Open Ventral Hernia Repair with Component Separation

Eric M. Pauli, MD, Michael J. Rosen, MD,*

KEYWORDS
• Ventral hernia • Incisional hernia • Abdominal wall reconstruction
• Retromuscular hernia repair • Transversus abdominis release (TAR)
• Rives-Stoppa technique

KEY POINTS
• Incisional hernias are the most common complication after laparotomy and the most common indication for reoperation after laparotomy.
• Recent advancements in mesh technology and technical refinements in the methods of herniorrhaphy have dramatically changed the way open hernia surgery is conducted.
• Abdominal wall reconstructive procedures, which typically include separation of the abdominal wall layers and release of one or more myofascial planes, require a clear understanding of the anatomy of the abdominal wall.
• The authors’ favored approach to open ventral hernia repair is a posterior component separation (retrorectus dissection with release of the transversus abdominis aponeurosis and muscle) with sublay of appropriately selected mesh between layers of vascularized tissues and subsequent reconstruction of the linea alba.
• Retromuscular hernia repairs have been shown in multiple studies to have a low recurrence rate (3%–6%) at long-term follow-up and have been accepted as the gold standard technique for open ventral hernia repair by the American Hernia Society.

INTRODUCTION

Despite improved outcomes in many other areas of surgery, abdominal wall hernia formation still complicates 11% to 50% of all laparotomies.1–6 It remains the most common complication following laparotomy and is the most common indication for reoperation by a 3:1 margin over bowel obstruction.7 With more than 2 million laparotomies performed in the United States annually, general surgeons are faced with...
epidemic numbers of patients requiring ventral herniorraphy. A reliable method with a low recurrence rate is still clearly necessary for the estimated 200,000 patients undergoing ventral hernia repairs annually.

Traditional methods of hernia repair have unacceptably high recurrence rates. Primary open suture repair of ventral hernias with simple fascial reapproximation results in recurrence rates in excess of 50% in long-term follow-up. Fifty-five years ago, the mesh herniorraphy was introduced. The principle of a tension-free mesh reinforced herniorraphy has undergone technical refinements since this time and is still considered to be the gold standard repair. Despite the widespread implementation of this “gold standard,” the addition of mesh to open repairs still results in long-term recurrence rates as high as 32%. Moreover, the ideal method of mesh implantation is the subject of ongoing debate.

With the advent of laparoscopic ventral hernia repair in 1993, minimally invasive techniques became the preferential method for many surgeons. Intuitively, these repairs had the advantage: they provided wide mesh overlap of the hernia defect without significant soft tissue dissection. Short-term data suggested decreased morbidity and a lower recurrence rate. Sadly, these data were not borne out in the long term, where recurrence rates in well-selected populations still reach 14% to 17%. As a consequence, one of the most pressing controversies of ventral hernia repair is whether to approach the problem in an open or laparoscopic fashion.

Parallel with the evolution of laparoscopic ventral hernia repair, novel methods of abdominal component separation were being developed. In 1990, Ramirez and colleagues originally described techniques of medial fascial advancement to aid in definitive reconstruction. In their components separation, Ramirez and colleagues first released the posterior rectus sheath. In 30% of their patients, this was insufficient to permit midline closure, and they therefore created large skin flaps to expose and release the external oblique muscle. Recurrence rates after such component separation hernia repairs range from 10% to 22%, with mean follow-up periods of 9.5 months to 4.5 years. Modifications of these myofascial advancement flaps have been developed to reduce the morbidity incurred by creating these skin flaps (and by default reduce the recurrence rate). Such methods include periumbilical perforator sparing (PUPS) methods, endoscopic release of the external oblique muscle, and, more recently, posterior component separation methods that avoid any skin undermining.

Posterior component separation methods are based on the Rives-Stoppa-Wantz retrorectus repair, which used the 6-cm-wide to 8-cm-wide potential space between the posterior rectus sheath and the rectus muscle to permit mesh positioning in a sublay fashion. Given its superior track record, this approach was deemed to be the gold standard method for open ventral hernia repair by the American Hernia Society in 2004. Although durable, the Rives-Stoppa-Wantz technique does not permit dissection beyond the lateral border of the posterior rectus sheath, making it insufficient to permit adequate mesh overlap and tension-free repair of larger abdominal wall defects. Methods to extend this potential space have been described and include preperitoneal dissection, intramuscular plane formation, and release of the transversus abdominis muscle. Using these methods, surgeons have been able to achieve recurrence rates as low as 3% to 6%.

In this article, we describe our current operative technique for open ventral hernia repair using component separation. Although we describe methods of anterior component separation, in our current practice, we primarily use posterior component separation with transversus abdominis release to permit dissection beyond the retrorectus space. This method adheres to the literature supported principles of a
tension-free midline fascial closure with wide mesh overlap of mesh positioned in a sublay position. Our experience with this method supports a low recurrence rate and reduced wound morbidity.

**PREOPERATIVE PLANNING**

**Physical Examination**
- Defect size, location of prior incisions or stomas, draining sinuses, exposed mesh, skin issues (eg, thinning, ulceration, cellulitis) should all be ascertained from physical examination.

**Operative History**
- Review of old operative reports is mandatory to identify what types of repairs have been previously attempted, what type of mesh was used (if any), and into which plane it was placed.

**Abdominal Wall Imaging**
- Computed tomography (CT) of the abdomen and pelvis remains the gold standard preoperative imaging modality for ventral hernia repair. Typically no contrast is required.
- CT scans demonstrate the size and location of the hernia sac(s), identify synthetic mesh as well as signs of mesh infection (fluid collections, inflammatory stranding, sinus tracts), and provide information about the remaining abdominal musculature.
- CT angiography can identify the periumbilical perforating vessels and may help in deciding between classical or PUPS anterior component separation.

**Managing Medical Comorbidities**
- Comorbidities associated with higher rates of recurrence and complication should be medically optimized; diabetic blood sugar control, cardiac risk factors, obesity, malnutrition, pulmonary function, methicillin-resistant *Staphylococcus aureus* (MRSA) colonization.
- Smoking cessation is an absolute requirement. Supplemental oxygen use also precludes surgery.
- Obese patients, especially those with a body mass index higher than 45, should undergo a medical bariatric evaluation to facilitate weight loss, improve exercise tolerance, reduce protein malnutrition, and possibly steer the patient to surgical weight loss surgery before herniorraphy is attempted.

**Preoperative Counseling**
- A frank discussion with the patient about the likelihood of one or more complications is part of the informed consent process. Hernia recurrence, mesh infection (and its potential consequences), abdominal compartment syndrome, and requirement for postoperative ventilation are all reviewed.
- We specifically address “unacceptable outcomes” with patients as part of our determination of what mesh (synthetic or biologic) to use. Some patients will accept the risk of synthetic mesh infection or draining sinus for a lower hernia recurrence rate; others will not.

**CLINICAL ANATOMY**

A thorough understanding of the anatomy of the abdominal wall is mandatory when performing ventral herniorraphy with component separation. This includes not only
an understanding of the neurovascular supply to muscle, fat, and skin, but also knowledge of force vectors each of the muscular layers generates. Such knowledge results in the best clinical outcomes by providing a well-vascularized, innervated, and correctly oriented abdominal wall reconstruction.

Normally, 2 vertically oriented rectus abdominis muscles originate at the pubic symphysis and insert on the costal cartilage of ribs 5 to 7. These muscles should lie on either side of the intact, midline linea alba. On each side of the rectus, 3 flat semihorizontally oriented muscles are found layered on one another: the external oblique muscle, the internal oblique muscle, and the transversus abdominis muscle (from superficial to deep). Disruption of the linea alba permits unopposed lateral pull on the recti by the lateral musculature and contributes to increase in size of incisional midline hernias.

At the lateral boarder of the rectus muscle, the aponeurosis of the lateral abdominal muscles alternately separate or fuse to contribute to the rectus sheath. Here, the external oblique aponeurosis and rectus sheath fuse to form the linea semilunaris. Above the arcuate line, the internal oblique aponeurosis splits to contribute to both the anterior and posterior rectus sheaths (Fig. 1). Below the arcuate line, the aponeurosis does not split but rather fuses with the external oblique fascia to form the anterior rectus sheath alone (see Fig. 1). The transversus abdominis muscle’s medial aponeurosis merges with the posterior lamina of the internal oblique to form the posterior sheath. For retrorectus repair, it is important to note that the transversus abdominis does not contribute to the linea semilunaris. Its muscle belly extends medial to the linea semilunaris, behind the rectus muscle, in the upper one-third of the abdomen (Fig. 2).

Each rectus muscle receives blood supply from the inferior and superior epigastric arteries as well as intercostal arterial branches that enter the muscle belly laterally. These intercostal branches are also the main blood supply to the lateral musculature. They travel with the thoracoabdominal nerves (branches of T7–T12) in the “neurovascular plane” located between the internal oblique and transversus abdominis muscles. In addition to supplying the lateral abdominal musculature and skin, these branches innervate the rectus muscle posteriorly and slightly medial to the linea semilunaris. Both anterior and posterior component separations are able to preserve these intercostal neurovascular bundles due to their location deep to the internal oblique.

For anterior component separation, where lipocutaneous flaps are created, knowledge of the skin vascularity is also critical. For a classic component separation (external oblique release), transection of the deep epigastric perforating vessels leaves the central abdominal wall without its major blood supply. PUPS component separation preserves these vessels to reduce the risk of ischemia-related wound complications.

**CHOICE OF MESH**

- For patients with clean wounds, we prefer a large (30.5 × 30.5-cm) lightweight, macroporous, polypropylene mesh. There is emerging evidence that use of this mesh is also acceptable in patients with multiple comorbidities (diabetes, obesity, prior mesh infection) or in clean-contaminated circumstances (fistula takedown, enterotomy closure, small bowel resection, stoma formation or relocation).
- Use of synthetic mesh with an antiadhesive coating can be considered if the viscera will be exposed to the mesh, but this is rarely necessary with either technique to be described.
Biologic mesh is appropriately considered for patients with a higher risk of developing a postoperative surgical site infection (SSI). This includes potentially contaminated or contaminated fields, patients with medical comorbidities (diabetes, obesity, immunosuppression, steroid use) or history of MRSA infection.

**SURGICAL TECHNIQUE: POSTERIOR COMPONENT SEPARATION**

**Positioning and Marking**
- The patient is positioned in a supine position with arms abducted.
- A Foley catheter and an orogastric tube are placed.
- The abdomen is clipped of hair and is widely sterilized with a 2% chlorhexidine gluconate and 70% isopropyl alcohol solution.
All old incisions (including old laparoscopic port sites and drain locations) are marked. Excess skin and old scar to be excised are similarly marked.

An iodophor-impregnated adhesive drape is used.

**Incision**
- A full midline laparotomy incision is made, with an elliptical skin component to remove old scar, thin skin over the hernia, or ulcerated wounds.
- In the morbidly obese, several other considerations are made:
  - The incision is stopped at the level of the pubis; we do not extend the incision onto or below the pannus where skin care issues may compromise the incision.
  - The umbilicus is typically removed during the repair.
  - Unless there is a compelling indication, we do not perform a panniculectomy concomitantly with the hernia repair because of the higher risk of SSI.
- Safe access to the abdominal cavity is critical to avoid bowel injury and is best achieved by traversing fascia in an area remote from the hernia (above or below the old incision).

**Adhesiolysis and Foreign Body Excision**
- Visceral adhesions to the anterior abdominal wall and pelvis are fully lysed. This is critical to allow full medial mobility of the posterior abdominal wall components.
- Care must be taken to avoid excess injury to the posterior layers of the abdominal wall (peritoneum and transversalis fascia) during this portion of the procedure.
- Interloop adhesions are typically ignored unless the patient has a history of adhesive related small bowel obstruction.
- Any encountered foreign bodies (tacks, suture material, old mesh) are fully removed.
- A sterile towel is packed over the viscera to protect them during the component separation.

**Retrorectus Dissection**
- Using electrocautery, an incision is made in the posterior rectus sheath within 0.5 cm of its medial boarder. This incision is extended superiorly and inferiorly, spanning the entire length of the rectus muscle (Fig. 3A).
Working medial to lateral, the plane is continued using blunt and electrocautery dissection. Care must be taken to avoid injury to the epigastric vessels, which should remain with the muscle, not the posterior sheath, during the dissection (see Fig. 3B).

The lateral limit of this dissection is the linea semilunaris at the lateral border of the rectus muscle, where the anterior and posterior rectus sheaths fuse (see Fig. 3B).

Identification and preservation of the intercostal neurovascular structures as they enter the posterior aspect of the rectus muscle is crucial.

Superiorly, this plane is extended into the retroxyphoid/retrosternal space (Fig. 4A). Inferiorly, the plane extends into the space of Retzius (see Fig. 4B). Blunt dissection in this avascular plane permits exposure to the midline symphysis pubis and Cooper’s ligaments bilaterally. Care must be exercised here to avoid injury to the inferior epigastric vessels at their origin on the iliac vessels.

Transversus Abdominis Release

- In many circumstances, dissection in the retrorectus space just to the linea semilunaris is insufficient to permit adequate abdominal wall reconstruction because of the following considerations:
  - Non-midline ventral hernias may occur lateral to this landmark
  - There may be insufficient retrorectus space to permit adequate prosthetic reinforcement of the hernia
There may be insufficient medial advance of both the posterior rectus sheath (to exclude the mesh from the peritoneal cavity) and of rectus muscles (to permit reconstruction of the linea alba anterior to the mesh).

- Methods to extend the retrorectus dissection lateral to the linea semilunaris include intramuscular dissection (by dividing the internal oblique muscle), dissection within the preperitoneal plane, or transversus abdominis release (TAR), which we favor.

- Approximately 0.5 cm medial to the linea semilunaris, electrocautery is used to incise the posterior sheath, exposing the transversus muscle (Fig. 5A). This is most easily accomplished in the upper half of the abdomen, where the muscle belly is well defined.

- Using a tonsil (Schnidt) or right-angled clamp to assist dissection, electrocautery is used to hemostatically transect the transversus abdominis muscle (see Fig. 5B). Care must be taken to avoid injury to the transversalis fascia/peritoneal layer that lays deep to this.

- Once divided, the muscle can be retracted anteriorly and the avascular retromuscular plane developed bluntly. Superiorly, this plane extends beyond the costal margin to the diaphragm, inferiorly to the myopectineal orifice, and laterally to the psoas muscle.

- The TAR is then completed on the contralateral side.

Reconstruction of Posterior Layer

- The posterior rectus sheath is reapproximated in the midline using running 2-0 polyglycolic acid (vicryl) suture (Fig. 6).

- Any holes created in the posterior layer during dissection must be closed; this prevents bowel from contacting the unprotected mesh and prevents bowel from slipping in-between the posterior layer and the mesh, which can result in a bowel obstruction from internal herniation.

- Fenestrations in the posterior layer are common in areas where the abdominal wall has been traversed (laparoscopic port sites, drain sites, old incisions) and below the arcuate line (where there is no transversus abdominis muscle within the posterior layer).

- Small holes that cannot be repaired primarily with suture can be closed with native tissue (omentum, colon epiploicae, hernia sac). Larger holes are best closed by patching the defect with absorbable mesh (vicryl) secured with a running absorbable suture.
The newly created visceral sac and abdominal wall are irrigated with 3 L of antibiotic lavage solution.

**Mesh Placement**

- The newly created visceral sac and abdominal wall are irrigated with 3 L of antibiotic lavage solution.

**Fig. 5.** (A) Incision of the posterior rectus sheath exposes the transversus abdominis muscle. (B) Transversus abdominis release exposes the transversalis fascia/preperitoneal plane, which can be extended to the psoas muscle. (*From* Rosen M, editor. *Atlas of abdominal wall reconstruction*. New York: Saunders; 2011; with permission.)

- The newly created visceral sac and abdominal wall are irrigated with 3 L of antibiotic lavage solution.

Mesh Placement

- The mesh is turned into a diamond configuration and is anchored inferiorly using a single transfascial stitch just above the pubic ramus or bilateral sutures placed into Cooper’s ligaments. We typically use slow-absorbing 0 monofilament absorbable suture (polyglyconate or polydioxanone) to secure the mesh.
- For inferior midline defects, the mesh can be positioned deep in the space of Retzius and the anchoring stitch(es) backed off the edge to permit adequate overlap (at least 4 cm). For concurrent inguinal or femoral hernias, the mesh can be positioned to cover the myopectineal orifice(s).
- For superior midline defects, the mesh is positioned well beyond the costal margin (at least 4 cm to allow adequate overlap of the defect) and is anchored with transfascial sutures placed around the xyphoid process.
Working on one side and then the other, full-thickness transfascial sutures are placed to secure the mesh in 3 cardinal points (Fig. 7). We prefer using a Reverdin needle (Fig. 8) to facilitate transfascial suture placement.

- Kocher clamps are placed on the medial edge of the rectus muscle on the ipsilateral side and the abdominal wall is pulled toward the midline as the transfascial sutures are placed. This permits the mesh to be tensioned “physiologically,” which has several advantages in the repair:
  - The mesh absorbs much of the force needed to move the rectus muscles toward the midline. This not only permits primary fascial closure over the mesh, but also reduces the tension on the midline closure.

Fig. 6. Reconstruction of the posterior layer. (From Rosen M, editor. Atlas of abdominal wall reconstruction. New York: Saunders; 2011; with permission.)

Fig. 7. Mesh is secured in the retromuscular space using the Reverdin needle to place transfascial sutures in cardinal locations. (From Rosen M, editor. Atlas of abdominal wall reconstruction. New York: Saunders; 2011; with permission.)
The mesh will not buckle or wrinkle when the linea alba is re-created, reducing the space for seroma to accumulate.

Reconstruction of the Anterior Layers
- With the mesh circumferentially secured, the linea alba is re-created by suturing the anterior rectus sheaths to each other in the midline using multiple figure-of-eight stitches of slow-absorbing 0 monofilament absorbable suture (Fig. 9).
- Before these stitches are tied, closed suction drains (typically 2) are positioned anterior to the mesh and in the dependent (inferior and lateral) portions of the repair.
- Because of the substantial rectus medialization afforded by TAR and by physiologically tensioning the mesh, it is uncommon to not complete the anterior fascial closure over the mesh.
- The subcutaneous tissues can be closed in layers with absorbable suture. The skin is stapled. Subcutaneous drains are placed only in circumstances in which there is a large dead space not effectively closed with sutures.
SURGICAL TECHNIQUE: ANTERIOR COMPONENT SEPARATION

- Incision, adhesiolysis, and foreign body (mesh) excision proceed identical to posterior component separation methods outlined previously.

Formation of Subcutaneous Flaps
- Once the fascia medial to the rectus has been identified, lipocutaneous flaps are created by dissecting the subcutaneous tissues off the anterior rectus sheath. These flaps extend superiorly to the costal margin, inferiorly to inguinal ligament, and laterally to just beyond the linea semilunaris (lateral boarder of rectus muscles) where the external oblique fascial release will occur.
- PUPS Variation
  - Two subcutaneous tunnels are created just above the anterior rectus sheath with electrocautery.
    - The epigastric tunnel extends from the xyphoid to 4 cm above umbilicus and runs laterally along the costal margin to just beyond the linea semilunaris.
    - The suprapubic tunnel extends from the pubic tubercle to 6 cm below the umbilicus and runs laterally along the inguinal ligament to just beyond the linea semilunaris.
  - The tunnels are then connected to each other lateral to the linea semilunaris. This method preserves the umbilicus and periumbilical branches of the inferior epigastric vessels (Fig. 10).
  - Use of a fiber-optic lighted retractor greatly facilitates this dissection.

External Oblique Release
- With electrocautery, the external oblique aponeurosis and muscle fibers are divided 1 to 2 cm lateral to the linea semilunaris from just above the costal margin to just above the inguinal ligament (Fig. 11).

![Fig. 10. PUPS technique. Superior and inferior flaps are connected with a lateral subcutaneous tunnel. (From Rosen M, editor. Atlas of abdominal wall reconstruction. New York: Saunders; 2011; with permission.)]
This maneuver is similar whether the classic or PUPS technique is being implemented. With PUPS, the lighted retractor again facilitates visualization.

An assessment is then made as to whether the linea alba can be re-created at the midline without undue tension.

- If no tension is found, mesh placement and fascial closure can begin.
- If the midline fascia will not reapproximate, retrorectus dissection (as described for posterior component separation) can be performed to permit greater medialization of the rectus muscle.

Mesh Placement

- Mesh can be placed as an underlay (within the peritoneal cavity), sublay (within the retrorectus space), or as an onlay, depending on the types of release performed, whether midline fascia can be approximated, and surgeon preference.
  - Underlay mesh is secured via transabdominal sutures passed through the lateral cut edge of the external oblique fascia. If synthetic mesh is used here, it must have an antiadhesive barrier.
  - Sublay mesh is placed within the retrorectus space after the posterior layer has been closed. Transabdominal sutures are passed through the medial cut edge of the external oblique at the level of the linea semilunaris.
  - Onlay mesh is placed over the closed midline repair, and is secured to the lateral cut edges of the external oblique bilaterally (Fig. 12).

- Regardless of implant location or type (biologic or synthetic), mesh should be secured with slowly absorbing monofilament suture and placed under physiologic tension.
- Drains are generally placed above the mesh regardless of its implant location.
Reconstruction of the Anterior Layers

- Because of the large skin flaps created with anterior component separation, several maneuvers have been proposed to reduce the risk of wound occurrences:
  - Subscapra fat may be removed if ischemic.
  - Redundant skin may be removed from the midline.
  - Skin flaps may be sutured to the abdominal wall to reduce dead space.
  - Multiple closed suction drains (2–4) are placed to evacuate fluid from the dead space. These subcutaneous drains are left in place for several weeks.
  - For PUPS, drains are specifically positioned in the right, left, and central subcutaneous compartments.
- The subcutaneous tissues can be closed in layers with absorbable suture. The skin is stapled.

POSTOPERATIVE CARE

Airway Management

- In cases with prolonged operative times, patients with underlying pulmonary disease, or cases ending late in the evening, the patient is kept intubated overnight.
- If the plateau airway pressure increases more than 6 cm H₂O following approximation of the linea alba, the patient is also kept intubated for 24 hours.⁴⁴
- The addition of 24 to 48 hours of chemical paralysis is a useful adjunct for more significant rises in plateau pressure (9 cm H₂O or greater).⁴⁴

Pain Management

- Epidural catheters are recommended in all patients and are maintained for 3 to 4 days postoperatively.
- For patients in whom an epidural cannot be placed (or is contraindicated) or who have delayed bowel function at the time of epidural removal, an intravenous patient-controlled analgesia device is used.
- Patients are transitioned to oral narcotic analgesia when they tolerate a diet.
Diet
- We are conservative with dietary advancement to avoid retching and emesis, which can jeopardize the repair.
- Patients are kept nil per os until flatus is passed, at which time clear liquids are begun.
- When bowel function has returned, patients are advanced to an appropriate diet (e.g., regular, diabetic).
- Nasogastric tube decompression is used only in patients with extensive adhesiolysis or in whom small bowel resection has been performed.

Drains (anterior component separation)
- Subfascial drains are typically removed before hospital discharge (within 7 days).
- Subcutaneous drains are left until output is less than 30 mL per day for 2 consecutive days. This can result in drains that are in place for several weeks postoperatively.

Drains (posterior component separation)
- When synthetic mesh is used, drains are removed when the output is less than 30 mL per day or on the day of discharge (whichever is first). This typically occurs on day 4 to 7.
- When biologic mesh is used, we leave drains in place for 2 weeks irrespective of the output volume.

Abdominal Binder
- We routinely use an abdominal binder in the immediate postoperative period.
- Following discharge, the patient may wear the binder as desired.
- If there is concern for the viability of lipocutaneous skin flaps, most will not place a binder.

General Postoperative Issues
- Mechanical and pharmacologic venous thromboembolism prophylaxis is instituted in all patients beginning in the operating room.
- Following Surgical Care Improvement Project (SCIP) guidelines, prophylactic antibiotics are given within 1 hour of skin incision and are discontinued within 24 hours.
- For patients with active mesh or soft tissue infections, antibiotics are given until resolution of the infection.

POSTOPERATIVE COMPLICATIONS
Wound Complications
- SSIs are a major source of morbidity following open ventral hernia repair. In the highest-risk populations, the SSI rate has been reported to be as high as 27% to 41%.
- Wound complications are more common and more severe in anterior component separation than posterior component separation techniques.
- Cellulitis is managed with appropriate antibiotics.
- Infected collections (including seromas and hematomas) are drained percutaneously or operatively.
- Asymptomatic fluid collections are generally followed conservatively.
- Necrosis of skin or subcutaneous tissues is addressed with early operative debridement.
- Prophylactic use of negative-pressure vacuum therapy on a closed surgical incision does not reduce the 30-day SSI rate following abdominal wall reconstruction.
Pulmonary Complications
- Diaphragm function and pulmonary toilet are both negatively affected by abdominal wall reconstruction, leaving patients vulnerable to pulmonary complications.
- On evaluation of the 2007 National Inpatient Sample, ventral hernia patients discharged with a diagnosis of respiratory failure and mechanical ventilation had a 4-fold greater length of stay and an 18-fold greater death rate.44
- As many as 20% of patients will experience a postoperative respiratory complication following component separation hernia repair.44
- Aggressive pulmonary toilet, including incentive spirometer use, chest physiotherapy, adequate analgesia, and upright posture, are all critical to minimizing these complications.

Gastrointestinal Complications
- Paralytic ileus is common following ventral hernia repair, although the exact rate is not reported.
- Prolonged ileus, or symptoms suggestive of an early small bowel obstruction, should prompt further investigation. A CT scan of the abdomen and pelvis will demonstrate an internal hernia (bowel is seen protruding through a rent in the posterior layer). Prompt surgical reexploration in this case is mandatory.

Intra-Abdominal Hypertension
- Except in the smallest ventral hernia repairs, some degree of intra-abdominal hypertension (IAH) is likely created in the course of reapproximating the linea alba.
- We do not routinely follow bladder pressure measurements, but are aggressive in our management of the secondary consequences of IAH, including the following:
  - Liberal use of paralytic agents if needed to permit adequate ventilation
  - Aggressive fluid resuscitation to permit adequate urine output
  - Maintaining endotracheal intubation for 24 to 48 hours postoperatively (as outlined previously)

Death
- Mortality following open ventral hernia repair is uncommon (0%–1%).
- Cardiac, pulmonary, and thromboembolic events are the leading sources of postoperative mortality.

OUTCOMES
Polarizing opinions are common among hernia specialists, and are driven by the lack of well-designed comparative trials evaluating outcomes of open ventral hernia repairs with the techniques described previously. Most of the available literature is retrospective in nature. Techniques vary greatly among investigators, as do definitions of postoperative events and duration of follow-up. The addition of innumerable types and sizes of mesh into this equation makes it difficult to draw firm conclusions. There is still a clear need to address these issues in well-designed, prospective randomized trials.

Anterior Component Separation
The separation of components technique described by Ramirez and colleagues28 has undergone many technical refinements since its original description. This method permits mobilization and medial advancement of the abdominal wall musculature, permitting reconstruction of the midline and obliteration of the hernia defect. Anterior component separation has gained wide acceptance today. Table 1 summarizes the
### Table 1
Outcomes of anterior component separation hernia repair

<table>
<thead>
<tr>
<th>Author, Year</th>
<th>n</th>
<th>Method</th>
<th>Wound Complication, %</th>
<th>Mortality, %</th>
<th>Mean Follow-up, mo</th>
<th>Recurrence Rate, %</th>
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<tbody>
<tr>
<td>Ramirez et al,28 1990</td>
<td>11</td>
<td>ACS</td>
<td>—</td>
<td>—</td>
<td>4–42</td>
<td>0</td>
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<tr>
<td>Jernigan et al,51 2003</td>
<td>73</td>
<td>Modified ACS</td>
<td>—</td>
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<tr>
<td>de Vries Reileigh,52 2003</td>
<td>43</td>
<td>ACS</td>
<td>32.6</td>
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<td>Girotto et al,53 2003</td>
<td>96</td>
<td>ACS with onlay mesh</td>
<td>26</td>
<td>—</td>
<td>26</td>
<td>22</td>
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<tr>
<td>Gonzalez et al,9 2005</td>
<td>42</td>
<td>ACS with onlay mesh</td>
<td>63</td>
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<td>3</td>
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<tr>
<td>Hultman et al,54 2005</td>
<td>13</td>
<td>ACS ± mesh</td>
<td>—</td>
<td>—</td>
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<tr>
<td>Jin et al,55 2007</td>
<td>22</td>
<td>ACS with onlay or underlay AHDM</td>
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<td>21.4</td>
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<td>39</td>
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<td>26</td>
<td>—</td>
<td>15</td>
<td>5</td>
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<tr>
<td>Diaz et al,57 2009</td>
<td>31</td>
<td>ACS with onlay AHDM</td>
<td>41.9</td>
<td>—</td>
<td>10.5</td>
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**Abbreviations:** ACS, anterior component separation; AHDM, acellular human dermal matrix.

*Data from Refs.9,28,51-57*
salient results from a number of trials involving anterior component separation. The major drawback to anterior component separation remains the need to create extensive skin flaps, which predisposes the patient to a variety of surgical site events. Wound complication rates as high as 26% to 63% have been found. Other investigators cite difficulty managing subxyphoid, suprapubic, and non-midline defects with this technique because of the absence of a reliable space for prosthetic reinforcement with wide overlap.

**PUPS Method**

PUPS component separation has the advantage of preservation of the lipocutaneous blood supply while permitting external oblique release. Table 2 summarizes the largest reports involving PUPS component separation. These studies have been generally retrospective comparisons of classic anterior separation methods with the PUPS technique. Although recurrence rates were not different between the groups, these studies have highlighted statistically significant differences in rate and severity of surgical site occurrences (skin necrosis, wound infection, abscess). Clarke noted a 25% rate of skin necrosis when using classical methods and 0% with PUPS technique. Similarly, Dumanian and colleagues at Northwestern University outlined their results from a series of 41 patients who had a 2% rate of wound complications compared with a 20% rate when using classic anterior component separation methods. Data suggest that with longer-term follow-up, the recurrence rate after PUPS rises to as high as 13.8%.

**Posterior Component Separation**

Although PUPS techniques address the wound-related morbidity of anterior component separation, it does not address issues with non-midline defects, suprapubic or subxyphoid hernias, or the need for a large space to permit wide mesh overlap of the hernia defect. Posterior component separation addresses all of these concerns. Table 3 summarizes the available data on posterior component separation methods. Overall, these studies consistently demonstrate a long-term recurrence rate well below 10%, far superior to the other techniques described. Although the wound complication rate appears to be no different from anterior component separation rates, it should be emphasized that the severity of the complications noted was far

<table>
<thead>
<tr>
<th>Year</th>
<th>n</th>
<th>Method</th>
<th>Wound Complication, %</th>
<th>Mortality, %</th>
<th>Mean Follow-up, mo</th>
<th>Recurrence Rate, %</th>
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<tr>
<td>Sukkar et al, 58, 2001</td>
<td>51</td>
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<td>38</td>
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Abbreviation: PUPS, periumbilical perforator sparing.

Data from Refs. 32, 58–60
<table>
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<th>Year</th>
<th>n</th>
<th>Method</th>
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<tr>
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<td>Retrorectus dissection only</td>
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<td>“Sublay Mesh”</td>
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<td>Krpata et al, 2012</td>
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<td>Posterior Component with TAR</td>
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Abbreviation: TAR, transversus abdominis release.

Data from Refs. 15, 35–38, 43, 61–63.
less. Few patients required operative debridement, and many of these data were prospectively collected to assess for a wide variety of wound related issues.

SUMMARY

Open ventral hernia repair with component separation represents a group of complex surgical techniques developed to address the ever-growing population of patients requiring abdominal wall reconstruction. The methods described share similar key elements: (1) fascial release permits myofascial advancement and reconstruction of the linea alba, and (2) the creation of vast spaces within the abdominal wall ensure wide overlap of mesh to maximize surface ingrowth. The key difference between anterior and posterior component separation techniques is the location of this potential space. Anterior separation methods create large lipocutaneous flaps and are usually accompanied by onlay of mesh. Posterior separation methods create no such flaps and permit a sublay of mesh. Differences in wound complications and recurrence rates are likely directly related to these 2 facts.

Posterior component separation with TAR detailed previously has several advantages over anterior component separation and other methods of posterior separation. First, it permits extensive lateral dissection in the avascular potential space beneath the transversus abdominis muscle. This creates an ideal space for mesh implantation, while at the same time preserving the entire neurovascular supply to the anterior abdominal wall. The release of the transversus abdominal muscle itself permits sufficient medicalization of the rectus muscles, so as to permit complete reconstruction of the abdominal wall layers posterior and anterior to the mesh. This places the mesh in a well-vascularized pocket, remote from the skin surface. Moreover, the retromuscular position of the mesh permits wide overlap of “difficult” defects (subxyphoid, subcostal, suprapubic). Based on these advantages, as well as its quoted 3% to 5% recurrence rate, posterior component separation with transversus abdominis release has become our preferred method of choice for the management of patients requiring open ventral hernia repair.

REFERENCES