Repair of Umbilical and Epigastric Hernias

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KEYWORDS
- Umbilical hernia
- Epigastric hernia
- Abdominal wall
- Incisional hernia
- Mesh

KEY POINTS
- Explicitly identify and document the goals and objectives of hernia repair for each patient.
- Align the patient’s goals with the entire surgical team.
- Choose a technique that best fits the goals in the context of the clinical scenario and the anatomy of the hernia.
- Choose a technique and prosthetic that best fits the patient’s history, physical examination, and is most likely to best achieve the patient’s goals.
- Make your prosthetic choice based on raw material and architecture of the prosthetic, keeping in mind the patient’s goals, clinical scenario, and proposed beneficial features of the prosthetic.

“It is unwise to be too sure of one’s own wisdom. It is healthy to be reminded that the strongest might weaken and the wisest might err.”
—Mahatma Gandhi

INTRODUCTION

Hernias in general are frequently misunderstood and underestimated in terms of complexity by both patients and doctors.\textsuperscript{1–3} Umbilical and epigastric hernias are no exception, and all hernia specialists have cared for patients with unanticipated
complications that arose from a “simple” hernia repair, often unbeknownst to the original surgeon. Because the overall complication rate is low, and frequently not temporally adjacent to the operation itself, some surgeons perceive that complications, such as recurrence, are nonexistent in their hands. Furthermore, some complications are catastrophic, and can be directly related to the technical aspects of the hernia repair itself, emphasizing the need to keep updated with the continuously changing knowledge base related to hernia repair. Additionally, aligning goals and expectations between the health care team and the patient can help many minor problems that may even be part of the normal postoperative course pass without fanfare, rather than become a source of consternation.

The presentation as an elective, urgent, or emergent problem will lay the foundation for the planning and performance of the repair. This will necessarily include details of the medical and surgical history, anatomic details of the hernia, and how they relate to the goals of operation. Although neither patients nor surgeons can predict the future, thoughtful discussion about future issues, such as pregnancy, promote a mutual sense of confidence and thoughtfulness that may have an impact on the psychological well-being of everyone involved, and could lead to improved clinical outcomes and patient satisfaction.4–7

This article details some relevant and interesting anatomic issues, reviews existing data, and highlights some common and important surgical techniques. Emphasis is placed on a patient-centered approach to the repair of umbilical and epigastric hernias, although this concept could be extrapolated to any hernia repair, and potentially any other disease.

ANATOMY

Embryology of the Abdominal Wall

The ventral body wall first begins to form during the third week of development. This process begins with the differentiation of the mesoderm, located between the ectoderm and endoderm. At this stage, the embryo is a flat disc, the circumference of which will eventually become the umbilical ring. The embryo begins folding during the fourth week of development, characterized by proliferation of the neuroectoderm and mesoderm, but at the same time, cell death and subsequent growth arrest occurs at the umbilical ring.8 At the fifth week, the umbilical vessels (2 arteries and 1 vein), the allantois, the yolk stalk, and the canal connecting the intraembryonic and extraembryonic cavities pass through the umbilical ring.9 This is also the period when there is rapid growth and expansion of the liver, which temporarily makes the abdominal cavity too small to contain all of the intestinal loops, which then enter the extraembryonic cavity through the umbilical ring, referred to as the physiologic umbilical herniation, during the sixth week of development. The intestines remain herniated until the 10th week, when they begin returning to the abdominal cavity. Abnormalities in this process can lead to congenital defects of the abdominal wall.

The umbilical ring remains located at the center of the abdomen and is a transition zone between the body wall and the amnion. By the 10th week, the epithelial tissues have fused in the midline of the embryo, leaving only the umbilical vessels in the region of the umbilical ring.8 At this time, the umbilical cord has formed. The cord contains 2 umbilical arteries, 1 umbilical vein, and the remnants of the allantois, which is referred to as the urachus after it becomes obliterated.9 These structures all have remnants in the adult abdominal wall and can be used as surgical landmarks (Fig. 1).
Anatomy of the Adult Abdominal Wall

The anatomy of the fully developed abdominal wall is very familiar to any surgeon repairing hernias. The vertical midline of the abdomen consists of the linea alba, which is the midline confluence of the aponeuroses of the rectus muscles and the oblique muscles. The composition of the rectus sheath changes depending on the location. Superior to the umbilicus, the anterior sheath is composed of the aponeurosis of the external oblique muscle, as well as the anterior aponeurotic lamina of the internal oblique muscle. Inferior to the arcuate line of Douglas, which is a variable distance below the umbilicus, the anterior sheath consists of all aponeurotic layers (internal/external oblique, and transversus abdominis). Conversely, the posterior sheath superior to the arcuate line of Douglas consists of the posterior aponeurotic lamina of the internal oblique and the aponeurosis of the transversus abdominis. Inferior to the umbilicus, the posterior sheath becomes the posterior aponeurotic lamina of the transversus abdominis muscle. 

Fig. 1. Adult anatomical remnants of the umbilical ring and its contents. (Netter illustration from www.netterimages.com. © Elsevier Inc. All rights reserved.)

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the arcuate line, the posterior sheath consists only of the transversalis fascia. Patterns of midline decussation of the aponeuroses can vary. Normal anatomy is thought to consist of triple lines of decussation anteriorly and posteriorly (Fig. 2).

ETIOLOGY

A hernia is defined as a protrusion of a structure or part of structure through the tissues normally containing it. In general, a hernia is either congenital or acquired. There are multiple theories of how and why hernias develop over time, and most likely each hernia has a multifactorial etiology. Furthermore, it is currently not possible in most cases to determine which factors are most important for a given patient at a given point in time. Etiologic factors are different among patients and even different for a single patient over time. For example, a patient may develop a traumatic hernia from a direct blow to the abdominal wall at one point in time, but develop an incisional hernia at another point in time due to a postoperative wound infection and/or closure technique. Even knowing the likely etiologies for those 2 clinical scenarios leaves us in the dark about an undiagnosed collagen disorder that otherwise has no clinical manifestations (Fig. 3).11

Congenital

Congenital ventral abdominal wall hernias are hernias present at birth, and include omphalocele and gastroschisis, which are not covered in this article. Congenital hernias also include small primary umbilical or epigastric defects. Umbilical hernias are quite common in infancy, and represent the only time hernias can be cured without

Fig. 2. (A) Single anterior and single posterior lines of decussation. (B) Single anterior and triple posterior lines of decussation. (C) Triple anterior and triple posterior lines of decussation. (From Askar OM. Surgical anatomy of the aponeurotic expansions of the anterior abdominal wall. Ann R Coll Surg Engl 1977;59:313–21.)
an operation; most defects are small and more than 80% will close spontaneously by the age of 5.12–16 Because of this, umbilical hernia repair is generally recommended only if the defect persists past the age of 5, or before the age of 5 if the defect is larger than 1 to 2 cm.13,15 Contrary to this, epigastric hernias are often incarcerated and surgical repair is indicated.14,17

Acquired: Primary Ventral Hernia

For this article, we define acquired midline hernias as all those diagnosed during adulthood, recognizing the fact that some of these will have been present at birth, and gone unnoticed by the patient and/or medical community for years. Pregnancy, weight gain, obesity, intra-abdominal tumors, and ascites can all increase the pressure inside the abdomen, causing an increase in size of an umbilical or epigastric abdominal wall defect.18–21 The other consequence of this increased pressure may be an increased likelihood of incarceration or strangulation of preperitoneal fat (falciform or umbilical ligaments), omentum, or bowel.

Patients will sometimes complain of feeling a hernia “come out” suddenly, especially those who participate in lifting heavy items at work, weight lifting, coughing, or any other events that cause significant straining of the abdomen. In the past, it was thought the transient extreme increase in intra-abdominal pressure caused the hernia.15,19 but more recent studies have shown that is probably not the case. There has been research to suggest that patients with hernias have less type I collagen and more elastin in the linea alba than patients without hernias.22,23 This type of connective tissue disorder is not otherwise clinically apparent, but likely predisposes certain individuals to developing a hernia. Of course, more obvious sources of trauma, such as blunt force from a motor vehicle collision or heavy blow to the abdomen, can cause a hernia as well.

Umbilical hernia

An umbilical hernia is a ventral hernia located at or near the umbilicus. These are sometimes referred to as a “periumbilical” hernia, because they are not always located immediately at the base of the umbilicus. Umbilical hernias, or “ruptures” as they were referred to in the past, were described in some of the earliest surgical literature, dating as far back as 1500 BC.24 In 1915, Dr Moschowitz of New York authored an article25 regarding the etiology if umbilical hernias, in which he suggested the pathogenesis is related to weaknesses at the umbilicus from the passage of the umbilical cord vessels. According to Gray’s anatomy, the area surrounding the cicatrix filling the umbilical
defect is weaker than the cicatrix itself, thus making all ventral hernias at the umbilicus “peri-umbilical.”

More recently, in 2011, Fathi and colleagues attempted to characterize the abdominal wall at the umbilical ring to determine what may predispose patients to developing umbilical hernias. They combined 2 previous umbilical ring classification systems into 5 types in an attempt to better define the morphologic characteristics at the umbilical ring and its relationship to the adjacent umbilical and falciform ligaments. It appears that the falciform (or round) ligament may function to protect against hernia when it crosses and covers the umbilical ring, inserting along the inferior border of the ring (Type 3 configuration) (Fig. 4).

Epigastric hernia
An epigastric hernia is a ventral hernia through the linea alba between the umbilicus and the xiphoid process. Controversy has surrounded the etiology of epigastric herniae, and the 2 main hypotheses are the vascular lacunae hypothesis and the tendinous fiber decussation hypothesis. The first descriptions of the former were by Moschcowitz in 1914. He theorized that vascular lacunae formed when small blood vessels penetrated the linea alba. These left a small space where preperitoneal fat from the falciform ligament could begin to herniate and enlarge over time. He found that a perforating blood vessel could always be found in the course of the dissection of epigastric hernias. The decussation hypothesis was popularized by Askar in 1978. He found that epigastric herniae occur exclusively in patients who do not have triple lines of decussation, and this is what predisposes patients to develop an epigastric hernia (see Fig. 2). Most likely, an element of both hypotheses likely predisposes certain patients to an epigastric hernia. These factors, coupled with undiagnosed collagen disorders and significant intra-abdominal pressure, and/or operative therapy requiring a midline incision turn these theories into the reality of a clinical hernia.

Acquired: Incisional Hernia
Another source of hernia is very prevalent in today’s society: iatrogenically caused hernias due to incisions. It is germane to discuss incisional hernia in this article because laparoscopic operations frequently use the umbilicus for an incision, and many open procedures involve the midline. Clinical experience shows that incisional hernias at the umbilicus are then frequently diagnosed and treated the same way a primary umbilical hernia would be. Incisional hernias began to be the subject of research beginning in the second half of the nineteenth century, the beginning of the era of modern abdominal surgery. Incisional hernias can vary widely in their size and extent. The fact that scar is not as strong as the initial tissue is taught to every surgeon in the earliest stages of practice. In 2006, Hollinsky and Sandberg exposed tensile loads to resected linea alba, rectus sheath, and scar tissue. They found that scar tissue has a significantly lower loading capacity and concluded that this poses a permanent risk for herniation.

Hernias have been described from all types of abdominal incisions, but midline incisions through the linea alba have significantly higher rates of subsequent hernia defects. Often a hernia will be noted at or near the umbilicus through a previous vertical midline incision, which may be above, below, or span the umbilicus. This is likely due to difficulties closing the fascia at the level of the umbilicus because of excessive subcutaneous fat, the umbilical stalk, the falciform, and the umbilical ligaments. It may also be due to an unrecognized existing hernia near the umbilicus (Fig. 5). Further complicating matters is that almost half of patients with incisional
hernias will have defects not palpable on physical examination as determined by laparoscopic abdominal wall exploration.34

Therefore, repair of a defect only at the umbilicus when it is part of a larger incision will have a higher rate of recurrence compared with covering the entire old incision, but

![Fig. 4. Type 1: 1 Round or oval UR, RL attached to the top and MdLs, MnL to the lower border of UR. Type 2: Obliterated or slitted UR with all ligaments attached to slit. Type 3: Round or oval UR, RL covered the whole ring and terminated at the inferior border of it with MdLs and MnL. Type 4: Round or oval UR, RL bifurcated and fused to both sides of the ring; MdLs and MnL attached to the lower border of it. Type 5: Round or oval UR, RL attached to top, MnL and MdLs joined before UR and attached as a single ligament to inferior border. Abbreviations: MdL, medial umbilical ligament; MnL, median umbilical ligament; RL, round ligament (falciform); UR, umbilical ring. (From Fathi AH, Soltanian H, Saber AA. Surgical anatomy and morphologic variations of umbilical structures. Am Surg 2012;78(5):540–4; with permission.)](image)
may be an option in select clinical circumstances. One example of this would be a patient with a xiphoid to pubis midline incision with a long-standing (20-year) small defect at the umbilicus who is a very high surgical risk because of advanced age, debility, and multiple comorbidities, and presents with progressively symptomatic hernia.

With the increased use of laparoscopy, an increasing number of trocar site hernias are being seen. In a recent meta-analysis by Helgstrand and colleagues, it was found that 96% of these hernias occur through trocar sites 10 mm or larger, and 82% were located at or near the umbilicus. Based on the size of the laparoscopic access incision, additional defects are less likely, but still include the potential for adjacent primary defects in the periumbilical region, a fact that must be considered during the evaluation and treatment process for port site hernias in this area.

**EPIDEMIOLOGY**

The exact incidence of primary midline hernias (umbilical and epigastric) is unknown owing to a variety of factors, among which are the definition of a hernia (physically visible, radiologically diagnosed, presence of symptoms, or those undergoing treatment) and the ability to track data for diagnosis and procedures in both the inpatient and outpatient setting. Whatever the definition, the incidence of primary midline hernias in the adult population is most likely variable among geographic regions, and probably has to do with many factors, such as the incidence of birth defects of the abdominal wall, and issues known to affect the acquisition and consequence of midline abdominal wall hernias, such as obesity, aortic aneurysm disease, access to surgical care, and HIV disease. Radiological and physical examination screening can find umbilical hernias in 23% to 50% of the adult population in some countries, and up to 90% of pregnant women. The true incidence in the United States is unknown, and even the number of repairs is difficult to ascertain. In 2003, estimates of the number of hernia repairs were 175,000 for umbilical and 80,000 for epigastric/Spigelian. 2010 data compiled by a health care analytics firm revealed that of a total of 988,483 hernia repairs, 504,845 were for ventral hernias of all types. Estimating from the 2003 data that umbilical and epigastric hernia repair make up roughly 22% of all ventral hernia repairs, this would yield 217,466 repairs of primary midline hernias for 2010 in the United States.
According to reports from other data analytics companies, ventral hernias comprised 32% of all hernia repairs in the United States in 2011 and 2012.\textsuperscript{44} Using Current Procedural Terminology and International Classification of Diseases, Ninth revision, coding information for 2012, there were 180,730 umbilical and 8994 epigastric hernia repairs (total = 189,724) identified in the United States.\textsuperscript{45} Sales data for deployable prosthetics designed for small ventral hernias (Ventralex; Bard, Proceed Ventral Patch; Ethicon, and V-Patch; Atrium) reveal that 127,424 units were sold in 2011.\textsuperscript{46}

Examining these data in aggregate and using clinical experience and logic, we recognize that incidence of umbilical and epigastric hernias will be higher for radiological and physical examination screening programs compared with incidence data from those who have had the diagnosis coded or the condition treated. Determining the incidence of the disease may be important for estimating prevalence, determining the burden to the health care system, and allowing industry to develop sensible business planning regarding research and development. Therefore, we have compiled a table with variable incidence rates (which would depend on definition and diagnostic methods) so as to make quick reference to the US population as a whole (Table 1). The table includes the percentage of existing primary midline hernias that are repaired based on variable estimates of the true incidence. Physical examination and ultrasound studies have shown that 23% to 50% of patients screened specifically for umbilical hernia actually had one. This study was performed at King Saud University in Riyadh, Saudi Arabia, over a 2-year period and included 302 patients.\textsuperscript{37} A physical examination study was conducted in Nigeria by the division of pediatric Surgery at the University of Texas Southwestern Medical Center.\textsuperscript{38} A noted that 49% of nonpregnant adults older than 18 had an “outie,” defined as “any protrusion of the umbilical tip past the periumbilical skin,” but only 8% had an umbilical hernia defined as “protrusion of at least 5 mm and diameter of at least 10 mm.” The data from Lau and colleagues\textsuperscript{40} reviewed diagnosis records from 14 California hospitals and identified those with the diagnosis of a ventral hernia (umbilical, incisional, ventral, epigastric, or Spigelian). There were a total of 2,807,414 patients in the regional database, of which 0.9% (25,267) had one of the specified diagnoses, and 74% (18,697; 0.7% of total) of those patients had an umbilical hernia. This suggests the prevalence of umbilical hernia in California is 0.7% of the population, and we could extrapolate this data to the US population as a whole (see Table 1).

<table>
<thead>
<tr>
<th>True Incidence of Adult Umbilical and Epigastric Hernia: Varies Depending on Method and Definition of Diagnosis (Based on 2012 Census Data)</th>
<th>2012 Umbilical and Epigastric Hernia Repairs, n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1%, n = 2,395,164</td>
<td>189,724 (7.9)</td>
</tr>
<tr>
<td>10%, n = 23,951,641</td>
<td>189,724 (0.8)</td>
</tr>
<tr>
<td>20%, n = 47,903,282</td>
<td>189,724 (0.5)</td>
</tr>
<tr>
<td>30%, n = 71,854,923</td>
<td>189,724 (0.3)</td>
</tr>
<tr>
<td>40%, n = 95,806,565</td>
<td>189,724 (0.2)</td>
</tr>
<tr>
<td>50%, n = 119,758,207</td>
<td>189,724 (0.16)</td>
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</tbody>
</table>

* 189,724 number is based on data from Aileron Solutions 2012.\textsuperscript{45} Data from Refs.\textsuperscript{36–38,45,47}
Since we know the approximate number of umbilical hernia repairs in the United States and the prevalence of umbilical hernia in California (0.07%), we can estimate the number of diagnosed umbilical hernias in the United States (US census 2012 population >18 years = 239,516,413) to be approximately 1,676,615. Estimating 189,724 repairs in 2012, the national percentage of diagnosed umbilical hernias repaired is about 11% (189,724/1,676,615).

Interestingly, the annual number of umbilical and epigastric hernia repairs seems to be decreasing. In 2003, there were an estimated 255,000 repairs, in 2010 an estimated 217,466 repairs, and in 2012 an estimated 189,724 repairs. If accurate, the reasons for the declining number of repairs are unknown. Regarding the repair technique, and using 2012 estimated repairs and 2011 US sales data, about 67% (127,474/189,724) of umbilical/epigastric hernia repairs use a deployable prosthetic. Given that some prosthetic repairs use a flat sheet, the overall percentage of repairs with a prosthetic is probably somewhat higher than this.

We have surmised that reasons for low use and potentially decreasing number of repairs of umbilical hernia include lack of symptoms, no diagnosis, outdated knowledge of surgical options, small size, fear of surgical procedures, and economic recession.

**CLASSIFICATION**

In 2009, the European Hernia Society (EHS) developed a classification system for all types of ventral hernias. This included primary and incisional. Epigastric and umbilical hernias are considered primary ventral hernias if they are not caused by an incision. Ventral hernias through a previous abdominal incision should be considered an “incisional hernia.” Primary umbilical and epigastric hernias are classified (1) by their location (either at or near the umbilicus or in the epigastrium) and (2) by the size of the defect. The EHS suggested that a primary hernia should be considered small if it is smaller than 2 cm in diameter, medium if it is between 2 and 4 cm, or large if it is larger than 4 cm.

**CLINICAL PRESENTATION**

The presentation of primary ventral hernias is highly variable and patient dependent, and no different than incisional hernias. Patients will often know about a primary umbilical or epigastric hernia for years before seeking medical attention. As symptoms, such as pain, discomfort, or an increase in the size of the herniated contents, develop, patients may seek medical attention.

Primary ventral hernias can also present as an acutely incarcerated hernia. Incarceration is the state of a hernia whereby the contents cannot be reduced into the abdomen. Patients will typically present with a painful bulge at the hernia site. This may be associated with variable amounts of tenderness, and occasionally changes in the skin, such as erythema, ulceration, or ischemic changes. There may be an associated bowel obstruction, but this may not be fully apparent if the symptoms have been present for a short period of time, even if small bowel is incarcerated. Regardless of whether or not the herniated contents are fat or intestine, acutely incarcerated hernias represent a scenario whereby urgent or emergent operation is warranted. Chronically incarcerated primary ventral hernias are considerably different from the acute variety, but may still present with emergent problems, such as bowel obstruction. The highly variable clinical situation dictates that the surgeon be aware of these issues, and apply the best course of action for the given scenario (Figs. 6 and 7).
Preoperative Planning

When a patient presents to the surgeon’s office with a hernia, the visit must involve much more than a physical examination of the hernia itself. Although it is important

Fig. 6. Primary umbilical hernia. The patient with this chronically incarcerated primary ventral hernia allowed this to enlarge because of a lack of symptoms, and reluctantly agreed to repair only after repeated bouts of small bowel obstruction. (A, B) Preoperative. (C) Five years postoperative. (D) Computed tomography scan 5 years postoperative.

SURGICAL TECHNIQUE

Preoperative Planning

When a patient presents to the surgeon’s office with a hernia, the visit must involve much more than a physical examination of the hernia itself. Although it is important

Fig. 7. An axial computed tomographic image showing a ventral hernia with incarceration of the anterior transverse colonic wall, consistent with a Richter hernia. There is surrounding edema of the herniated wall. There is also passage of contrast distally and lack of bowel dilatation. (From Kim R, McCoy M, Bistolarides P, et al. Richter’s epigastric hernia with transverse colon strangulation. Am Surg 2012;78(5):E301–3; with permission.)
that symptoms, such as pain, enlargement, and so forth, are delineated, we believe it is more important to explicitly identify the patient’s goals for repair, and then align those goals with the surgical team. This will allow the surgeon to select the best approach for the specific patient. A patient with a large hernia sac at the umbilicus could undergo a laparoscopic repair and adequately repair the hernia, but the patient might consider the operation a failure if the large bulge and excess skin is not resolved (Fig. 8), especially if the patient’s goal is to have a normal abdominal wall contour. This issue will be different among all patients, regardless of age, body habitus, and activity level, and underscores the fact that the simple and explicit identification of their goals will help align expectations and plan the appropriate operation.

Fig. 8. Large hernia sac at umbilicus after laparoscopic repair. (A) Preoperative: umbilical hernia with larger hernia sac. (B) Appearance of sac immediately postoperatively. (C) Appearance of sac at 1 year postoperatively.
Generally, the surgical options include an open or laparoscopic repair, with or without mesh, and with or without defect closure. A laparoscopic-assisted approach could be used for a large hernia sac with a relatively small defect. In the future, we may be able to offer a Natural Orifice Translumenal Endoscopic Surgery (NOTES) approach.\textsuperscript{50–55}

Selection of the approach will in part be directed by the explicitly defined patient goals, but must also take into account the medical/surgical history, as well as the details of the hernia, particularly related to the size of the defect and the hernia sac. For example, a patient with a 2-cm periumbilical defect with an associated epigastric diastasis who wants to (or should) avoid general anesthesia will be better served with an open approach using a prosthetic designed for this approach (Fig. 9) compared with a laparoscopic approach (Fig. 10).

Fig. 9. Open prosthetics (for repair of small hernias). (A) Ethicon Proceed Ventral Patch. (B) Atrium Medical Corp. V-Patch. (C) Bard Ventralex ST Hernia Patch. (D) Covidien Composite Ventral Patch. (E) CA.B.S. Air Surgical Mesh. (Courtesy of (A) Ethicon, Cincinnati, OH, with permission; (B) Atrium Medical Corp, Hudson, NH, with permission; (C) Bard, Warwick, RI. © 2013 C.R. Bard, Inc. Used with permission; and (D) Covidien, Mansfield, MA, with permission.)
Mesh Repair Versus Primary Repair

From an anatomic standpoint, the goal of an umbilical or epigastric hernia repair is to stop and/or prevent intra-abdominal contents from protruding through the hernia defect. This can be accomplished by closing the defect primarily, sealing it with a prosthetic, or a combination of these two. Detailing all of the options regarding suture selection and placement, direction of defect closure, and prosthetic placement is beyond the scope of this article. Although the issues are outlined, we highlight operative details of common and increasingly important techniques. Pertinent issues related to the advantages and disadvantages of primary versus prosthetic repair are in Table 2.

The choice on whether or not to use a prosthetic should be based on clinical factors related to the patient’s anatomy, physiology, and presentation, as well as environmental factors, such as the availability of prosthetics (Box 1). Further complicating matters is the decision about which prosthetic to use. Having an algorithm that takes into account patient goals, anatomic factors, and overall medical condition will help the surgeon choose a technique, which in turn can help guide prosthetic choice (Fig. 11).

It is important, however, to recognize that all primary repairs are not the same, and variability exists among suture choice, suture technique, direction of defect closure, and number of layers closed. There are also a host of existing clinical factors that come into play, such as obesity, strenuous work environments, physically demanding sporting or leisure activities, smoking status, and wound-healing capabilities. Further complicating matters are historical events, such as previous operations, wound infections, and issues that may predict a higher risk of future operations, such as inflammatory bowel disease and planned pregnancies, particularly if there have been previous cesarean sections that involve an incision that includes the umbilicus.

Surgical Procedure

Primary repair

Primary repair of umbilical and epigastric hernia refers to suture repair without the use of a prosthetic. It is important to note that these are not a uniform group of repairs. This can be accomplished with permanent, short-acting or long-acting absorbable sutures. The sutures can be monofilament, multifilament, or barbed sutures. Additionally, the defect can be closed vertically or transversely using a short or long suture technique with continuous or interrupted sutures. One additional variable of primary repair is the use of multiple suture lines, with overlapping or imbricated fascial layers. The relative advantages and disadvantages of these options are listed in Table 3.
Mayo originally described a repair with multiple suture lines: some interrupted permanent sutures and some running absorbable sutures. He found that the transverse direction of closure was also advantageous, as it allowed for closure of larger defects, and seemed to have less tension, and presumably better results. This is logical given that all vertical incisions will have perpendicular tension with bilateral oblique muscle contraction with Valsalva maneuvers, whereas transverse incisions are not subject to this. Additionally, the linea alba is more compliant longitudinally.

Table 2
Relative advantages and disadvantages of prosthetic versus primary repair

<table>
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<tr>
<th>Advantage</th>
<th>Disadvantage</th>
<th>Comment</th>
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<tbody>
<tr>
<td><strong>Prosthetic repair</strong></td>
<td>— Short-term cost, availability of prosthetics</td>
<td>— Learning about prosthetic choices and new techniques</td>
</tr>
<tr>
<td>Lower recurrence rate</td>
<td>— Availability of prosthetics</td>
<td>— Potential prosthetic-related complications</td>
</tr>
<tr>
<td>—</td>
<td>— Learning about prosthetic choices and new techniques</td>
<td>Mesh contraction, mesh infection, chronic pain—all very low incidence.</td>
</tr>
<tr>
<td>—</td>
<td>— No prosthetic-related complications</td>
<td>— Higher recurrence rate</td>
</tr>
<tr>
<td>Ubiquitous availability</td>
<td>— Availability of a wide range of high-quality suture material varies among geographic locations.</td>
<td></td>
</tr>
<tr>
<td>— Lower procedure cost</td>
<td>— May be offset by higher recurrence rates.</td>
<td>— Multiple techniques available</td>
</tr>
<tr>
<td>— No prosthetic-related complications</td>
<td>— Complications related to permanent sutures are similar in terms of incidence and morbidity compared with prosthetics.</td>
<td></td>
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<tr>
<td>—</td>
<td>— Permanent vs absorbable suture; simple closure vs layered closure; transverse vs vertical closure; running vs interrupted suture; short vs long stitch technique.</td>
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Long-term cost may be the same considering lower recurrence rates with a prosthetic. A simple list, however, does not take into account the complexity of the issue due to continuously changing variables among patients, surgeons, and facilities.
compared with transversely, a fact that would also favor less tension on a transverse suture line.56,57

Although prosthetic repair in North America is common, recent European reports state that in Sweden and Denmark, primary repair is performed in 70% to 77% of cases,58,59 thus making it worthwhile to detail this technique.

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**Box 1**

Factors that in most clinical scenarios would favor primary versus prosthetic repair. Departure from these factors does not constitute a breach in the standard of care, but should be accompanied by a logical thought process specifically designed to achieve the goals of repair in the unique clinical situation.

**Favors Use of Prosthetic Repair**
- Larger-size defect (>2–4 cm)
- Any size defect associated with the following:
  - Increased intra-abdominal pressure
  - Strenuous work environment
  - Physically demanding sports or leisure activities
  - Chronic cough (severe allergies, chronic obstructive pulmonary disease, and so forth)
  - Planned pregnancies
- Etiology is previous operation (incisional hernia)
  - Previous port site with defect closure
  - Previous postpartum tubal ligation
- Anticipated poor wound healing
  - Chronic steroid use
  - History of poor wound healing
  - Poorly controlled ascites
- Known collagen disorders
  - Ehlers-Danlos syndrome
  - Marfan disease
  - Personal history of multiple hernias
- Associated midline diastasis rectus

**Favors Primary Repair**
- Smaller size (<2–4 cm) without associated conditions mentioned above
- Active skin infection, especially at the site of hernia repair
- Emergent indication with strangulated omentum or bowel
- Skin ulceration with leaking ascites
- No appropriate prosthetic available (typically due to administrative and/or financial constraints)
- Informed patient choice—any reason

One technique is a simple apposition of the edges. One investigator in 1959 found this technique to reduce tissue ischemia and improve suture line strength compared with methods with multiple suture lines in a rabbit model. There are still variables associated with this that are related to suture technique, defect closure direction, and suture type (see Table 3). One early method of a multiple suture line repair was described by William J. Mayo in Rochester, Minnesota. He began by vertically closing the edge of one side of the umbilical ring to the opposite side 1.0 to 1.5 inches from the edge with nonabsorbable silver wire interrupted horizontal mattress sutures. The free remaining edge of the ring was then closed with running, absorbable (gut) suture (Fig. 12). Dr Mayo subsequently found that closing the defect transversely allowed closure of larger defects, as the tension was generally less with the transverse closure. His recurrence rates were reported to be 2 of 75, and a modern case series revealed 0% to 5.4% recurrence with this technique at 24 to 70 months of follow-up. Others have reported higher recurrence rates with this method. Interestingly, some of these higher recurrence rates are for different clinical scenarios, such as incisional and emergency umbilical hernia repairs, which may have an impact on perceptions regarding repair of elective primary ventral hernias.

Open Prosthetic Repair

Using a prosthetic for open repair of a primary ventral hernia (umbilical or epigastric) is not as simple as it sounds. Options for prosthetic choice include a variety of raw materials and designs, and can be placed in a variety of locations with or without defect closure. Options for open prosthetic repair are listed in Table 4.

In the fairly recent past, small primary ventral hernias using a prosthetic were difficult to perform with a small incision, prompting many surgeons to adopt a laparoscopic approach, a technique we detail later. New prosthetic designs, however, have made prosthetic deployment easier and quicker than using a flat sheet.
Table 3
Variables in primary repair of umbilical and epigastric hernia

<table>
<thead>
<tr>
<th>Technique</th>
<th>Advantages</th>
<th>Disadvantages</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suture selection</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Permanent</td>
<td>No loss of suture strength</td>
<td>Increased risk of long-term suture sinus formation</td>
<td>Risk of infection and sinus formation slightly increased with braided vs monofilament sutures</td>
</tr>
<tr>
<td>Long-acting absorbable</td>
<td>Higher tensile strength through wound-healing period</td>
<td>Only available in monofilament suture More inelastic memory often perceived as poorer handling characteristics</td>
<td>Barbed monofilament sutures are also available Has the best chance for long term wound strength and avoiding suture sinus formation</td>
</tr>
<tr>
<td>Short-acting absorbable</td>
<td>Available in both braided and monofilament</td>
<td>Lower tensile strength through wound-healing period Braided suture has slightly increased risk of infection</td>
<td>May appeal to a larger group of surgeons’ preference for braided suture</td>
</tr>
<tr>
<td>Suture technique</td>
<td>Short stitch technique (5–8 mm bites of tissue in terms of depth and travel, avoids muscle)</td>
<td>Long stitch technique (&quot;standard&quot; technique of 1-cm bites of tissue on terms of depth and travel)</td>
<td>Single layer closure</td>
</tr>
<tr>
<td>------------------</td>
<td>---------------------------------------------------------------</td>
<td>---------------------------------------------------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td></td>
<td>• Distributes tension over larger area</td>
<td>• Reduced area of tension distribution</td>
<td>Technically easy</td>
</tr>
<tr>
<td></td>
<td>• Higher suture line strength compared with long-stitch technique</td>
<td>• Weaker suture line strength compared with short-stitch technique</td>
<td>No redundancy</td>
</tr>
<tr>
<td></td>
<td>• Tissue pull-through results in small defect</td>
<td>Theoretically will have a higher recurrence rate, generate more tissue ischemia, and have a higher infection rate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Shown to reduce hernia rates by almost 25%*</td>
<td>Data extrapolated from primary laparotomy closure still applies regarding tissue ischemia, but outcomes in hernia repair are unknown</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Shown to reduce surgical site infection rate by 50%*</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Requires a minor practice modification</td>
<td>• Importantly reduces tension over a larger area</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Slightly increases operative time</td>
<td>• Importantly reduces tension over a larger area</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Important to avoid muscle in the closure line</td>
<td>• Importantly reduces tension over a larger area</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Data for reducing hernia and infection rates based on primary laparotomy closure*</td>
<td>• May not be useful for defects smaller than 1 cm as a running suture, but concepts still apply</td>
<td></td>
</tr>
</tbody>
</table>

* The data referring to the primary laparotomy closure is ref. 71
These “ventral patches” are designed to allow a prosthetic larger than the defect to be deployed under the fascia, then anchored to the fascia with or without defect closure with attached suture straps. The prosthetics are designed for intraperitoneal use by using barrier-coated or partially absorbable prosthetics (see Fig. 9). Table 5 is a list of currently available prosthetics designed specifically for use in small ventral hernias.

We highlight only one technique of repair using a newly designed ventral patch. A skin incision is made over the defect, the size and direction depending on the size of the defect, previous scars, and degree of obesity. The herniated contents are resected and/or reduced, as appropriate. A space large enough for the prosthetic is then dissected between the abdominal wall and the umbilical and/or falciform ligaments. If using a monopolar energy device for hemostasis, take appropriate precautions to avoid thermal injury of the underlying viscera. We believe it is not important to avoid breaching the peritoneal cavity when using a prosthetic designed for intraperitoneal use. The purpose of the preperitoneal dissection is primarily to allow the prosthetic to lie flat, in intimate contact with the abdominal wall fascia. Occasionally, the defect is enlarged slightly in a transverse orientation to allow for a proper dissection. The prosthetic is then folded, and placed in the preperitoneal space. The fixation straps are pulled up through the fascial defect, cut the appropriate length, and the defect is then closed transversely with a short running suture, incorporating the shortened fixation tabs into the closure. We use a long-acting, absorbable, barbed suture with the short-stitch technique for defect closure. If the umbilical skin was elevated by the hernia and/or dissection, it is tacked down to the subcutaneous and/or abdominal wall fascia with

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**Fig. 12.** Original graphics from Mayo’s 1901 description of “An Operation for the Radical Cure of Umbilical Hernia.” (A) Depiction of the closure of the peritoneum. (B) Depiction of the closure of the aponeurosis. (From Mayo WJ. VI. An operation for the radical cure of umbilical hernia. Ann Surg 1901;34(2):276–80.)
<table>
<thead>
<tr>
<th>Prosthetic Types</th>
<th>Options</th>
<th>Design</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Permanent</td>
<td>Polypropylene</td>
<td>Barrier</td>
<td>Prosthetic deployment designs allow for easier subfascial placement.</td>
</tr>
<tr>
<td></td>
<td>Polyester</td>
<td>Deployment design for subfascial</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PTFE</td>
<td>placement</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Composite</td>
<td>Fixation tabs</td>
<td></td>
</tr>
<tr>
<td>Absorbable</td>
<td>Synthetic</td>
<td>Short acting</td>
<td>Should use in an augmentation, rather than bridging fashion, ie, close</td>
</tr>
<tr>
<td></td>
<td>Biologic</td>
<td>Long acting</td>
<td>the defect over or under the prosthetic.</td>
</tr>
<tr>
<td>Prosthetic placement</td>
<td>Intraperitoneal</td>
<td>Subfascial, extraperitoneal location</td>
<td>Subfascial, extraperitoneal location may be intraperitoneal or extraperitoneal, but the prosthetic should lay flat against the abdominal wall, and superficial to umbilical and falciform ligaments. Onlay technique requires small skin flaps.</td>
</tr>
<tr>
<td></td>
<td>Extraperitoneal (subfascial)</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inlay (edge to edge): not recommended</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Onlay: anterior aspect of fascia</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>Defect closure</td>
<td>None</td>
<td>Single vs multiple suture lines</td>
<td>Running suture technique may not be feasible for very small defects.</td>
</tr>
<tr>
<td></td>
<td>Transverse</td>
<td>Short-stitch vs long-stitch technique</td>
<td>Defect may be closed with onlay or subfascial mesh placement.</td>
</tr>
<tr>
<td></td>
<td>Vertical</td>
<td>Running vs interrupted</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Permanent vs absorbable sutures</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Absorbable short vs long acting</td>
<td></td>
</tr>
</tbody>
</table>

Prosthetics may be used with or without defect closure.

*Abbreviation:* PTFE, polytetrafluoroethylene.
Table 5
Listing of currently marketed prosthetics specifically designed for open, retro-fascial placement during repair of umbilical and epigastric hernias

<table>
<thead>
<tr>
<th>Prosthetic Trade Name</th>
<th>Manufacturer</th>
<th>Materials</th>
<th>Shape and Sizes</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ventralex ST Hernia Patch</td>
<td>CR Bard - Davol; Warwick, RI</td>
<td>PP and PGA fibers, PDO ring, absorbable barrier (HA, CMC, PEG)</td>
<td>Round</td>
<td>Partially absorbable, barrier coated</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4.3 cm</td>
<td>102 g/m² and 37 g/m² layers of PP creating a “pocket” for fixation tacks</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>6.4 cm</td>
<td>Stiff at implantation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>8.0 cm</td>
<td>Pair of fixation straps</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Absorbable component short acting (30 d)</td>
</tr>
<tr>
<td>Proceed Ventral Patch</td>
<td>Ethicon; Cincinnati, OH</td>
<td>PP, PGA, PDO rings, sutures and film, absorbable barrier (oxygenated regenerated cellulose)</td>
<td>Round</td>
<td>Multiple layers of polymers laminated together</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4.3 cm</td>
<td>45 g/m² PP after absorption</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>6.4 cm</td>
<td>Stiff at implantation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Pair of fixation straps anchored at center</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Absorbable component short acting (30 d)</td>
</tr>
<tr>
<td>C-Qur V-Patch</td>
<td>Atrium Medical; Hudson, NH</td>
<td>PP, fully coated with omega 3 fatty acids (absorbable)</td>
<td>Round</td>
<td>2 layers of 85 g/m² creating a “pocket”</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4.3 cm</td>
<td>Fixation straps</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>6.4 cm</td>
<td>Absorbable O3FA ring for deployment</td>
</tr>
<tr>
<td>Parietex Composite Ventral Patch</td>
<td>Covidien; Mansfield, MA</td>
<td>PET, PGLA ring, absorbable barrier (porcine collagen and glycerol)</td>
<td>Round</td>
<td>Partially absorbable (ring only)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4.6 cm</td>
<td>4 fixation tabs located near center</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>6.6 cm</td>
<td>Removable positioning handles</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>8.6 cm</td>
<td>80 g/m² PET after absorption</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Absorbable barrier</td>
</tr>
<tr>
<td>Biomesh CA.B.S. Air</td>
<td>Cousin Biotech; Saddle Brook, NJ</td>
<td>PP, PP/PTFE</td>
<td>Round</td>
<td>Balloon deployment</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>6.8 cm (PP)</td>
<td>Comes with 2 or 4 preplaced sutures</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5, 7, and 9 cm (PP/PTFE)</td>
<td>PP version: 2 layers of mesh</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>PP/PTFE version: 2 layers of PP, 1 layer ePTFE</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Each PP layer &lt;40 g/m²</td>
</tr>
</tbody>
</table>

Abbreviations: CMC, carboxymethyl cellulose; HA, hyaluronic acid; O3FA, omega-3 fatty acid; PDO, polydioxanone; PEG, polyethylene glycol; PET, polyethylene terephthalate; PGA, polyglycolic acid; PGLA, poly(glycolic-co-L-lactic) acid; PP, polypropylene; PTFE, polytetrafluoroethylene.
at least 2 short-acting, interrupted absorbable sutures. We use more than one suture to avoid disruption in the unlikely event of a subcutaneous hematoma or seroma.

**Laparoscopic Repair**

Laparoscopic repair of small, readily identifiable primary midline ventral hernias in thin patients is generally not necessary, and often more invasive than the open mesh repair described previously. There are circumstances, however, when a laparoscopic approach is warranted. These include incisional hernias, incarcerated hernias (acute or chronic), suspicion for multiple defects, suspicion for a defect larger than 4 cm, and obesity. Incisional hernias that are present at the umbilicus, but are part of a longer midline incision that traverses or ends at the umbilicus are frequently associated with multiple defects discovered during laparoscopic exploration, but not detected clinically. Acutely or chronically incarcerated hernias can be difficult to repair laparoscopically, but a laparoscopic approach may be beneficial to assess viability of the gastrointestinal tract compared with a small incision immediately over the hernia defect. Occasionally, there is suspicion for multiple or large defects based on history and/or physical examination, including obesity and chronically incarcerated hernias, which can also increase the uncertainty regarding defect size and number. In these scenarios, a diagnostic laparoscopy can help determine whether or not the defect is large or small. For larger and/or multiple defects, a larger prosthetic may be required, and the surgeon can proceed with a laparoscopic, or laparoscopic-assisted, technique. If the defect turns out to be single and small, the surgeon could then proceed with a less painful open repair with a deployable prosthetic designed for this purpose.

We will make a few points about the technical aspects of diagnostic laparoscopy and laparoscopic repair of small midline ventral hernias. It is important to dissect the falciform and/or umbilical ligaments away from the abdominal wall to identify other defects, and allow the prosthetic to intimately adhere to the abdominal wall, rather than the peritoneum and fat in these embryologic remnants. Identification of all defects will allow use of the most appropriately sized prosthetic. We also believe it is important to use a prosthetic that extends to the lateral border of the rectus muscles to avoid fixation injury to the epigastric vessels or muscle, and to give the prosthetic a better mechanical advantage, particularly if there is a diastasis of the rectus muscles (Fig. 13). It is our practice to use both suture and tack fixation, and place a prosthetic large enough to extend to the lateral borders of the rectus muscles to avoid fixation injury to the epigastric vessels. Prosthetic size, as well as fixation type and amount, should be appropriate for the defect and patient, keeping in mind that recurrence rates will be higher for smaller mesh:defect size ratio, larger defects, and recurrent hernias.

**Pain Management**

Commonly, local anesthetic administered at the hernia location by the surgeon is sufficient for intraoperative and early postoperative pain relief. Longer-term postoperative pain relief is accomplished by orally administered nonsteroidal anti-inflammatory, acetaminophen, and/or narcotic-based medications. Recently there has been research in regional anesthetic blocks for umbilical hernia repair. The rectus sheath block, first described in 1899, is the subject of many scientific articles, mostly in the pediatric surgery literature. Many studies have shown a benefit to using a rectus sheath block in pediatric patients undergoing umbilical hernia repair in the form of decreased postoperative pain scores and use of narcotic pain medication. The rectus sheath block involves injecting local anesthetic into the potential space between the rectus muscle and the posterior rectus sheath bilaterally. It has classically been described as a procedure performed blindly, but more recently there have been
descriptions of performing the block in an open fashion during the umbilical hernia repair, or using an ultrasound probe to visualize the muscles, fascia, and peritoneal cavity. The goal is to infiltrate local anesthetic into the area where the sensory nerves of the abdominal wall travel.

Another regional abdominal wall anesthetic technique is the transversus abdominis plane (TAP) block. It was first described as a blind technique, using anatomic landmarks, by Rafi in 2001. The technique is now commonly performed using ultrasound guidance. The anesthetic is injected into the space between the internal oblique muscle and the transversus abdominis muscle, and is usually performed bilaterally so as to achieve midline anesthesia (Table 6).

Our practice is to use local anesthetic infiltration into the wound for all small and medium umbilical and epigastric hernias in adults, when approaching the repair in an open fashion. If a laparoscopic procedure is performed, or when using an open technique for a larger hernia, we (surgical team) perform an ultrasound-guided bilateral TAP block at the conclusion of the procedure.

Immediate Postoperative Care and Recovery

After performing a small to medium-sized open umbilical or epigastric hernia repair, the postoperative care is rather routine. The wound should be dressed as the
operating surgeon sees fit. We ask the patients to refrain from getting the wound wet for 24 to 48 hours, or at least until there is no drainage. We also recommend returning to normal activities as tolerated by pain, and do not dictate specific restrictions. Because return to work has many factors that weigh in to the decision, we engage the patient in that decision-making process.

Complications

Even though umbilical and epigastric hernia repairs are often considered “minor” procedures, our experience at a referral center has demonstrated that they can be fraught with complications. Most problems are wound related, including seromas, hematomas, superficial or deep surgical site infections, and mesh infections. Patients also may experience chronic pain at the site of the repair. Many of these complications do not require specialized treatment, but are often associated with multiple visits to the surgeon’s office, medical therapy, hospital admission, or additional operative procedures. Long-term complications related to suture sinuses are probably no different from laparotomy closure, making long-acting absorbable suture material an attractive choice. Long-term complications specifically related to the prosthetic are very uncommon, even when used for emergent repair of incarcerated and strangulated hernias.

Another major source of morbidity is hernia recurrence. Hernia rates of up to 54% have been quoted in the past literature for a simple sutured repair. More recent studies have found recurrence rates to be from as low as 0% to 3% with a mesh repair, to up to 14% for a sutured repair. Cost and availability influence prosthetic use; however, the cost of another hernia repair because of recurrence should also be considered when looking at economic issues. Additionally, issues from a patient perspective, such as inconvenience and morbidity of a second operation, are also important.

SPECIAL CONSIDERATIONS

Acutely Incarcerated Hernia

Acutely incarcerated umbilical and epigastric hernias range from life-threatening conditions requiring emergent operation, to simple reduction of the hernia with outpatient

<table>
<thead>
<tr>
<th>Anesthesia</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local Skin, subcutaneous tissue, and fascia at hernia location</td>
<td>Administered by surgeon, duration usually less than 6 h</td>
</tr>
<tr>
<td>Regional block Rectus sheath, TAP</td>
<td>Administered by surgeon or anesthesia, lasts up to 24 h, TAP usually performed with ultrasound guidance</td>
</tr>
<tr>
<td>IV medication NSAIDs, narcotics, acetaminophen</td>
<td>Administered by nurse in hospital setting</td>
</tr>
<tr>
<td>PO medication NSAIDs, narcotics, acetaminophen</td>
<td>Self-administered at home</td>
</tr>
<tr>
<td>Topical NSAIDs, narcotics</td>
<td>Administered at home</td>
</tr>
</tbody>
</table>

Abbreviations: IV, intravenous; NSAIDs, nonsteroidal anti-inflammatory drugs; PO, oral; TAP, transversus abdominus plane.
follow-up. It is important to keep in mind that the typical patient goal of treatment of an acutely incarcerated hernia is pain relief, and there is also a desire to fix the problem so it does not return. This scenario requires the surgeon to balance the risk of prosthetic use in a potentially contaminated operative field versus risk of a recurrent hernia. Because of the higher recurrence rates when repaired without mesh, recent research has shown that prosthetics can actually be placed in the setting of an incarcerated hernia. In 2007, Abdel-Baki and colleagues randomized 42 patients with acutely incarcerated paraumbilical hernia into 2 groups: one with onlay polypropylene mesh repair, and one with tissue repair only. Over an average of 16 months, 19% of the tissue repair group had a hernia recurrence, whereas no patients in the mesh repair group recurred. There were no significant differences in rates of wound infections, seromas, or any other complications. A retrospective study from The Netherlands found that suture repair had more than twice (24%) the rate of wound infection compared with mesh repair (11%) for acutely incarcerated umbilical hernias. Furthermore, only 1 of 99 patients with mesh repair had to have their mesh removed. Univariate and multivariate analysis revealed, however, that the type of repair (mesh vs suture) did not have an impact on wound infection, rather bowel resection was associated with an odds ratio of 3.5 for development of a wound infection. In spite of this, the overall wound infection rate for all cases was only 12.3%. It appears that mesh implantation can be safe, even in an acutely incarcerated hernia, and should always be considered to decrease recurrence rates. Further research and analysis regarding type of prosthetic and prosthetic placement technique are warranted to improve outcomes even further.

**Pregnancy**

The challenge of the hernia diagnosed during pregnancy lies in deciding when to operate. Generally, a watchful waiting approach is encouraged for asymptomatic patients until the postpartum period. Buch and colleagues found that there were no complications with 12 patients who underwent postpartum inguinal or umbilical hernia repairs anywhere from 4 to 52 weeks after delivery. All of the hernias were diagnosed during pregnancy and none of the patients had incarceration of their hernia before it was repaired. Four patients had subsequent uncomplicated pregnancies.

A more difficult problem is the pregnant patient presenting with an acutely incarcerated hernia. There is very little literature published regarding this circumstance, but general surgical principles still apply. It is important to remember that the health of the mother is of paramount importance to the survival of both mother and fetus. Careful consideration should be paid to the age of the pregnancy, anesthesiology issues, pain intensity, duration of incarceration, and ability to reduce the hernia. The contents of the hernia are also an important factor in the decision making. In later stages of pregnancy, the uterus will protect the umbilical area from incarceration of the intestine, but it is still possible to have incarcerated omentum that can be quite painful. As always, a clear discussion should be had with the patient and family regarding the issues involved in the decision making and the risks and benefits of observation versus operative repair should be detailed.

**Diastasis Recti**

The surgeon should always assess every patient with a primary midline ventral hernia for the presence of diastasis recti, a fact that we have seen commonly overlooked during examination of a relatively “simple” problem (see Fig. 10). The patient should be examined while standing and while lying down, with and without Valsalva maneuvers. As the diagnosis of diastasis alone is not a surgical problem, when it accompanies the
presence of a hernia, the problem becomes more complex. By definition, having a separation between the 2 rectus muscles in the midline naturally causes a thinning of the linea alba.\textsuperscript{104–106}

It is logical that suturing together a thinned out linea alba will have a higher recurrence rate than suture repair with a normal linea alba. Therefore, we believe that a patient with an umbilical or epigastric hernia that resides within or at the terminus of a rectus diastasis should generally undergo a prosthetic repair versus a primary suture repair.

\textit{Cirrhosis and Ascites}

Umbilical hernia repair in the cirrhotic patient with ascites has been the topic of much debate and literature. Classical surgical teaching of a “wait and see” approach is no longer recommended, as the consequences of skin necrosis and ascites leak are disastrous (Fig. 14). Most studies since 2000 advocate for early, elective repair of umbilical hernias in patients with cirrhosis and ascites\textsuperscript{107–112}; the patient needs to be optimized for the surgery and ascites controlled. Many different techniques have been used for surgical repair, and it is unclear at this time if any method is superior. A study by Ammar in 2008\textsuperscript{113} showed that cirrhotic patients who had a mesh repair had a trend of more wound infections compared with those repaired without mesh, but a significantly decreased recurrence rate. More recently, Cho and colleagues\textsuperscript{114} found that the Model for End-Stage Liver Disease (MELD) score was very important to predict preoperative mortality for elective hernia repair in patients with portal hypertension. Patients with a MELD score higher than 15 had a mortality rate of 11.1% compared with a rate of 1.3% in those patients with a MELD score lower than 15.

Fig. 14. Patient with umbilical hernia that was not repaired due to presence of cirrhosis and ascites. Patient developed rupture of umbilical hernia sac with leaking ascites, as shown.
SUMMARY

Umbilical and epigastric hernias are primary midline defects that are present in up to 50% of the population when screened for with physical examination and radiological studies. In the United States, only about 1% of the population carries this specific diagnosis, and only about 11% of these end up being repaired, which would be approximately 263,000 per year. Actual data regarding repairs, however, reveal as low as 189,000 repairs in 2012, but accurate data collection is very difficult because of the lack of a robust national medical record.

The repair of these hernias are aimed at symptom relief and/or prevention, and the patient’s goals and expectations should be explicitly identified and aligned with the health care team. Although the overall success rates of prosthetic versus suture repair are high, use of a prosthetic repair consistently offers lower recurrence rates compared with suture repair in both elective and emergent situations, with a very low prosthetic-related complication rate. Precise technical issues related to both types of repair are complex, and highly variable. Some of this variability is related to an endless number of unpredictable clinical scenarios related to the patient, the surgeon, and the institution, such as urgency of repair, associated diastasis recti, pregnancy, ascites, surgeon preference, and product availability.

Although reducing variability can be good when considering poor outcomes, it can also adversely affect outcomes by stifling innovation. With so many assumptions in the diagnosis and treatment of umbilical and epigastric hernias, use of a continuous quality improvement program may help to improve poor outliers, and maintain innovation in techniques and policies that improve outcomes even further.

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