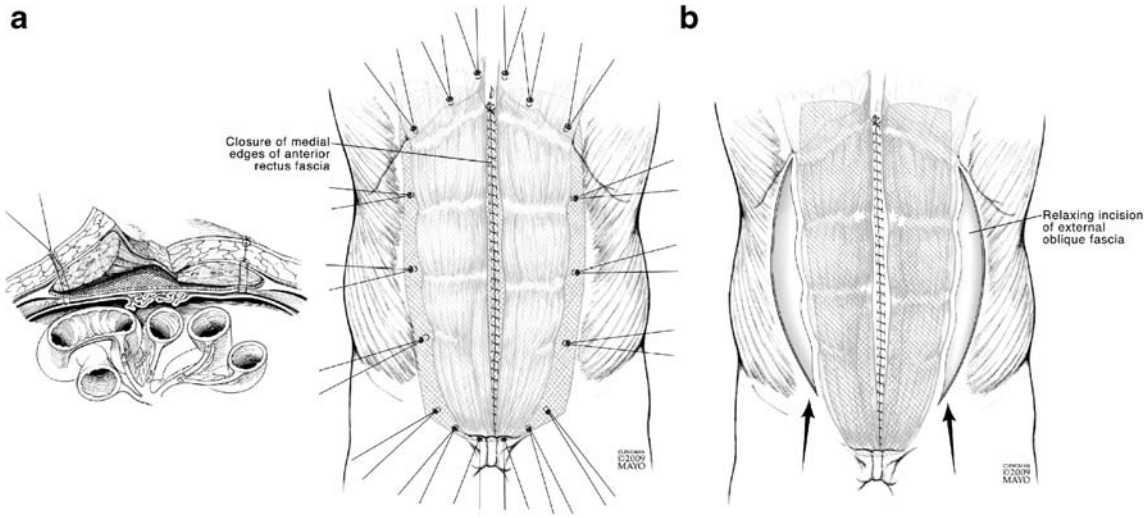

Figure 5 Fixation of prosthesis. **a** Lateral, rostral, and caudal fixation at the edges of the prosthesis; note closure of the anterior rectus fascia medially. **b** Use of a lateral relaxing incision through external oblique aponeurosis (components separation) if necessary to approximate the medial edges of the anterior rectus fascia. Copyrighted and reproduced with permission of Mayo Foundation for Medical Education and Research.

relying on future tissue transgrowth to anchor the meshed prosthesis in place permanently. Rostrally, we place two #1 polypropylene sutures either through the sternum when possible or on either side of the sternum rostral to the xiphoid; these sutures are attached to the prosthesis behind the xiphoid and lower sternum to assure a solid fixation and then passed back anteriorly through the same stab wound. Caudally, if the hernia defect extends to ≤5 cm from the pubis, we sew the prosthesis in three or more places to the pubis; this maneuver requires mobilizing the peritoneal sac off the posterior aspect of the pubis and exposing Cooper's ligament bilaterally (Fig. 6). We also sew the prosthesis to the medial aspect of Cooper's ligament using at least three individual polypropylene sutures; the needle is forced through the bony part of these structures and not just the periosteum. This maneuver requires a heavy needle and a bit of force; we have had no success with use of the laparoscopic tacker for a secure bony fixation. On occasion, fixation laterally in the lower abdominal wall is less reliable, and on occasion, we will also fix the prosthesis to the bony aspect of the anterior superior iliac spine if deemed necessary; a drill may be required for this fixation. Again, the fixation is not solely to the periosteum but rather a more solid fixation to the bone itself. Similarly, in the rostral aspect, the prosthesis can be sewn directly to the costal margin (in addition to extending the prosthesis rostrally over the costal margin). We keep the prosthesis unfolded but do not pull it tight because we fully expect some shrinkage of the surface area of the prosthetic material.

After irrigating the prosthesis with a topical antibiotic (in which the prosthesis was soaked during mobilization of the rectorectus plane), we usually place two closed-suction drains on top of the prosthesis which exit the abdominal wall rostrally (not in the groin where the skin may have more bacteria); these drains are removed usually the first or second postoperative day (for fear of a hospital-acquired bacterial infection). Then, every attempt is made to reapproximate the anterior rectus fascia in the midline (Fig. 5a) for two reasons: first, this maneuver brings another layer of autogenous tissue between the prosthesis and the bacteria-laden skin, and second, this reapproximation of the rectus muscles medially restores the biomechanics of the abdominal wall.

Special Situations

Prior Incision Extending Up to Xiphoid or Down to Pubis In these situations, it will be more difficult to develop the retrorectus plane; also, to allow the prosthesis to cross the midline will require transecting the attachment of the posterior rectus fascia to the resutured midline fascial closure.

Loss of Abdominal Musculature When parts of the rectus muscle have been lost and the retrorectus space is not wide enough, this space can be extended lateral to the lateral border of the rectus muscle by transecting the fascia lateral to the rectus muscle and remaining anterior to the internal oblique muscle but posterior to the external oblique muscle/fascia. This space can be mobilized out to the posterior axillary line if necessary with fixation of the prosthesis to the anterior fascia of the back musculature.

Large, but Not Huge Fascial Defects When reapproximation of the midline fascial edges is not possible without addition of a components separation, strong consideration

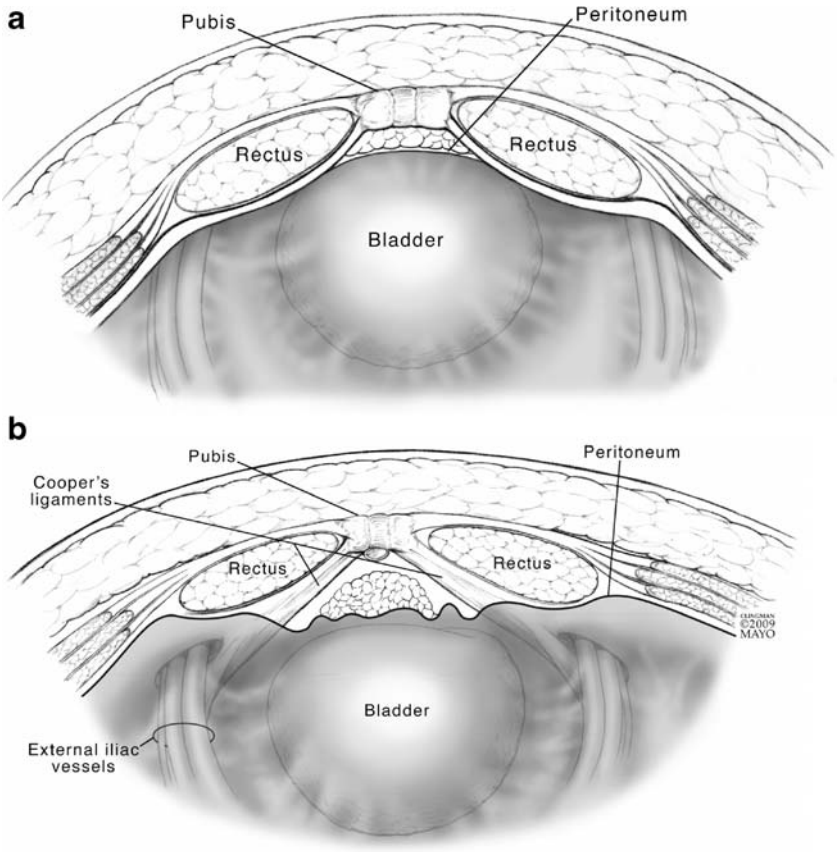

Figure 6 Caudal dissection. When necessary, the peritoneum and/or hernia sac is dissected from the posterior surface of the pubis to expose the pubis and Cooper's ligaments bilaterally. Note absence of the posterior rectus fascia caudal to semicircular line. Copyrighted and reproduced with permission of Mayo Foundation for Medical Education and Research.

should be given to performing this type of lateral fascia release (Fig. 5b), *provided the medial advance obtained will allow reapproximation of the fascia* (see below—minimal access approach). This medialization of the rectus muscles will not only help to restore the biomechanics of the abdominal wall but will also prevent a large surface area of prosthesis from being exposed in the subcutaneous space. Covering the mesh with another layer of autogenous tissue should decrease seromas and the possibility of infection of the prosthesis.

Huge Fascial Defect When the fascial defect is too large to allow midline fascial reapproximation, we do not use the rectorectus repair but rather proceed to a wide, intraperitoneal sublay repair. In this situation, we enter the peritoneum directly and do not mobilize the hernia sac laterally for several reasons; the lateral freeing up of the hernia sac will create a large subcutaneous dead space, the hernia sac will be devascularized, and the prosthesis will still be placed posterior to this sac.

When placing the prosthesis intraperitoneally, there are two choices of fixation. One is to place the prosthetic fully intraperitoneal and use a similar technique of transabdominal suture fixation using the laparoscopic suture passer. Unlike in the retrorectus space, all the lateral edges of the intraperitoneal prosthesis need to be fixed to the peritoneum so that no bowel can become entrapped between fixation sutures. We tend to place many more fixation sutures than the usual four fixation sutures used for a primary laparoscopic repair; we place these fixation sutures every 3 cm or so, and before tying down the rostral fixation sutures, we obliterate the spaces between these lateral and caudal areas of suture fixation using a laparoscopic tacker (Stryker, Kalamazoo, MI, USA) passed behind the prosthesis and fired totally under vision at the lateral extents of the prosthetic material. Although the risk of bowel entrapment rostrally is less, we still use the laparoscopic tacker rostrally but tend to place the tacks anterior to the prosthesis. For intraperitoneal repairs, two of the authors (JF and MGS) prefer a composite prosthesis with ePTFE facing the bowel and polypropylene anteriorly (Bard Composix, E/X mesh, Davol, Cranston, RI, USA). Our reasoning for choosing this prosthesis is that ePTFE has *no* ingrowth, while the other prosthetics bonded with an absorbable adhesion barrier always have the risk of visceral adherence. In contrast, the other author (MJR) prefers the Parietex™ composite graft (Covidien).

The second option of fixation is to develop the retrorectus space from a posterior approach by incising the medial edge of the posterior rectus fascia bilaterally. The prosthesis that will be placed intramurally can be a mesh (without a non-adhesive barrier) which should lead to

Figure 7 Trocar location for bilateral endoscopic component separation.

a more stable fixation with a lesser risk of seroma. After lateral fixation, the medial edge of the posterior rectus fascia can then be sewn to the posterior aspect of the prosthesis. We tend to use this more extensive approach for younger patients who are laborers.

The abdominal wall is then closed over two to three suction drains by approximating first the hernia sac over the prosthesis, then the subcutaneous tissue whenever possible, and then the skin. The drains are left in for only 1 or 2 days, but quite frankly, we have no idea how long they should be left in place; again, the worry is infection.

Laparoscopic Approach to Ventral Hernia Repair

After being first described in 1993, laparoscopic ventral hernia repair was accepted rapidly as an approach to ventral hernia repair.[8] The laparoscopic repair provides the advantage of placing a large prosthetic as a sublay in the intraperitoneal position. The major advantage of the laparoscopic approach is that it avoids the need for an anterior incision and the requisite extensive subcutaneous soft-tissue dissection, thereby bringing a predictably lesser rate of wound complications and mesh infections compared to open approaches.[9] The classic laparoscopic approach of bridging the defect from behind with the prosthesis prevents bowel herniation but does not reconstruct a functional, dynamic abdominal wall. The prosthesis in essence patches the hernia defect from behind. In an active, thin patient, some form of a bulge or paradoxic motion will remain and may result in patient dissatisfaction with the repair. In our practice, we reserve this approach typically for patients who are obese or are elderly and less active; the slight bulge is often imperceptible, and the risk of wound complications outweighs those issues.

Laparoscopic Ventral Herniorrhaphy with Abdominal Wall Reconstruction An entirely minimally invasive hernia repair but combined with abdominal wall reconstruction is suited particularly well for those patients with either an active lifestyle or a physically demanding profession and for thin active patients who would otherwise note a bulge (and be unhappy) after a standard laparoscopic ventral hernia repair with a prosthesis which bridges the defect. Appropriate patient selection is crucial; defects of >8–12 cm or lateral abdominal walls with repeated scarring from multiple prior stomas, drains, or infection may not be able to be reapproximated in the midline, and adding a minimally invasive component separation will not be advantageous and may lead ultimately to less abdominal wall stability.

In 1990, Ramirez et al.[10] described techniques of components separation designed to provide a tension-free, musculofascial advancement. This technique has undergone several technical modifications but essentially involves

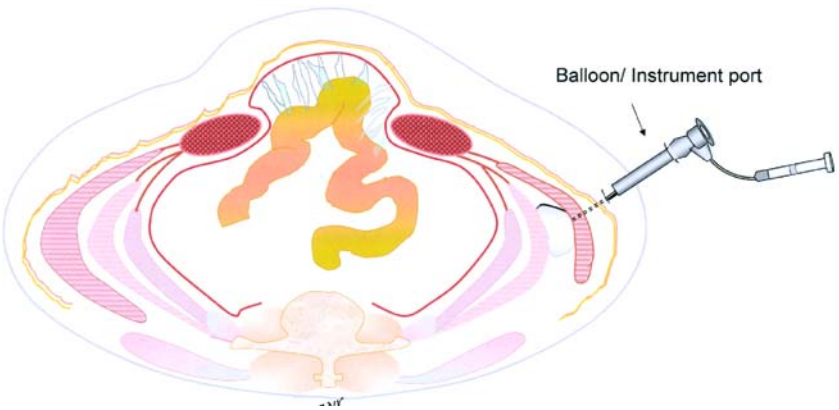

Figure 8 Initial placement of laparoscopic balloon dissector in between internal and external oblique muscles.

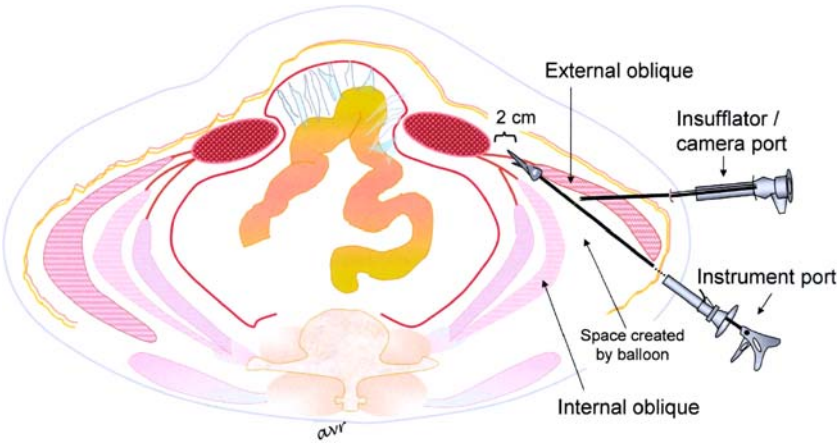

Figure 9 The external oblique muscle is released using the lateral laparoscopic port 2 cm lateral to the linea semilunaris.

gaining access to the lateral abdominal muscular compartment bilaterally typically by raising large lipocutaneous flaps, incising the external oblique fascia 2 cm lateral to the linea semilunaris, and separating the external and internal oblique in their avascular plane, allowing medialization of the rectus muscles. Some have claimed that this technique has been able to approximate defects up to 20 cm wide at the umbilicus; we believe these claims to be a generous overestimation of realistic medial advancement of the rectus muscles. The technique of component separation does, however, accomplish the goals of preventing bowel eventration but also reconstructs a mechanically more functional abdominal wall by restoring the muscular aponeurosis to the midline. Despite these seemingly important advantages, most surgeons reserve this technique for very complicated repairs because of reluctance to perform this lateral fascial release due to the high rate of associated wound complications.

Concepts of Repair

The ideal abdominal wall reconstruction for a ventral hernia would provide a minimally invasive technique to release the rectus abdominal wall musculature, enable laparoscopic adhesiolysis, reapproximate the midline, and reinforce the repair with permanent prosthetic material.[11] Ideally, this goal could be performed without creation of the large, lipocutaneous tissue flaps. Our approach to performing an endoscopic component separation can be combined with a midline incision and retrorectus mesh placement (as described above) or via a laparoscopic approach as described below.

Totally Laparoscopic Approach

Patients are positioned supine on the operating table with the arms out on arm boards. Placing the arms out is important because the lateral port for the component separation must be in the posterior axillary line which otherwise would be obscured. Placement of two laparoscopic towers at the patient's head facilitates everyone's view of the operation. The procedure is begun first by performing bilateral, endoscopic component separations;[12,13] performing this maneuver part first prevents potential problems with air leak into the abdomen if the ports were placed initially into the peritoneal cavity. The

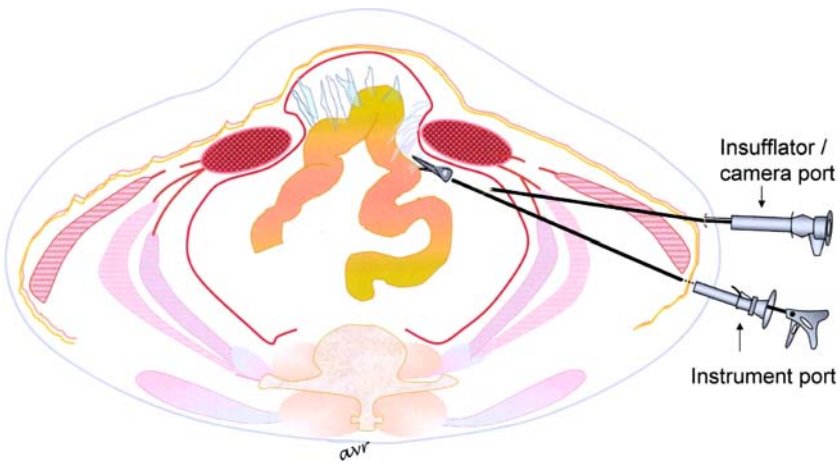

Figure 10 The laparoscopic ports are placed intraperitoneally, and adhesiolysis is performed.

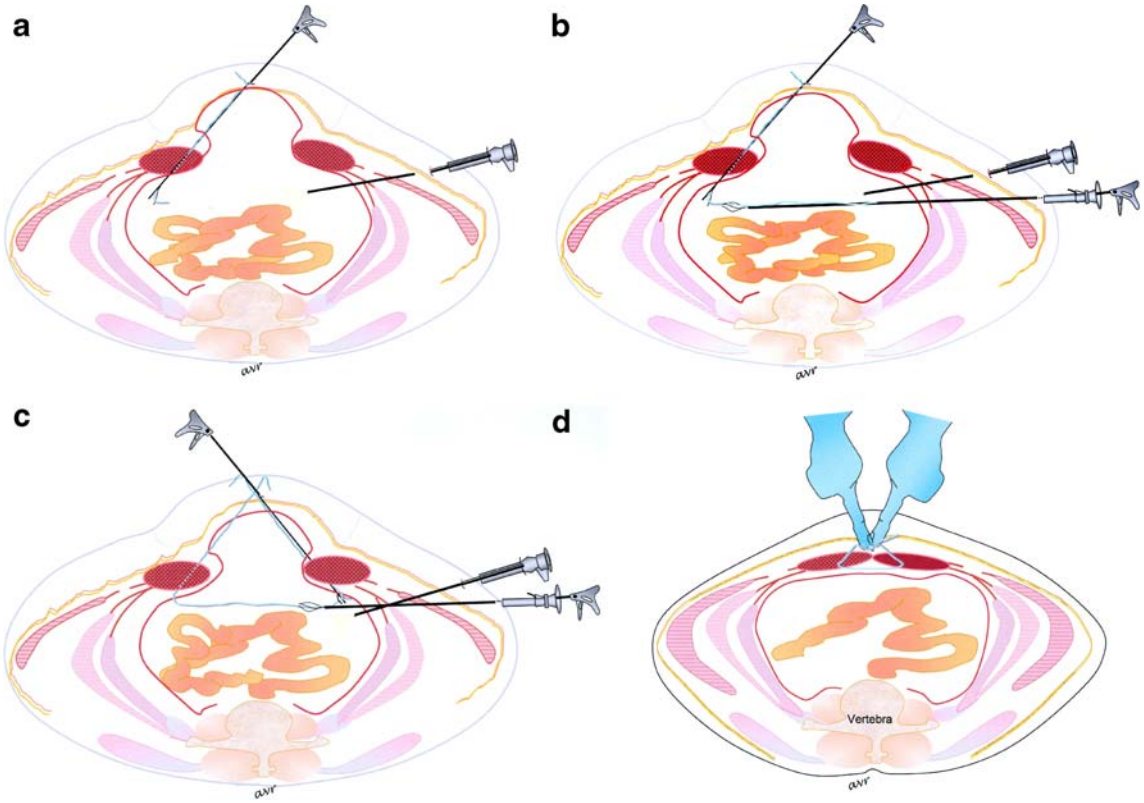

Figure 11 Reapproximation of the midline fascial defect. **a** Via a stab wound, a suture passer with a #1 polypropylene suture is passed through one fascial edge into the peritoneum, **b** retrieved by a forceps, **c** the suture passer now passed through the edge of the other fascial edge and removed through the stab wound, and **d** the suture tied with the knot subcutaneously.

costal margins and inguinal ligaments are identified and marked. The linea semilunaris representing the lateral edge of the rectus muscle is typically 8–10 cm from the midline and is then drawn on the patient's abdomen bilaterally. It is quite important to confirm this landmark because placing the port too far medially or in the rectus muscle may prevent the accomplishment of the procedure endoscopically and require conversion to an open procedure. To insure lateral placement, we place the initial port just off the tip of the 11th rib (Fig. 7). Using a 1-cm incision, the external oblique fascia is localized with Kocher clamps, incised sharply, and spread in the line of its fibers. The internal oblique muscle with its filmy anterior fascia is identified underneath, and the avascular plane between the external and internal oblique fascias is created with retractors. A bilateral, laparoscopic inguinal hernia balloon dissector (Covidien) is passed into this plane and advanced caudally down to the inguinal ligament. Because this is an entirely avascular plane, the balloon should meet little or no resistance. Inflation of the balloon separates the external oblique fascia from the underlying internal oblique fascia covering the internal oblique muscles (Fig. 8). This

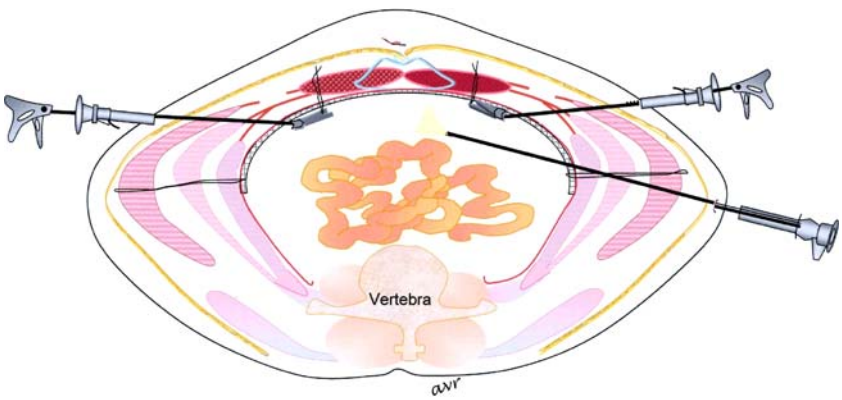

Figure 12 An appropriately sized piece of mesh is placed intraperitoneally to reinforce the fascial closure.

maneuver is performed under direct visualization from within the balloon to confirm the appropriate orientation of the respective muscle fibers. The balloon is removed, and a 30-ml, balloon-tipped port is placed. Insufflation pressures of only 10–12 mmHg will allow adequate visualization but prevent subcutaneous emphysema. The tip of the camera can be used to complete the posterior lateral dissection bluntly. A 5-mm port is then placed as far laterally as possible to provide an adequate angle to incise the external oblique fascia 2 cm lateral to the linea semilunaris. Using scissors and cautery, the external oblique fascia is transected in a caudal direction down to the inguinal ligament (Fig. 9). The surgeon must identify the linea semilunaris carefully during this dissection and avoid dividing it which would result in a full thickness defect and a lateral hernia, which is very difficult to repair and would require changing the operative approach. Maintaining a lateral distance of at least 2 cm from the linea semilunaris for the fascial release will prevent this complication. Once the fascia is released caudally, another 5 mm port is placed through the area of the fascial release medial to the initial camera port to provide adequate visualization of the fascial transection rostrally. The camera is then repositioned in the posterior axillary line, and the scissors are placed in the inferior port. Transection of the external oblique fascia in the other direction is then continued for at least 3–5 cm rostral to and above the costal margin. Meticulous hemostasis should be maintained during this maneuver because the external oblique muscle in this region can bleed postoperatively.

After completing the bilateral components separation, the ports for the intraperitoneal hernia repair are then placed into the abdominal cavity (Fig. 10). The posterior surface of the entire anterior abdominal wall is freed of adhesions. The hernia defect is measured internally using spinal needles in conjunction with a 15-cm ruler in a rostrocaudal and medial-lateral orientation. At this point, the fascial defect is reapproximated as follows. A small stab wound is made just above the hernia, and a suture passer is placed with a #1 polypropylene suture through the skin and through the fascial edge of the hernia defect (Fig. 11a) and retrieved with a laparoscopic grasper (Fig. 11b); the suture passer is then removed and passed through the same skin incision to the contralateral side of the hernia defect, and the suture is retrieved (Fig. 11c). A series of these interrupted sutures are placed throughout the length of the hernia defect to allow a secure, musculofascial approximation, the insufflation pressure is decreased, and the sutures are tied with the knots below the skin on the fascia (Fig. 11d). An appropriately sized piece of prosthesis based on the measurements required is placed intraperitoneally and secured with transfascial fixation sutures (Fig. 12). A laparoscopic tacker then obliterates the lateral defects of the prosthesis. We prefer the use of Parietex™ Composite (Covidien) for intraperitoneal placement and Parietex™ TET (Covidien) for intramurally placed prosthetic.

Combined Open and Endoscopic Repair

This combined approach is utilized either when an open herniorrhaphy is needed (as described above—"Open Ventral Hernia Repair") or when the anterior abdominal wall is contaminated or there has been a prior mesh infection—in these latter situations, once the infectious source has been removed and gastrointestinal continuity restored. After assessing the size of the defect, if the defect is too large to close primarily, we perform the endoscopic component separation. The lateral border of the rectus muscle is assessed easily by compressing the lateral abdominal wall bimanually and identifying the ridge of the rectus muscle. The initial port is placed at least 2 cm lateral to this landmark, and the procedure is performed as above.

We try not to repair an incisional hernia with a permanent prosthesis whenever the bowel is opened electively (clean contaminated) or with local contamination. On occasion, we will carry out such a combined repair when taking down a relatively simple enterocutaneous fistula, an ileostomy, or a colostomy, but both we as the surgeons and the patient must acknowledge the increased risk of infection and weigh the risk/benefit ratio.

Conclusion

The hernia surgeon has many available options to choose from when repairing abdominal wall defects. Understanding the physiology and biomechanics of the abdominal wall and the need to recreate a functional dynamic platform may result in increased postoperative patient functional recovery and satisfaction with the repair.

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