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CHAPTER 95 ■ Abdominal Wall Reconstruction

Brett Phillips and Howard Levinson

KEY POINTS

- By addressing patient modifiable risk factors, such as hemoglobin A1C, obesity, nutrition, and tobacco preoperatively, postoperative outcomes are likely to be optimized.
- Hernia mesh reduces hernia recurrence by about 50%.
- Mesh and graft selection is a continuously evolving field with great controversy, but, in general, lightweight meshes and microporous meshes have lost favor because of their adverse effects.
- Surgical techniques vary widely, and with the exception of a few specific approaches, such as small bites 5 mm apart, 5 mm from the fascia edge to close laparotomy wounds, there are many reasonably good options for reconstructing the abdominal wall.
- Prophylactic hernia mesh or graft is an emerging field that will likely become a part of abdominal wall reconstruction.

DEFINITION OF HERNIA, BULGE, AND DIASTASIS RECTI

An abdominal wall hernia is defined as a defect in the abdominal wall fascia or musculature through which intra-abdominal contents protrude. In general, the goal of hernia surgery is to restore normal muscle anatomy and maintain the muscles in normal alignment. Common examples of hernia include ventral, inguinal, lumbar, Spigellan, umbilical, paraesophageal, diaphragmatic, and femoral (Table 95.1). Ventral hernia in adults is the most common hernia a plastic surgeon will typically manage, so it will be the focus of this chapter. An abdominal wall bulge is a weakness in the abdominal wall musculature where abdominal wall anatomy is normal but the muscles are denervated. Bulges typically form from previous surgery causing nerve injury or from an inability to restore normal muscle anatomy but may also be caused by neuromuscular disease. Diastasis recti is a widening of the linea alba fascia with lateralization of the rectus abdominis muscles but no fascial defect. Hernia, bulge, and diastasis recti are often differentiated by a combination of history, physical exam, and sometimes imaging.

EPIDEMIOLOGY

Approximately two million laparotomies are performed annually in the United States, with ventral hernia being a frequent complication in 10% to 30% of patients.[1–5] The timing of hernia recurrence is not well understood and there is likely a range of months to years from when they may recur.[6] The 10-year ventral hernia recurrence rate ranges from 63% without mesh to 32% when a mesh is added to a repair.[7–9] Approximately 350,000 ventral hernia repairs are performed each year in the United States and practically all include the use of a hernia mesh.[10] Given the above complication rate, incidence of ventral hernia repair, and average cost/patient for each hernia operation in the United States (in 2006, this amount was ~$15,899), an estimated $3 to $6 billion is spent annually on these operations.[10] However, these numbers underestimate recurrence rates in the rapidly growing morbidly obese population in the United States.[11,12] With significant increases in the morbidly obese population, ventral hernia formation is expected to significantly increase as well.[13] In fact, this industry is on the cusp of a giant boom as several publications, including a recent landmark paper in the Lancet, support the use of hernia mesh prophylactically in high risk undergoing laparotomy to prevent hernia occurrence.[14]

TABLE 95.1. ABDOMINAL WALL AND TRUNK HERNIAS

Hernia	Definition/Anatomic Location
Direct inguinal	Inguinal canal through direct fascial defect, medial to epigastric vessels
Indirect inguinal	Inguinal canal through deep inguinal ring, lateral to epigastric vessels
Femoral	Femoral canal, deep to inguinal ligament, medial to femoral vein
Umbilical	Fascial defect at umbilical stalk
Epigastric	General term for fascial defect in superomedial abdominal wall
Incisional	Fascial defect as a result of previous surgery
Ventral	General term for fascial defect of the abdominal wall
Parastomal	Enlarged fascial defect surrounding an ostomy site
Hiatal	Paraesophageal diaphragmatic defect or weakness
Reducible	Hernia defect in which contents can be manually relocated into the organ space
Nonreducible	Hernia defect in which contents are fixed and cannot be manually relocated into the organ space
Incarcerated	Nonreducible hernia that may cause pain and bowel obstruction
Strangulated	Incarcerated hernia with compromised blood supply
Sliding	Hernia defect in which a portion of the hernia sac is formed by another viscus (i.e., colon, stomach)
Littre	Hernia that contains a Meckel's diverticulum, omphalomesenteric duct hernia
Amyand	Hernia that contains the appendix
Obturator	Pelvic floor hernia defect through the obturator foramen
Petit	Posterior lateral inferior lumbar triangle hernia; borders are external oblique, iliac crest, latissimus dorsi
Grynfeltt	Posterior lateral superior lumbar triangle hernia; borders are internal oblique, quadratus lumborum, 12th rib
Cooper	Femoral hernia with two sacs, one protruding through the superficial fascia
Pantaloon	Combined indirect and direct inguinal hernia; two sacs
Spigelian	Hernia defect along semilunar line, at the lateral border of the rectus muscle
Richter	Hernia defect that contains only the antimesenteric border of bowel

ANATOMY

Muscle/Fascia Anatomy

The abdominal wall is a multilayered structure composed of skin, subcutaneous fat, muscle, nerves, blood vessels, and fascia (Figure 95.1). Its function is to provide structural support and mobility of the trunk and to protect underlying abdominal organs.[15] In terms of musculofascial anatomy, the linea alba is central fascia between the paired recti and the semilunar line is the lateral border of the recti. The recti originate from the symphysis pubis and the pubic crest and insert onto the fifth, sixth, and seventh costal cartilages and the xiphoid process. They are encased in an anterior and a posterior rectus sheath. The arcuate line is a horizontal line below the umbilicus that demarcates the lower limit of the posterior rectus sheath, and it is also where the inferior epigastric vessels perforate the rectus abdominis. The anterior rectus sheath is composed of two overlapping fascia layers that are continuations of the external oblique aponeurosis and internal oblique aponeurosis, respectively. The posterior rectus sheath, cephalad to the arcuate line, is also composed of two overlapping fascia layers that are continuations of the internal oblique aponeurosis (the internal oblique aponeurosis splits into an anterior and a posterior layer at the semilunar line to envelope the recti) and the transversalis fascia. The muscular/fascial layers lateral to the semilunar line (from superficial to deep) include the external oblique aponeurosis, external oblique musculature, internal oblique aponeurosis internal oblique musculature, transversalis fascia, and transversus abdominis. External oblique flaps can be raised between the internal and external oblique muscles. Posterior to the transversalis fascia is the parietal peritoneum.

Nerve Anatomy

Understanding the path of nerves and preserving them during surgery is critically important to prevent postoperative denervation and bulges. If nerves are injured, bulges will occur and bulges are difficult to manage because adynamic fabric or scar underperforms innervated muscle. The rectus muscle is innervated by the lower intercostal and lumbar neurovascular bundles traveling between the internal oblique and transversus abdominis muscles and is a target for regional nerve blocks. They enter the rectus sheath laterally and pierce and innervate the rectus muscle and can be injured during dissection leading to bulges.

Vascular Anatomy

Blood supply of the abdominal wall comes from the distal internal mammary vessels and multiple perforating vessels from the iliac and femoral vessels. Understanding the blood supply of the abdominal wall and the superior thigh is important because it is the basis of local flap reconstruction. The deep inferior epigastric vessels are critical for blood supply of the abdominal wall and are often the donor vessel for abdominal autologous tissue reconstruction. The superior epigastric artery is the inferior extension of the internal mammary

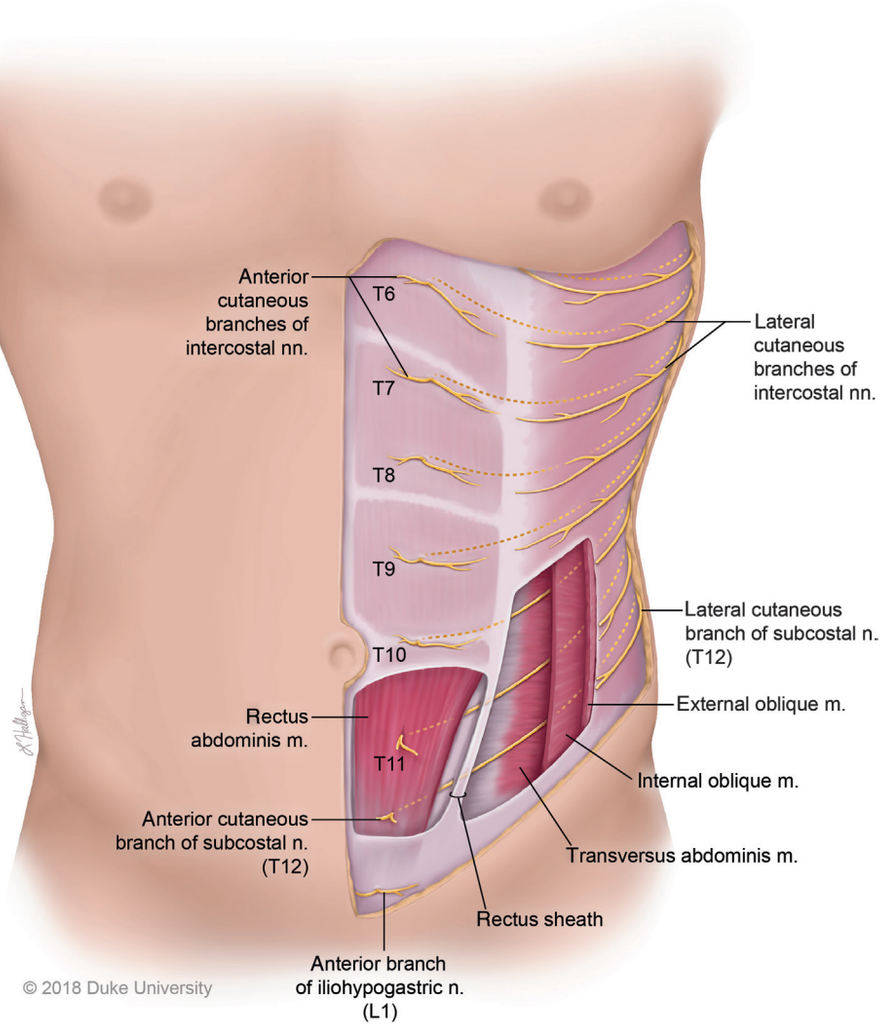

FIGURE 95.1. Abdominal wall anatomy and innervation.

artery and is critical for superior-based rectus pedicle flap that can be used for superior abdominal, back, and chest wall reconstruction. The superior artery runs the length of the rectus muscle and joins the deep inferior epigastric artery that originates from the external iliac artery superior to the inguinal ligament. Inferiorly based abdominal wall flaps can be used for breast (i.e., free TRAM), groin, thigh, and abdominal wall reconstruction. Branches of the common, superficial and profundal femoral arteries will supply options for superior thigh flaps that can be rotated superiorly to assist with middle and lower abdominal wall reconstruction.

[AU1]

PATHOPHYSIOLOGY

There are multiple risk factors that affect outcomes of ventral hernia repair, and these factors should be considered for each patient before surgery. Some of these risk factors are modifiable, in which case surgery may be delayed until after the risks have been managed. In many cases, the risks cannot be reduced but recognition of risk factors nonetheless helps predict outcomes and enhances informed consent. Below, risk factors are classified according to three areas: intrinsic factors, extrinsic factors, and technical factors.

Intrinsic Factors

Intrinsic factors are biologic factors specific to the patient such as collagen disorders; Ehlers Danlos and Marfan syndrome and neurologic diseases such as amyotrophic lateral sclerosis or shingles may weaken the abdominal wall musculature.[16] Although intrinsic factors are not necessarily modifiable, awareness may help with the decision to proceed to surgery. Some surgeons may use additional fixation techniques during repair to enhance outcomes.

Extrinsic Factors

Extrinsic factors are comorbid conditions and medications that adversely affect wound healing. These include but are not limited to tobacco (modifiable), corticosteroids (potentially modifiable), abdominal aortic aneurysm, surgical site infection, chronic obstructive pulmonary disease, multiple surgeries, chemotherapy agents (potentially modifiable), immunodeficiency, radiation, uncontrolled diabetes (potentially modifiable), morbid obesity (potentially modifiable), parastomal hernias, and nutritional status (potentially modifiable).[17] The reader is referred to the literature for a deeper understanding of each factor because space is limited here.

Technical Factors

Technical factors are surgical performance, hernia mesh (graft or textile) selection, and anchoring techniques. Many of these technical factors are widely debated; yet, there are a few agreed upon principles listed below. In terms of surgical performance, a recent prospective, multicenter, double-blind, randomized controlled trial demonstrated that small tissue bites of 5 mm every 5 mm with 2-0 absorbable suture lead to fewer hernias (13%) versus large tissue bites of 1 cm every 1 cm (21%).[18–20] In terms of mesh selection, lightweight meshes have been associated with ventral hernia recurrence because of mesh tearing,[21] whereas moderate-weight and heavy-weight meshes do not appear to be at risk of tearing. Degradable meshes are significantly more expensive than nondegradable meshes but purportedly safer for use in clean-contaminated and contaminated cases, but these benefits are questionable,[22–24] particularly in bridging (rectus muscle cannot be reapproximated in the midline) repair. Mesh fixation technique is also critically important in preventing recurrence. An increased number of fixation points do not necessarily distribute tension across the abdominal wall. One study revealed that more than three fixation points along a 7-cm region does not increase bursting strength.[25] Therefore, sutures should be placed approximately 1 to 2 cm apart circumferentially around the mesh. A final point to consider is that, even with modification of technical factors, ~>20% of ventral hernia repairs recur and this is most often due to failure at the mesh, suture, and tissue interface from suture cheese wiring through the tissue or through the mesh.[26,27]

DIAGNOSIS

History

A thorough history and physical exam is helpful in diagnosing ventral hernias. The most common predictor of ventral hernia is previous abdominal surgery. Patients with signs and symptoms of a ventral hernia may present for elective or emergent repair. In general, surgery is indicated for all ventral hernias but not all patients are good candidates for surgery.[28] A special note is made for postpartum women who develop new onset abdominal bulges. These bulges are typically not hernias but rather diastasis recti from pregnancy. Although diastasis recti condition is an anatomic abnormality, there is no hernia so the disease is classified as cosmetic rather than reconstructive. Care should also be taken in the patient with a history of a pelvic malignancy because the patient may have received radiation through the abdominal wall—a fact can be overlooked in the history. Operating on an irradiated abdominal wall can lead to challenging complications.

Physical Exam

Abdominal Wall

Examination of the abdomen for surgical scars and obvious bulges is done during the initial evaluation. Common physical exam findings, which are typically best done with the patient lying flat yet flexing their abdominal wall muscles by raising their shoulders from midline hernia or twisting for flank hernias, are a separation of muscle edges and pain on palpation. Performing a Valsalva maneuver may also elucidate an incidental hernia. Of course, hernias may be difficult to ascertain in the morbidly obese patient whose occult hernias may surprisingly be encountered at the time of panniculectomy if imaging has not been completed.

Laboratory Assessment

Depending on a patient's medical and surgical history, additional testing may be required. In a diabetic patient, hemoglobin A1C should be obtained to ascertain proper glycemic control. If nutrition is a concern, a nutrition evaluation can be obtained before elective surgery. Patients with respiratory disease may need pulmonary function tests to assess lung capacities. Patients with a history of tobacco use may be tested for cessation by assessing urine cotinine.

Imaging

Routine imaging surveillance, including CT scan, MRI, or ultrasound may identify asymptomatic ventral hernias or recurrences from previous abdominal surgery. Imaging is more reliable at diagnosing incisional hernias than physical exam. The caveat is that asymptomatic hernias not found on clinical exam require treatment.[19] The disadvantage to utilize CT scans is increased cost and radiation exposure. Ultrasound is user dependent but is more accessible and cheaper than CT and there is no radiation.

EMERGENCY VERSUS ELECTIVE SURGERY

Emergent need for ventral hernia repair is most commonly found in the setting of bowel obstruction or following abdominal trauma. Patients with bowel obstruction may complain of distension, abdominal pain, nausea, vomiting, absent flatus, or absent bowel movements. Abdominal findings include tenderness, distension, obvious mass or bulge, tympany, or overlying skin changes. Hernia contents can be

reduced back through the fascial defect are considered reducible. An incarcerated hernia is a nonreducible hernia that may contain bowel but has no findings of vascular compromise. A strangulated hernia is a nonreducible hernia in which the blood supply to the hernia contents is obstructed and will result in necrosis if not repaired. Depending on the clinical situation, hernia repair may be performed during the initial surgery or in a delayed fashion. Obviously, trauma patients with an open, distended abdominal will have their hernia repaired in a delayed fashion, and these cases are typically complicated.

Elective ventral hernia repair is performed to relieve symptoms, improve abdominal wall appearance, prevent need for emergent surgical intervention, and improve quality of life. Hernia repair is often performed as a combined procedure with other surgical services, or it may be scheduled in a delayed fashion if the abdomen cannot be closed from the initial operation because of abdominal compartment syndrome, need for second look operation, or transplant mismatches, for example.

PATIENT-CENTERED OUTCOME TOOLS

Over the past decade, there have emerged several patient-centered areas of investigation and tool development to measure and improve surgical outcomes, including quality-of-life scales, patient registries, and preoperative risk assessment tools. These areas continually mature and rapidly evolve.

Quality of Life Scales

There are a number of validated scales to measure patient-related outcomes following ventral hernia repair, these include but are not limited to generic Short Form-36 (SF-36), and disease specific hernia-related quality-of-life assessment tool (HerQLes), and Carolinas Comfort Scale.[29] The generic SF-36 is useful to compare outcomes across different populations and interventions for cost-effectiveness studies, but it is less effective at assessing disease specific concerns. The Carolinas comfort scale is designed to measure quality of life after mesh implantation during hernia repair, so it cannot measure longitudinal outcomes because patients do not have mesh before surgery, whereas the HerQLes scale is meant to measure abdominal wall function pre- and postoperatively. The two scales complement each other.[29] This 12-question tool with questions related to activities of daily living found improvement in quality of life from preoperative to postoperative patients in as short as 4 weeks postoperatively.

Registries

The two best-known national registries are the National Surgical Quality Improvement Program from the American College of Surgeons, American Hernia Society Quality Collaborative from the American Hernia Society. These two widely used databases collect data from across the United States and the databases are available for inquiry. Each database has led to a number of publications, and this number is likely to increase exponentially over the years and *big data* systematically grows. Peer-reviewed studies have shown that both registries are effective in improving the quality of surgical care.

Risk Analysis

Risk analysis tools are intended to be used by patients and physicians preoperatively to inform both about predicted outcomes. Each of these tools calculates clinical outcomes from a database and the fidelity of the tools will obviously increase as the databases grow. From the AHSQC registries come the outcomes reporting app for clinician and patient engagement (ORACLE). The AHSQC ORACLE uses preoperative and intraoperative information to estimate important 30-day and 1-year outcomes following elective ventral hernia repair using mesh. From the Charlotte Carolina group comes the Carolinas Equation for Quality of Life (CeQOL). The CeQOL predicts the chances of having chronic pain after inguinal hernia repair. The same group has also created the Carolinas Equation for Determining Associated Risks (CeDAR). This free app predicts a patient's risk for wound-related problems and associated costs following ventral hernia repair. The CeDAR app: [AU3]

USE OF MESH IN HERNIA REPAIRS

Mesh and Graft Selection

There are a wide variety of hernia meshes or grafts that one can choose from for repair. They can be classified according to material (e.g., polypropylene, polyester, poly-4-hydroxybutyrate, poly-l-lactic acid, expanded polytetrafluoroethylene, or animal tissue), manufacturing approach (e.g., knitting or weaving of textiles versus tissue processing (allografts and xenografts)), presence of antiadhesive coating, physical characteristics (e.g., for textiles this includes pore size, filament diameter, thickness, areal density (this parameter differentiates light-weight, moderate-weight, and heavy-weight meshes)), and permanence (nondegradable versus degradable). For any given knitted or woven textile, the fabrics physical characteristics will vary according to the diameter of filament used to create the textile (typical filament diameters range between 100 and 150 μm) and the knit or weave structure. Physical characteristics, material selection, and manufacturing approach together affect the textiles mechanical performance (e.g., ball burst, suture retention strength, tear resistance, and stress strain). Current thinking on the clinical relevance of physical characteristics, material selection, manufacturing approach, and mechanical performance is briefly described later, with the understanding that the field is constantly advancing and concepts will become outdated.

The first consideration in choosing a product is whether to choose a textile or a graft. All hernia grafts degrade whereas many synthetic hernia textiles do not. Although each specific graft has its differentiating factors, it is difficult to state that any one graft has a clear competitive advantage over another graft. Hernia grafts were popularized in the 1990s as a means to overcome mesh infection because there was a belief that these were either resistant to infection or would degrade during an infection so there would not be a need to remove these at a second operation.[30] There was also a belief that grafts led to a more durable repair than a textile. These topics are still hotly debated. In 2010, a Ventral Hernia Working Group published consensus guidelines concluding that hernia grafts are appropriate for use in patients at high risk for a surgical site occurrence (e.g., clean-contaminated or contaminated cases) and most surgeons would probably agree with this approach.[31] The main disadvantages to using a hernia graft are that they are orders of magnitude more expensive than synthetic meshes and they lose their mechanical properties as they degrade. In general, the purpose of a synthetic degradable textile is to replace the use of grafts with a less-expensive textile.

The second consideration is whether to use a textile with an antiadhesive coating. Currently, mesh labeling contains warnings that meshes should not be placed in direct contact with the viscera because they may cause erosion, adhesion, fistula formation, or lead to sepsis. This labeling creates a surgical conundrum because meshes are often needed to treat bridging hernias defects. The purpose of an antiadhesive coating is to prevent viscera from adhering to mesh, so most surgeons would use a textile with an antiadhesive coating when bridging a fascia defect or when placing the mesh in a location where it could contact viscera.

Finally, when it comes to choosing a specific mesh for VHR, all [AU4] FDA cleared meshes have met mechanical performance metrics and these metrics appear to meet all clinical needs. There have been a few case reports of lightweight mesh tearing. So, many surgeons prefer moderate-to-heavy weight meshes.[32] In terms of which moderate- or heavy-weight mesh to choose, each mesh will have its specific advantages but it is difficult to state that any mesh is superior to another. In

general, there is a belief that it is advantageous to choose a mesh with the largest pores because large-pore meshes have less material, which clinically related to less chance of infection and less pain because of reduced inflammation.[33] Oftentimes, mesh availability and surgeon preference lead to device selection. Perhaps, the greatest deficiency in mesh today is not which mesh to use but rather how to anchor mesh to tissue.[34] Many surgeons use suture, glue, tacks, or screws to anchor meshes; yet, despite these various approaches failure at the anchor point is common and ventral hernias recur in ~20% of patients. Some groups have invented novel sutures, meshes, and adjuncts in an attempt to overcome this problem, but these products are still under development.[27,35,36] Care should be taken in using permanent mesh in patients who grow show as children or women of child-bearing age.

Anatomic Mesh Placement

The most common locations for mesh placement are as follows[37] (Figure 95.2):

Onlay: anterior to the anterior rectus sheath
Retrorectus: between the recti and posterior rectus sheath
Preperitoneal: posterior to the posterior rectus sheath but anterior to the peritoneum
Intraperitoneal: within the abdomen

Care should be taken when placing a mesh intraperitoneally, because the bowel may come into contact with the mesh, leading to adhesions, erosions, sepsis, and fistula.

In almost all instances, the goal is to restore the recti to their normal anatomic position and to add mesh to bolster the repair, whichever tissue plane is chosen. In select patients, the rectus muscles may not be able to be reapproximated in the midline at the time of hernia repair, in which case a mesh or graft would bridge the defect. In a bridged repair, the mesh serves as surrogate abdominal wall to prevent evisceration. Because the mesh or graft is adynamic, it is inferior to an anatomic repair. Use of a degradable mesh in bridge repair has a high incidence of hernia recurrence.[38]

Mesh Controversies

Mesh type and location continue to be controversial to this day. Literature supports and contradicts itself and varies among geographic locations and patient populations. Because of this ongoing debate, specific recommendations for the location of mesh placement and in what clinical situations should specific mesh types be placed, continue to be based on personal experience and interpretation of the literature. The Ventral Hernia Working Group classified patients into four groups—clean, clean-contaminated, contaminated, dirty—based on contamination, complication risk, and mesh recommendations. They recommend the use of prosthetic mesh in all cases of incisional hernia repair except in situations of gross contamination. Bioprosthetic mesh was recommended in patients with medical comorbidities or any gross contamination.[31,39] Another recent multicentered retrospective review actually found that synthetic mesh when placed in a sublay position had decreased surgical site occurrences and decreased

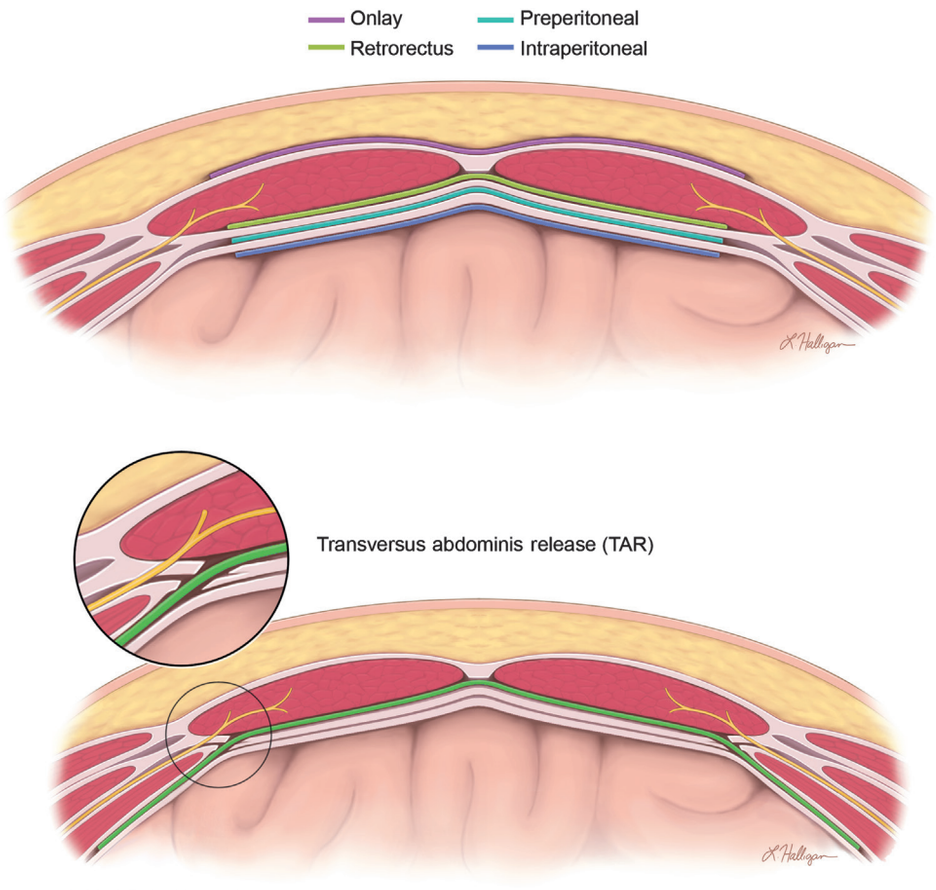

FIGURE 95.2. Anatomic mesh placement.

hernia recurrence rates compared with biologic mesh. High-level evidence with randomized prospective multicenter trials is needed to solve this ongoing debate.[22]

HERNIA REPAIR TECHNIQUE

Hernia repair techniques vary widely and there are oftentimes more opinions than surgeons. A few of the more commonly debated topics are listed below with evidence where applicable.

Suturing Techniques in Laparotomy Closure

A slowly absorbable or permanent monofilament running suture in small bite increments is recommended for primary fascial closure. Smaller bites that are <10 mm from the wound edge are obtained by using a smaller needle at smaller 5 mm intervals. Increased smaller bites and avoiding excessive suture tension will improve the suture length to wound length ratio to above 4.[20,40]

Mesh and Suture

Mesh placement is generally secured where the mesh overlaps the fascia by 3 to 5 cm in all directions. Of course, some studies suggest much wider overlap. There are a variety of techniques used to anchor the mesh including, glue, tacks, screws, and suture. Whichever technique is chosen, the surgeon should keep in mind that a durable repair is paramount. There are insufficient data to suggest that one type of suture is superior to another.

Component Separation

Ramirez described component separation in 1990 with the purpose of realigning the recti in the midline without the use of mesh or local flaps.[41,42] The rationale to the component separation is to release the lateral pulling or retracted oblique muscles, allowing the recti to centralize, without damaging the recti nerves or destabilizing the abdominal wall. The original paper describes relaxing incisions that are made 2 cm lateral to the rectus sheath through the external oblique fascia. The incision is made from costal margin to inguinal ligament. An avascular plane is developed between the external and internal oblique muscles. The posterior rectus sheath is released from the rectus muscles to obtain medialization of the recti 5 cm in epigastrium, 10 cm at the umbilicus, and 3 cm at the suprapubic region. Since the original publication in 1990, component separation has gained traction in the field and the addition of mesh further enhances the repair.[43] Previous stoma or surgery through the rectus muscle is not an absolute contraindication to component separation.[44]

Multiple adaptations of the original component separation have taken place since its original description, including general surgery laparoscopic and plastic surgery limited open approaches. The goal of these adaptations is to provide the same release while limiting dissection to reduce seroma formation and skin necrosis. Umbilical perforator sparing endoscopic techniques, creation of lateral tunnel incisions to provide external oblique aponeurosis release, and the laparoscopic transversus abdominis muscle release are a few examples of these approaches.[37,45]

Laparoscopic/Open Incisional Hernia Repair

Laparoscopic hernia repair with mesh was first reported in 1993 by Leblanc and colleagues.[46] A recent meta-analysis of several randomized controlled trials found that laparoscopic and open incisional hernia repairs with mesh had comparable outcomes including recurrence rates less than 10%.[47]

Local/Regional Flaps

Local and regional flaps for abdominal wall reconstruction are a special class of hernia cases that, in the adult, often occur following trauma or tumor resection. Fasciocutaneous, myocutaneous, and muscle flaps derive from the abdomen, back, and thighs. The most common flaps are listed in **Table 95.2**, where they have been categorized according to upper third, middle third, and lower third reconstruction. In general, lower and middle defects have thigh-based flaps available for reconstruction whereas the upper abdomen is limited to local tissue and the latissimus muscle. Defects of the epigastric and xiphoid regions pose the greatest challenges. In general, tissue expansion does not work well for abdominal wall reconstruction unless expanders are placed above a stable bone platform like ribs or pelvis.

Free Flaps

The same flaps that are listed as local rotational flaps can also be used as free tissue transfer. Typically, free flaps are indicated for very large epigastric defects that are difficult to cover with pedicled flaps. Recipient vessels could include superior and inferior epigastric vessels, and superficial or deep circumflex iliac vessels. If these vessels are not available, then vein grafts could be used to gain access to internal mammary recipient vessels. Intra-abdominal gastroepiploic vessels have also been used as recipient vessels when other vessels are not available. Functional free tissue transfer can also be done with an innervated chimeric anterolateral thigh, rectus femoris, and tensor fascia lata flaps, but the long-term results of these approaches are unknown.[39]

Abdominal Wall Transplant

A special consideration in abdominal wall reconstruction is patients with massive abdominal wall defects who have lost most of their muscle. These patients may be considered candidates for composite tissue allotransplantation. To be a candidate for allotransplantation, the patient should be actively taking immunosuppressive therapy for other transplanted organs. The reason for this is that immunosuppression has been associated with de novo cancer formation and death. Abdominal wall transplantation is still considered experimental with less than 25 cases performed worldwide since 1994 and should only be performed in centers that have the necessary multidisciplinary teams in place.[39]

PROPHYLACTIC HERNIA PREVENTION

Recent studies suggest that there is a role for application of mesh or graft at the time of laparotomy closure in high-risk patients to prevent hernia formation. This is a relatively new concept that is gaining traction with a number of quality clinical trials. In a couple of meta-analyses of clinical trials of elective primary midline laparotomy patients, onlay mesh placement was found to have the least hernia occurrence rates compared to primary suture repair and sublay mesh placement. Onlay mesh repair was found to have higher seroma rates due to the increased subcutaneous tissue elevation.[14,48–50]

CONCLUSION

Incisional ventral hernia is perhaps one of the most common complications in all surgery. The field is ripe with intense debate and controversies and ongoing scrutiny of patient modifiable factors and risk mitigation strategies have lowered the complication rate, but in general better performing medical devices such as suture and mesh or graft are needed. A surgeon who is well versed in the hernia and abdominal wall reconstruction field and takes time to develop their skills appropriately will likely remain busy for a long time.

TABLE 95.2. PEDICLE FLAPS FOR ABDOMINAL WALL RECONSTRUCTION[37,39]

Location and Pedicle Flap	Blood Supply	Flap Characteristics
Upper Third		
Rectus abdominis	Superior epigastric	Inferior or superiorly based flap to cover wounds from chest wall, abdomen, groin, and perineum
		Vertical, horizontal, or oblique skin paddle orientations
External oblique	Lateral intercostal perforators	Ideal for lower chest wall and upper third abdominal defects due to arc of rotation
Latissimus dorsi	Thoracodorsal	Muscle or myocutaneous flap with large arc of rotation to reach superolateral abdominal wall defects
Omentum	Right gastroepiploic	May not be available in patients with previous intra-abdominal surgery or pathology
		Requires persistent abdominal wall defect to pedicle the flap
		Can provide soft tissue coverage for various abdominal wall defects, cover with skin graft
Middle Third		
Rectus abdominis	Superior or deep inferior epigastric	Inferior or superiorly based flap to cover wounds from chest wall, abdomen, groin, and perineum
		Vertical, horizontal, or oblique skin paddle orientations
External oblique	Lateral branches of posterior intercostal perforators	Ideal for lower chest wall and upper third abdominal defects due to arc of rotation
		Medial flap advancement for medial abdominal wall wounds
Tensor fasciae latae	Ascending branch of lateral circumflex femoral	Large skin paddle, distal flap prone to necrosis, fascial use for abdominal wall support
Anterior lateral thigh/vastus lateralis	Descending branch of lateral circumflex femoral	Large flap that usually reaches to umbilicus without difficulty, minimal donor-site morbidity
		Fascia can be used for abdominal wall fascial reconstruction
Anterior medial thigh/rectus femoris	Descending branch of lateral circumflex femoral	Muscle or myocutaneous flap that can be used alone or combined with ALT or vastus lateralis
Lower Third		
Rectus abdominis	Deep inferior epigastric	Inferior or superiorly based flap to cover wounds from chest wall, abdomen, groin, and perineum
		Vertical, horizontal, or oblique skin paddle orientations
Internal oblique	Deep circumflex iliac	Limited arc of rotation, myocutaneous flap
Tensor fasciae latae	Ascending branch of lateral circumflex femoral	Large skin paddle, distal flap prone to necrosis, fascial use for abdominal wall support
Anterior lateral thigh/vastus lateralis	Descending branch of lateral circumflex femoral	Large flap that usually reaches to umbilicus without difficulty, minimal donor-site morbidity
		Fascia can be used for abdominal wall fascial reconstruction
Anterior medial thigh/rectus femoris	Descending branch of lateral circumflex femoral	Muscle or myocutaneous flap that can be used alone or combined with ALT or vastus lateralis
Gracilis	Medial circumflex femoral	Small muscle or myocutaneous flap that could be used for inferior abdominal wall, groin, or perineal wounds

[AU9]

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QUESTIONS

1. A 55-year-old man is undergoing a surgical repair of a recurrent ventral hernia. At the end of the case, the anesthesiologist asks the surgical resident whether or not they should provide a local anesthetic block to help with pain control. Where is the correct abdominal wall anatomic location to provide maximal local anesthesia in this patient?

- **a.** 1 cm medial to the lateral border of the rectus sheath
- **b.** Lateral to the femoral artery on a line connecting the anterior superior iliac spine and pubic tubercle, superficial to the iliopsoas muscle
- **c.** Three fingerbreadths below the anterior superior iliac spine, between the sartorious and tensor fascia lata muscles
- **d.** 2 cm lateral to the rectus sheath, between internal oblique and transversalis muscle
- **e.** 2 cm medial and inferior to the anterior superior iliac spine

2. In a standard component separation as described by Ramirez, where do you get the least advancement in a component separation?

- **a.** Epigastric region
- **b.** Suprapubic region
- **c.** Umbilical region
- **d.** All regions are equal

3. In a high-risk patient with an incisional midline hernia, which one of the following reconstructions is most likely to decrease the chance of hernia recurrence?

- **a.** Bridge repair with mesh
- **b.** Primary fascial closure no mesh
- **c.** Bilateral component separation with mesh placement and primary fascial closure
- **d.** Unilateral component separation, primary fascial closure, no mesh
- **e.** Unilateral component separation with bridged mesh placement without primary fascial closure

4. What is the primary blood supply to a vertical rectus abdominis muscle flap used to reconstruct a chest wall and xiphoid wound?

- **a.** Superficial circumflex iliac artery
- **b.** Superficial epigastric artery
- **c.** Deep Inferior epigastric artery
- **d.** Musculophrenic artery
- **e.** Superior Epigastric Artery

5. What is the optimal abdominal wall primary fascial closure technique?

- **a.** Double looped 0-PDS continuous suture with 2-cm fascial bites every 2 cm
- **b.** #1 PDS interrupted simple sutures with 1 cm fascial bites every 1 cm
- **c.** #0 Polyester braided nonabsorbable continuous suture with 1-cm fascial bites every 1 cm
- **d.** #1 PDS continuous suture with 5 mm fascial bites every 5 mm
- **e.** #0 Prolene continuous suture with 2-cm fascial bites every 2 cm

[AU5]

1. Answer: d. Transversus abdominis plane block is a peripheral nerve block of T6-L1 intercostal nerves that has been shown to improve postoperative pain control in midline laparotomies and abdominal-based breast reconstruction. The correct location of the sensory nerves is between the internal oblique and transversus abdominis muscle lateral to the rectus sheath. The femoral nerve is found lateral to the femoral artery along the inguinal ligament. The lateral femoral cutaneous nerve is found inferior to the ASIS between the sartorious and TFL muscles. The correct location for an ilioinguinal nerve block is 2 cm medial and inferior to the ASIS.

[AU6]
[AU7]

2. Answer: b. Components separation described by Ramirez et al. in 1990 states that approximately 5-, 10-, and 3-cm advancements can be made in a unilateral or 10-, 20-, and 6-cm advancements in a bilateral in the epigastric, umbilical, and suprapubic regions, respectively. Of note, to obtain these advancements, Ramirez described both anterior component release and release of the rectus muscle from the posterior sheath.

3. Answer: c. Although hernia reconstruction remains controversial, hernia recurrence is significantly reduced with the addition of mesh and the ability to obtain primary fascial closure. Component separation strives to advance the abdominal wall toward the midline to achieve primary fascial closure. The addition of mesh further decreases risk of recurrence.

4. Answer: e. In a superiorly based rectus abdominis flap, the primary blood supply is the superior epigastric artery, which is a continuation of the internal mammary artery. The internal mammary branches into the musculophrenic and Superior Epigastric Artery, which is the primary blood supply to the superiorly based rectus abdominis muscle flap. The superficial epigastric artery is incorrect nomenclature. The superficial circumflex iliac artery supplies the SCIP or groin flap and the deep inferior epigastric artery is the primary blood supply for an inferiorly based rectus abdominis muscle flap.

[AU8]

5. Answer: d. Midline laparotomy fascial closure has been shown to have the highest closure strength and resistance to hernia occurrence with the use of a slowly absorbable, monofilament suture with small fascial bites in smaller increments. This technique increases the suture to incision length ratio to greater than 4:1, which provides the additional strength of the closure.