# Hernia Emergencies

D. Dante Yeh, MD[a,*], Hasan B. Alam, MD[b]

**KEYWORDS**

• Hernia • Emergencies • Acute care surgery

**KEY POINTS**

- Hernia emergencies are commonly encountered by the acute care surgeon.
- Although the location and contents may vary, the basic principles are constant: address the life-threatening problem first, then perform the safest and most durable hernia repair possible.
- Mesh reinforcement provides the most durable long-term results.
- Underlay positioning is associated with the best outcomes.
- Components separation is a useful technique to achieve tension-free primary fascial reapproximation.
- The choice of mesh is dictated by the degree of contamination.
- Internal herniation is rare, and preoperative diagnosis remains difficult.
- In all hernia emergencies, morbidity is high, and postoperative wound complications should be anticipated.

## INCARCERATED INGUINAL AND FEMORAL HERNIAS

### *Definitions*

A hernia is a weakness or disruption of the fibromuscular tissues through which an internal organ (or part of the organ) protrudes or slides through. Collectively, inguinal and femoral hernias are often lumped together into groin hernias. Inguinal hernias can be indirect or direct. Indirect hernia protrudes through the internal inguinal ring, which is an opening in the transversalis fascia, located laterally to the inferior epigastric artery. Direct inguinal hernia, on the other hand, comes out through the Hesselbach triangle (bounded laterally by the inferior epigastric vessels, medially by the lateral border of the rectus muscle, and inferiorly by the inguinal ligament). Femoral hernias protrude through the femoral canal, which is located below the inguinal ligament on the lateral aspect of the pubic tubercle. It is bounded by the inguinal ligament anteriorly, pectineal ligament posteriorly, lacunar ligament medially, and the femoral vein laterally. This is a tight opening bordered by sturdy ligaments, which makes it more susceptible

[a] Department of Surgery, Massachusetts General Hospital, Harvard Medical School, 165 Cambridge Street, Suite 810, Boston, MA 02114, USA; [b] Department of Surgery, University of Michigan Health System, 1500 East Medical Center Drive, Ann Arbor, MI 48109, USA
* Corresponding author.
*E-mail address:* DYEH2@PARTNERS.ORG

Surg Clin N Am 94 (2014) 97–130
http://dx.doi.org/10.1016/j.suc.2013.10.009 **surgical.theclinics.com**
0039-6109/14/$ – see front matter 

to strangulation. It is also located rather deep, which obscures the physical examination and often delays the diagnosis.

The following terms are important to clarify when discussing hernias: (1) reducible, which refers to a hernia that can go back into the body cavity easily (either manually or spontaneously); (2) irreducible/incarcerated, which refers to a hernia that cannot be reduced; it does not automatically mean that the hernia is strangulated or that obstruction is occurring (although both are possible); and (3) strangulated, which refers to a hernia in which the blood supply to the incarcerated contents is compromised.

## *Epidemiology*

Hernias are among the oldest recorded afflictions of humans, and inguinal hernia repair is one of the most common general surgical procedures.[1] Inguinal hernias comprise 70% to 75% of all abdominal wall hernias and are more common in men, whereas femoral hernias account for less than 5% and are more common in women.[2,3] Overall, 96% of groin hernias are inguinal and 4% are femoral. These hernias are more common in men. The lifetime risk of developing a groin hernia is 25% in men, but less than 5% in women. Men are also 20-fold more likely to need a hernia repair.

## *When to Repair?*

Surgery remains the only effective treatment, but the optimal timing and method of repair remain controversial. Although strangulation rates of 3% at 3 months have been reported by some investigators,[4] the largest prospective randomized trial (n = 720) of (watchful waiting) men with minimally symptomatic inguinal hernias showed that watchful waiting is safe.[5] Frequency of strangulation was only 2.4% in patients followed up for as long as 11.5 years. Long-term follow-up shows that more than two-thirds of men using a strategy of watchful waiting cross over to surgical repair, with pain being the most common reasons. This risk of crossover is higher in patients older than 65 years.[6] Once an inguinal hernia becomes symptomatic, surgical repair is clearly indicated. Femoral hernias are more likely to present with strangulation and require emergency surgery[7] and are thus repaired even when asymptomatic. Because this article focuses on incarcerated hernias, nonoperative options are not discussed.

## *How to Repair?*

### *Open versus laparoscopic*

The laparoscopic approach has gained popularity for the repair of nonincarcerated groin hernias, but randomized trials have shown that this approach has a higher recurrence rate, more serious complications, requires a substantial learning curve, and is not cost-effective.[8,9] A large European study showed that laparoscopic repair was no better than open, with a higher chance of technical errors.[10] In expert hands it remains an attractive option, and often its selection for elective repairs is driven by patient demand. However, once the hernia has become incarcerated, an open approach is the safest, because it allows for proper evaluation of the hernia contents, safe reduction, resection (if needed), and a secure repair.

### *Mesh versus primary*

In recent years, Lichtenstein tension-free mesh-based repair has become the criterion standard for elective hernia repair.[11] Numerous permanent meshes are available, with no convincing data establishing the superiority of any particular brand/mesh type. In the setting of bowel incarceration, if there is no ischemia and no need for resection, use of permanent mesh is still relatively safe.[12,13] However, implantation of permanent synthetic mesh in the setting of bowel ischemia/resection can lead to an unacceptably

high risk of mesh infection and long-term complications. Biological meshes have been shown to be resistant to infections, but their use in contaminated fields is associated with poor long-term durability of the repair.[14] Because fixing the acute problem is a higher priority than the long-term durability of the repair, our preference is to either use a biological mesh or perform a traditional mesh-free tissue repair (eg, Bassini, McVay, or Shouldice repairs). Hernia recurrence rates are no doubt higher with this approach, but at the time of recurrence, an elective repair with a permanent mesh repair can be performed more safely.

## *Perioperative Decision Making*

### *Should a painful hernia be reduced before surgery?*

A strangulated hernia should not be reduced preoperatively. Doing so results in pushing a loop of dead/threatened bowel into the peritoneal cavity and converts a localized process into diffuse peritonitis. Also, this procedure forces the surgeon to perform laparoscopy/laparotomy to evaluate the bowel and to decrease the chances of delayed complications (eg, perforation of ischemic bowel or ischemic stricture). The safest approach is to immediately take the patient to the operating room for a local exploration via a groin incision (but be ready for laparotomy). The surgeon must ensure the viability of the bowel in the sac before it is reduced into the peritoneal cavity. Should an incarcerated hernia be managed in a similar fashion? In an acutely incarcerated hernia that shows no signs of impending ischemia (eg, tenderness, increased white blood cell count, fever, skin changes), an attempt at reduction is not unreasonable. This strategy can prevent its progression to strangulation and allow a more elective operation. Our preference in such cases is to repair the hernia during the same hospital admission, typically after a 12-hour to 24-hour period of observation (after reduction). This period of observation should identify the small subset of patients in whom the reduced bowel is nonviable. At the same time, vigorous attempts to reduce an incarcerated hernia, especially if tender or incarcerated for more than a short period, are misguided. The safest approach is to take such a patient to the operating room for examination of hernia sac contents and careful reduction under general anesthesia after ensuring bowel viability.

### *Radiographic workup*

Incarcerated or strangulated inguinal hernias do not require any radiographic workup unless the diagnosis is in doubt (eg, unreliable examination in an obese patient), or the contribution of hernia to the symptoms is unclear (eg, possible epididymitis/orchitis/torsion in a patient with hernia). Radiographic studies can delay the definitive operative intervention and worsen the outcomes. Femoral hernias are notoriously difficult to appreciate on physical examination and are often discovered on radiologic studies (computed tomography [CT] or ultrasonography).

### *Unable to reduce- what now?*

Infrequently, the hernia neck is too tight (or sac too large) to permit open intraoperative reduction, even under general anesthesia. Opening the sac and putting the patient in a steep Trendelenburg position helps. If this strategy is unsuccessful, then the surgeon should not hesitate to enlarge the hernia defect. A solid familiarity with the anatomic boundaries of the defect is essential to avoid causing iatrogenic injury to critical adjacent structures. In case of indirect inguinal hernia, the internal oblique/conjoint fibers can be incised in an upward direction. Direct hernias rarely pose this problem but can be treated the same as indirect hernia. Femoral hernias are more challenging. A small incision to partially divide the inguinal ligament anteriorly should suffice. Alternatively, the lacunar ligament can be divided medially (be aware of an aberrant obturator artery, which can pass in the anterior margin of the lucanar ligament in up to 30%). In very

large, chronic hernias, reduction may be challenging because of loss of domain, but they rarely need emergent surgery. Despite being nonreducible, strangulation is a rare event in these giant hernias.

#### *Loop of dead bowel in the hernia: what next?*

If dead bowel is found on opening the hernia sac, the next step depends on the quality of the surgical exposure. If the hernia defect can be enlarged sufficiently to permit safe resection and anastomosis of the bowel, then performing the procedure through the groin incision is reasonable. After reducing the anastomosed bowel back into the abdomen, the hernia defect can be repaired either with a biological mesh or primary tissue approximation. However, there should be a low threshold to convert the operation into a laparotomy if better exposure is required for the bowel resection, or if the extent of the threatened bowel is unclear. The hernia can then be fixed either from inside the abdomen or through the groin incision.

### *Other Issues*

#### *Bilateral hernias*

There seems to be increasing consensus that for elective repair of bilateral symptomatic hernias[15] or recurrent hernias, the laparoscopic approach is appropriate. However, for an emergent situation, our recommendation is to repair the incarcerated/strangulated hernia using an open approach, without worrying about the contralateral hernia. Once the patient has recovered from the acute episode, an elective repair of the other side can be performed either open or laparoscopically.

#### *Cancer*

Rarely, incarcerated bowel is found to have a mass that might be malignant. In such cases, basic surgical oncology principles apply. An appropriate cancer resection of the bowel, including adequate mesentery/lymph nodes, should be performed. This situation invariably requires converting the procedure to a standard laparotomy.

## INCARCERATED UMBILICAL/INCISIONAL/ABDOMINAL WALL HERNIA

### *Epidemiology*

Ventral hernias (VH) are a family of hernias involving the anterior abdominal wall. They are diagnosed on physical examination by the presence of a bulge and often come to the patient's attention because of visual appearance, discomfort, pain, intestinal obstruction, or intestinal infarction. Some VH can enlarge to such an extent that the bulk of abdominal contents come to reside within the hernia sac and it becomes physically impossible to reduce back into the abdominal cavity proper. This scenario is referred to as loss of domain.

The natural history of VH is to progressively enlarge over time. Emergency repair, required in up to 20% of VH, is naturally associated with poorer outcomes, and elective repair is generally recommended on diagnosis.[16] Incarceration with strangulation is less common in cases with a very small hernia neck (<1 cm) or very large hernia neck (where bowel loops can easily move in and out of the sac without restriction). VH can be broadly classified into congenital and acquired causes; however, the principles of treatment are similar for all hernia emergencies of the abdominal wall.

### *Congenital*

#### *Epigastric*

Located between the xiphoid process and umbilicus, epigastric hernias occur in approximately 3% to 5% of the population and are more common in men.[17] Most

are small (1 cm), and only 50% are symptomatic. Twenty percent are multiple. Hernia contents are usually preperitoneal fat, and it is rare that bowel becomes incarcerated in congenital epigastric hernias.

#### *Umbilical*

As the name implies, umbilical hernias occur in the periumbilical region. Most congenital umbilical hernias close spontaneously by the age of 5 years, and most umbilical hernias encountered in adults are acquired.

#### *Hypogastric*

Hypogastric hernias occur below the umbilicus and rarely develop spontaneously.

### *Acquired*

#### *Incisional*

Most abdominal wall hernias are acquired postoperatively through the surgical incision, although there are some rare acquired hernias, which are discussed later. Incisional hernias are estimated to occur after 10% to 30% of laparotomies,[18–20] and almost 150,000 incisional hernia repairs are performed each year in the United States. Risk factors for postoperative incisional hernia development include wound infection, obesity, male gender, older age, smoking, steroid use, chemotherapy, connective tissue diseases, and malnutrition.[21] Less well-studied factors include closure technique (suture material, continuous vs interrupted) and incision type. The highest incidence occurs after midline incisions, with lower incidence after transverse and paramedian incisions.[22] Almost 20% of incisional hernias are incarcerated or strangulated on initial presentation, and these emergent repairs are associated with worse outcomes.[23,24]

Although less common, incisional hernia can also occur after laparoscopic operations, with the reported incidence between 0.6% and 2.8%. Most trocar-site hernias occur through ports more than 10 mm in the umbilicus, and it is strongly recommended to primarily close these trocar sites at the completion of laparoscopic surgery.[25]

#### *Umbilical*

Acquired umbilical hernias are believed to develop secondary to increased intra-abdominal pressure and are associated with conditions such as pregnancy, cirrhosis with ascites, obesity, and large abdominal tumors. They are more common in women, and it is estimated that only 5% require emergent repair.[26]

Umbilical hernia develops in 20% of patients with liver cirrhosis, which is significantly increased above the 2% incidence seen in the general population.[27,28] If ascites is present, this incidence increases further to 40%.[29] Reasons for this increased incidence include increased intra-abdominal pressure secondary to ascites, malnutrition, and dilation of the recanalized umbilical vein. These dilated umbilical veins (secondary to portosystemic collateral flow) can make the dissection treacherous (**Fig. 1**). The risk of precipitating esophageal variceal bleeding after umbilical hernia repair is controversial, and claims of an association have not been confirmed.[30–32]

Historically, surgeons were reluctant to repair these hernias electively, because early reports documented perioperative mortality as high as 16% to 31%.[30,31] However, recent series have shown that, with modern perioperative care, mortality after elective umbilical hernia repair does not differ between cirrhotics and noncirrhotics. It is recommended to repair umbilical hernias electively in cirrhotic patients, because emergency operation is significantly more morbid than elective repair.[33,34]

Reasons for emergency repair include bowel incarceration, skin ulceration/erosion with leakage of ascites, and bowel evisceration.[35] Patients usually report progressive

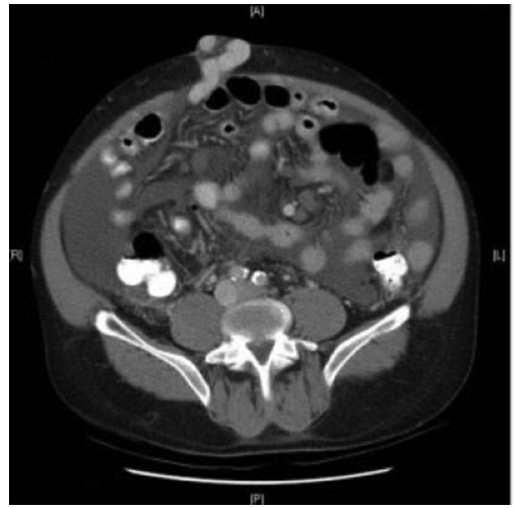

**Fig. 1.** Dilated umbilical veins. (*From* Shlomovitz E, Quan D, Etemad-Rezai R, et al. Association of recanalization of the left umbilical vein with umbilical hernia in patients with liver disease. Liver Transpl 2005;11(10):1298–9; with permission.)

enlargement, although 1 rare presentation is sudden incarceration after ascites decompression via paracentesis.[36,37] history of antecedent skin ulceration is elicited in most patients (80%) presenting with ruptured spontaneous paracentesis, and this finding should be considered an indication for urgent repair, because mortality after spontaneous rupture is up to 30%.[28,38] Depending on the degree of physiologic derangement, the repair may be delayed if resuscitation and metabolic correction are required. In the interim, the hernia should be covered with a sterile occlusive dressing and the patient treated with antibiotics. Nonsurgical management of ruptured umbilical hernia is associated with mortality up to 88%.[38]

The strongest factor influencing umbilical hernia recurrence after repair in cirrhotic patients is the presence of ascites.[39] Recurrence rate after primary repair in cirrhotic patients with ascites is as high as 73%.[31,39] Multiple adjuncts have been described, including medical diuretic therapy, peritoneovenous shunting,[40,41] transjugular intrahepatic portosystemic shunting,[28,42,43] and temporary peritoneal dialysis catheter placement.[44] Our preference is to use closed-suction drainage combined with skin adhesive 2-octyl cyanoacrylate (Ethicon) reinforcement of the skin closure for a watertight seal. The optimal duration of postoperative ascites drainage is unknown, and the decision to remove the drain should be considered on a case-by-case basis.

### *Anatomy of the Anterior Abdominal Wall*

A thorough understanding of the musculature of the anterior abdominal wall is required to effectively repair herniation in this body region (**Fig. 2**). Laterally, from most superficial to deep, the 3 muscles are the external oblique, internal oblique, and transversus abdominis. Medially, a paired longitudinal muscle, the rectus abdominis, is enveloped by a strong fascial sheath comprising the fused aponeurotic extensions of the aforementioned lateral muscles. The right and left rectus sheath are fused at the midline structure, the linea alba.

The umbilicus is the obliterated remnant of the umbilical cord, and is marked by the confluence of adult remnants of fetal circulation: the ligamentum teres, the medial umbilical folds, and the median umbilical ligament.

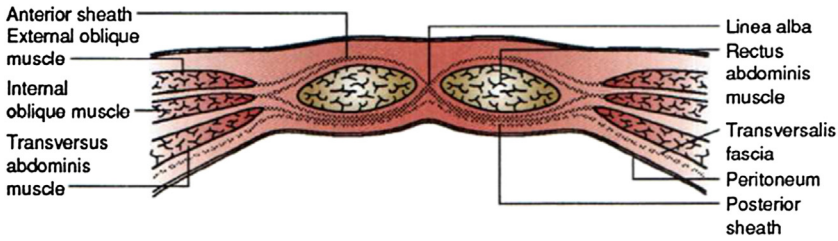


**Fig. 2.** Layers of the anterior abdominal wall. (*From* Fitzgibbons RC Jr, S, Quinn TH. Abdominal wall hernias. In: Mulholland KD, Lillimoe KD, Doherty GM, et al, editors. Greenfield's surgery: scientific principles and practice. New York: Wolters Kluwer/Lippincott Williams & Wilkins; 2011. p. 1163; with permission.)

An important anatomic landmark is the arcuate line, located a few centimeters caudal to the umbilicus. Below this boundary, the posterior rectus sheath is absent, and all aponeurotic layers pass anterior to the rectus muscle.

***Mesh options***

An in-depth description and comparison of all available meshes is beyond the scope of this review. The choice of a particular brand is commonly dictated by hospital availability and surgeon familiarity. With a confusing array of options, it is helpful to broadly categorize meshes according to their basic characteristics. The main distinction is between synthetic and biological material.

**Permanent synthetic** The term prosthetic applies to a mesh composed of a permanent, synthetic material, usually polypropylene, polyester, or expanded polytetrafluoroethylene. Prosthetics are available in a variety of weights and pore sizes, allowing for varying rates of native fibroblast ingrowth and incorporation into the host tissue. Only certain prosthetic meshes with a smooth microporous surface are appropriate for intraperitoneal placement (**Table 1**). Direct contact between macroporous meshes and bowel is associated with unacceptably high rates of erosion or fistulization. If there is no risk of bowel contact, microporous mesh is not recommended, because the tight weave prevents adequate vascular ingrowth (but still allowing bacterial infiltration), increasing the risk of infection, encapsulation, and seroma formation.

**Absorbable** Absorbable synthetic meshes such as polyglactin (Ethicon) are not durable enough for definitive repair but may be considered in a grossly infected wound, in which permanent prosthesis implantation is contraindicated and an expensive biological graft is quickly digested by the high collagenase activity present in the wound.

**Table 1**
**Prosthetic mesh options**

| Extraperitoneal Only | Intra-abdominal |
|---|---|
| Prolene (Ethicon) | DualMesh, DualMesh Plus (W. L. Gore) |
| Marlex (Bard) | Dulex (Bard/Davol) |
| Ultrapro (Ethicon) | Composix (Bard/Davol) |
| ProLite (Atrium) | Sepramesh (Genzyme) |
| TiMesh (Biomet) | Proceed (Ethicon) |
| Parietex (Covidien) | C-Qur (Atrium) |
| Mersilene (Ethicon) | Parietex Composite (Covidien) |
| MotifMesh (Proxy Biomedical) | |

**Biological** Biological grafts have been available for VH repair since 2003 and are derived from human, porcine, and bovine tissue (dermis, small intestine, or pericardium). Not only can they serve initially as a mechanical bridge but they may also function as a scaffold during subsequent tissue remodeling, when the host's native tissue digests and replaces the graft with native collagen. Postprocurement processing is performed to remove cellular material, preventing a foreign body response by the host, and leaving behind the collagen/elastin matrix. In addition, some grafts are treated with cross-linking to prolong the time required by the host to integrate the graft.[45] Because of infiltration by host immune cells and abundant vascularity secondary to angiogenesis, it is thought that biological grafts have enhanced ability to resist infection, making them a preferred choice for use in contaminated fields (**Box 1**).

Bioprosthesis durability in hernia repair is questionable, with recurrence rates as high as 80% reported when used without fascial support.[46–48]

Although the use of biological grafts is favored in heavily contaminated operative fields, their cost-effectiveness in clean and minimally contaminated cases remains to be determined, because these grafts are, on average, 10 times more expensive than prosthetic meshes. A recent systematic review reported wound complication rates of 26.2% and a recurrence rate of 15.7%, comparable with results with synthetic meshes.[49] Comparisons between biological grafts suggest that human-derived grafts are more likely to stretch and result in hernia recurrence but less likely to become infected and require explantation.[50,51]

In a study of single-stage VH bioprosthetic repairs in contaminated or infected fields, Rosen and colleagues[14] reported a 31% hernia recurrence rate at a mean follow-up of 21 months. However, only a small percentage of these patients required reoperation (5.5% of the original cohort). Postoperative wound complications occurred in one-half of patients. Despite manufacturer claims and general support

**Box 1**
**Biological graft options**

- Human dermis
  - Alloderm (LifeCell)
  - Allomax (Bard/Davol)
  - Flex HD (MTF)
- Porcine dermis
  - Permacol (TSL)
  - Collamend (Bard/Davol)
  - Strattice (LifeCell)
  - XenMatrix (Brennan Medical)
- Porcine small intestine
  - Surgisis (Cook)
- Fetal bovine dermis
  - Surgimend (TEI Bioscience)
- Bovine pericardium
  - Tutopatch (Tutogen)
  - Veritas (Synovis)

in review articles, the bulk of the primary literature supporting the use of biological grafts for VH repair in contaminated fields consists of case series and case reports (the lowest level of evidence), and that their use in these scenarios has not been cleared or approved by the US Food and Drug Administration.[52]

***Components separation***

Components separation (CS) or separation of parts, first described by Ramirez and colleagues[53] in 1990, is a technique designed to enlarge the abdominal cavity by separating the layers of muscle and disconnecting them from their fascial attachments, allowing for individual translation and maximal expansion. It entails a relaxing incision through the external oblique aponeurosis 2 cm lateral to the rectus sheath and dissection in the plane between the external oblique and internal oblique muscles, as well as dissection and release of the rectus abdominis from the posterior rectus sheath (**Fig. 3**). This dissection is carried superiorly to the costal margin and inferiorly down to the inguinal ligament. Some investigators recommend extending the superior aspect 5 cm above the costal margin to decrease the risk of epigastric recurrence, the most common site of recurrence.[54]

CS can provide up to 10 cm of unilateral medial advancement of the fascial edge (20 cm if performed bilaterally) and is a useful technique to achieve primary fascial closure in cases of massive VH. The CS procedure is accompanied with its own set of complications, which are more common in the setting of contamination.[55] Because of the extensive dissection required, the patient is left with large skin flaps; wound complications such as surgical site infection and seroma/hematoma are common.[54,56]

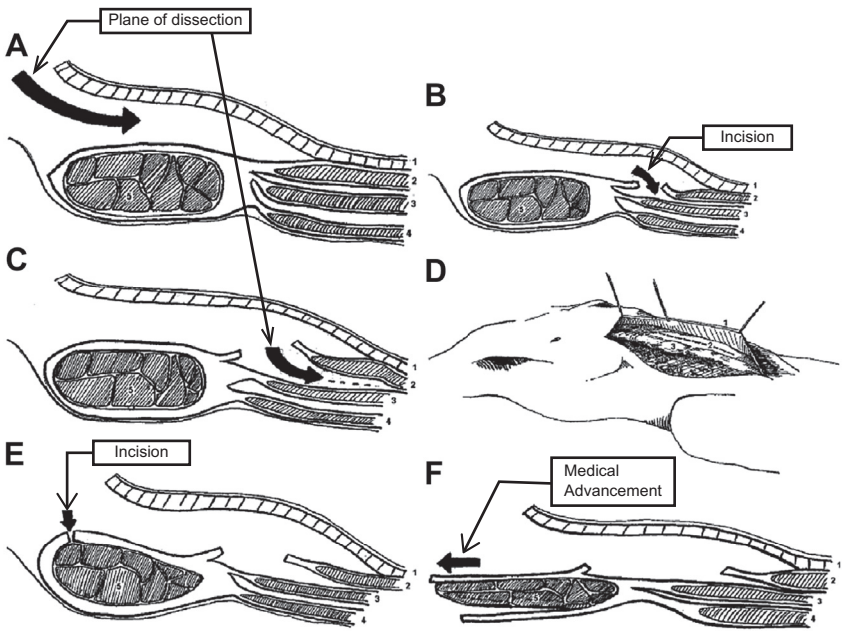


**Fig. 3.** Technique of CS. (*A*) Suprafascial lateral dissection (*B*) External oblique aponeurosis incision, (*C*) Dissection deep to external oblique muscle, (*D*) Medical traction, (*E*) Rectus sheath incision, (*F*) Additional Medical Advancement. (*From* de Vries Reilingh TS, van Goor H, Rosman C, et al. "Components separation technique" for the repair of large abdominal wall hernias. J Am Coll Surg 2003;196(1):32–7; with permission.)

A more serious complication is ischemia and necrosis of the flaps, occurring in up to 6%. When used alone without mesh reinforcement, CS is associated with recurrence rates as high as 53%.[54,57]

To address these complications, several modifications to the technique have been developed:

1. Mesh reinforcement: to decrease the incidence of hernia recurrence, the use of both prosthetic and biological prosthesis reinforcement of the primary fascial closure has been described in both onlay, inlay, and underlay configurations. A sandwich technique using both underlay and onlay reinforcement has been reported to have a recurrence rate of only 3.9%.[56] The Ventral Hernia Working Group (VHWG) recommends reinforcement of CS closure.[58]
2. Rectus abdominis muscle plication: a recent report described 13 patients who underwent rectus plication (similar to abdominoplasty or tummy tuck) as tissue reinforcement of CS. The investigators contend that this technique decreases tension along the line of closure, provides an additional barrier of tissue atop the hernia closure, and does not require additional dissection. With only 1 recurrence over a mean follow-up of 24 months, this technique may be a more cost-effective method of reinforcement than prosthesis, but more studies are required before strong recommendations can be made.[59]
3. Minimally invasive CS: using 2-cm to 3-cm incisions and laparoscopic equipment, several investigators have reported comparable operative times and hospital length of stay, with the benefit of significantly decreased wound complications when compared with traditional CS (**Fig. 4**).[60–62] One disadvantage to this method is that the degree of abdominal wall advancement is only 86% of that achievable by open CS, likely because of tethering of the abdominal wall muscles to the overlying tissue.[63]
4. Posterior CS: in this variation, only the posterior component of the original Ramirez technique is performed. The posterior rectus sheath is incised 1 to 2 cm lateral to the midline, and the rectus abdominis muscle is dissected free from the sheath.[64]

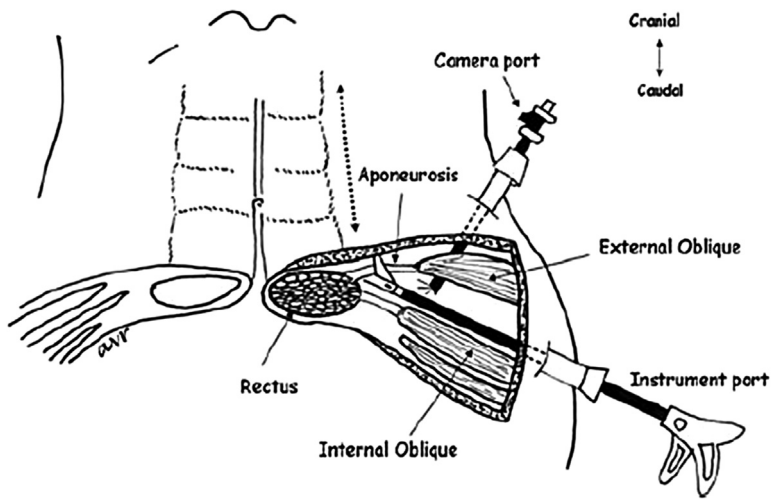


**Fig. 4.** Endoscopic CS. (*From* Rosen MJ, Jin J, McGee MF, et al. Laparoscopic component separation in the single-stage treatment of infected abdominal wall prosthetic removal. Hernia 2007;11(5):435–40; with permission.)

The lateral posterior rectus sheath (ie, the posterior leaflet of the internal oblique aponeurosis) is subsequently incised, allowing the surgeon to access the plane between the internal oblique muscle and the transversus abdominis muscle (Fig. 5). This technique allows for not only medial advancement of the abdominal wall musculature but also a plane for the placement of an underlay mesh reinforcement. The advantage of this technique is that it avoids the need for an extensive subcutaneous dissection and its attendant wound complications; however, the extent of medial advancement afforded is less than that of external oblique release.[65,66]

After dissection of the subcutaneous plane, superficial seroma is near universal, and it is customary to leave closed-suction drains until the output is less than 30 mL/d for 2 consecutive days. This process may take up to 4 weeks. Prolonged antibiotic prophylaxis is not indicated.

***Intraoperative decision making***

Intraoperative decision making during emergency hernia repair should proceed in a logical fashion. First and foremost, the problem necessitating emergent operation should be addressed. The 2 most common reasons are complete bowel obstruction and incarceration with strangulation. After entering the abdomen (usually through the midline or previous incision), the hernia sac is reduced, enlarging the constricting ring as necessary. Any frankly necrotic segments of intestine should be resected, and marginal-appearing segments may be left in situ for later reassessment. If the patient is severely physiologically compromised, it may be prudent to apply the damage control principles of performing the minimum necessary to sustain life (arrest hemorrhage and control contamination), leaving the bowel in discontinuity and returning for definitive repair under more favorable conditions after correction of metabolic derangements.

Only after life-threatening issues have been fixed should the surgeon attempt hernia repair. With the understanding that emergent hernia operations present less than ideal circumstances, the surgeon should perform the safest and most durable repair possible. A single-stage repair should be attempted, unless massive loss of domain precludes closure and thus a staged repair is necessary.

***Umbilical***

If the fascial defect is less than 3 cm, primary repair alone is acceptable. For the better part of the twentieth century, umbilical hernia was repaired according to the vest-over-pants overlap technique described by Mayo in 1901.[67] However, recurrences up to 54% have been reported with the Mayo repair, and this repair method has been largely abandoned.[68,69] Data from randomized trials show that recurrence of umbilical hernia is significantly lower (as low as 1%) with tension-free mesh repair when compared with primary fascial repair.[70,71] In the absence of contraindications, mesh prosthetic reinforcement is strongly recommended for defects larger than 3 cm. Some investigators have even reported superior outcomes with mesh reinforcement for defects smaller

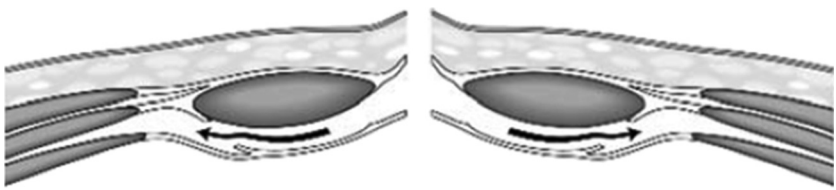

**Fig. 5.** Technique of posterior CS. (*From* Carbonell AM, Cobb WS, Chen SM. Posterior components separation during retromuscular hernia repair. Hernia 2008;12(4):359–62; with permission.)

than 3 cm.[70] Options for prosthetic mesh closure include plug reinforcement, sheet underlay, and Prolene hernia system (PHS).[72,73]

***Incisional***

For defects larger than 3 cm, every attempt should be made to achieve midline approximation of the rectus abdominis for primary fascial closure, using CS techniques if necessary.[58] However, because of the high recurrence rate of primary fascial repair alone (50%), mesh reinforcement should be considered in all circumstances.[21] Strong long-term, high-quality evidence supports the routine use of mesh reinforcement for repair of incisional hernias.[74–76] The American Hernia Society declares that the use of mesh represents the current standard of care for incisional hernia repair, and the VHWG makes a strong recommendation for routine mesh reinforcement of all incisional VH repairs.[58,77] The choice of mesh (prosthetic vs biological) depends on the degree of contamination. Although prosthetic mesh offers the most durable repair, the risk of subsequent infection necessitating removal should be carefully considered, because mesh explantation is a morbid operation.

Under clean conditions in which a prosthetic is used, the next decision is whether to use a simple or composite mesh, and this is determined by whether the mesh comes into contact with bowel. Macroporous prosthetic is favored when there is no chance of contact, because the looser weave allows for superior host vascular ingrowth.

In cases of significant contamination, the safest choice for reinforcement is likely biological mesh.[58] However, in cases of bladder or bowel injury with minimal or no spillage, the risk of prosthetic infection may be sufficiently low to justify use of permanent synthetic material. One potential strategy is to place the patient on antibiotics and return to the operating room in several days for prosthetic mesh repair, assuming the absence of signs of infection, although this course of action has not been adequately studied. In cases of frank infection, it may be more cost-effective to consider an absorbable mesh rather than a biological graft, because the likelihood of recurrence is high no matter what type of mesh is used. In these cases of high-risk operations, postoperative wound complications are common (almost 50%) and should be anticipated.[47]

Once an appropriate mesh has been chosen, the final decision is the position of mesh placement: onlay, inlay (bridge), or underlay (intraperitoneal or retromuscular) (**Fig. 6**). Onlay mesh placement is favored by some because it avoids any chance of bowel contact and does not place any tension on the primary repair. However, it is generally discouraged because of the extensive subcutaneous dissection required and its attendant wound complications. In addition, the superficial location of the mesh theoretically increases the risk of mesh infection, and the recurrence rate is only marginally superior (if at all) to primary suture repair alone. Inlay mesh placement should be used only if primary tension-free fascial reapproximation is impossible despite CS, because this configuration is associated with high rates of recurrence.[46] It is our opinion (and that of the VHWG) that underlay mesh placement (retrorectus via the Rives-Stoppa technique) should be the default choice, because this method is associated with the lowest rate of wound complications and the lowest recurrence rate.[58,78,79] When affixing the mesh, it is important to ensure at least 4 cm of overlap on each side.[80] Recurrences rarely occur as a result of direct graft failure. The more common site of recurrence is laterally at the mesh-tissue interface.[81]

There have been several reports of the use of multilayered mesh repairs. For example, Petersen and colleagues[82] reported a series of 175 consecutive patients undergoing underlay prosthetic mesh repair of incisional hernias. In 50 cases, primary fascial reapproximation was not possible, and this group was further divided into

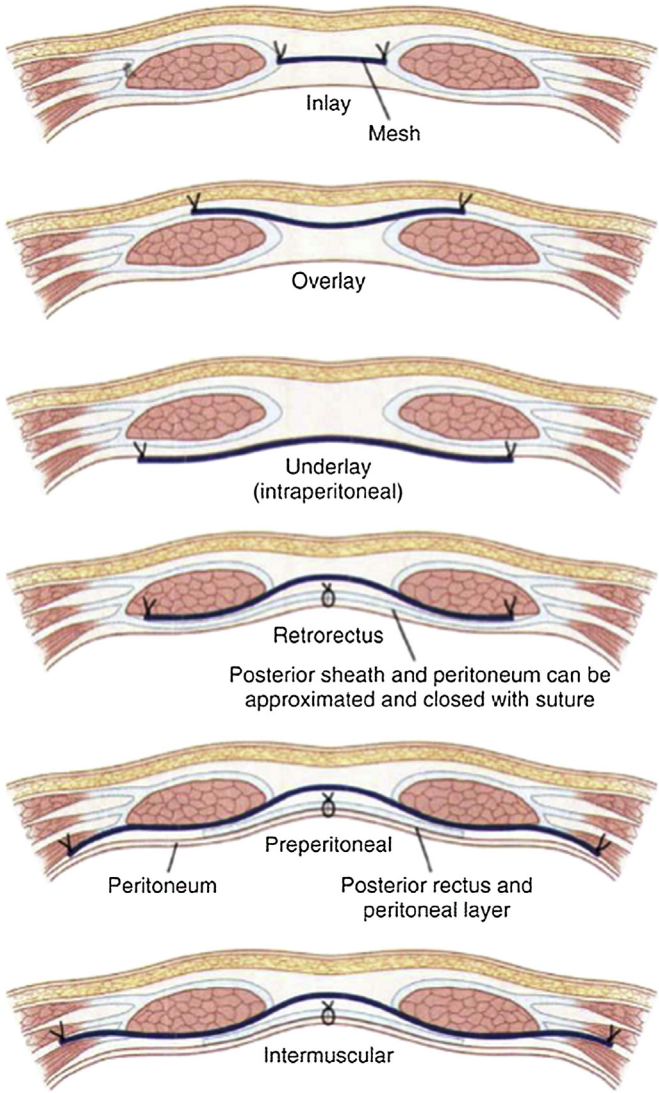


**Fig. 6.** Options for mesh placement. (*From* Malangoni MA, MJ. Hernias. In: Townsend RD, Beauchamp RD, Evers BM, et al, editors. Sabiston textbook of surgery: the biological basis of modern surgical practice. Philadelphia: Elsevier Saunders; 2012. p. 1133; with permission.)

those who had a second mesh placed as an inlay bridge and those without a mesh interposition. Although there was no significant difference in hernia recurrence rates, the investigators reported a significantly decreased mesh infection rate associated with the addition of the mesh interposition technique. A second technique, termed the pork sandwich, has been described, whereby porcine bioprosthesis is used in both underlay and overlay to reinforce a primary fascial closure after CS (**Fig. 7**). Satterwhite and colleagues[83] report using the pork sandwich on 19 patients, with no recurrences after a mean of 11 months, which compares favorably with a matched control group with 19% recurrence. Although these and other reports are interesting

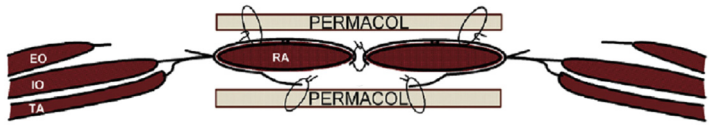


**Fig. 7.** Pork sandwich herniorrhaphy. (*From* Satterwhite TS, Miri S, Chung C, et al. Abdominal wall reconstruction with dual layer cross-linked porcine dermal xenograft: the "pork sandwich" herniorraphy. J Plast Reconstr Aesthet Surg 2012;65(3):333–41; with permission.)

and encouraging, the multilayered use of mesh has not been adequately studied to make recommendations for routine application.[84]

***Parastomal hernias***

A parastomal hernia is similar to other hernias of the anterior abdominal wall, with the added complicating factor of an intentional, permanent defect through the fascia and muscular layers. These hernias are common, and a 10-year longitudinal study reported that the parastomal herniation rate for ileostomies and colostomies is 16% and 36.7%, respectively, although most occur within the first 2 years.[85,86] It is generally agreed that stoma maturation through the rectus abdominis muscle, as opposed to lateral to the muscle, is associated with lower rates of herniation, although there is no high-quality evidence to support this belief.[87] However, aperture size has been shown to correlate with parastomal hernia, with a 10% increase in risk of hernia for every millimeter increase in stoma aperture size.[88] These hernias are well tolerated, and life-threatening complications are uncommon. Less than 20% of parastomal hernias require operative intervention, and, therefore, routine elective repair is not recommended. Parastomal contents are usually omentum, small bowel, or colon, although herniation of the gallbladder and stomach has been reported.[89,90] Indications for operation are local pain, poor appliance fit, severe prolapse, obstructive symptoms, incarceration, and rarely, cosmesis. More than half of parastomal hernia repairs are performed under emergent conditions.[91]

The same general principles apply: correct the life-threatening problem first, then attempt the safest and most durable hernia repair possible. Like all abdominal wall hernias, parastomal hernias can be repaired by several methods, including stoma relocation, and primary repair with or without mesh.

1. Stoma relocation: stoma relocation has been reported in the past as the optimal treatment. However, this exposes the patient to 3 potential sites of future herniation: the old stoma site, the new stoma site, and the laparotomy incision. With this approach, the recurrence rate at the stoma site is reported to be 33%. Incisional hernia at the accompanying laparotomy site occurs in more than 50%.[91]
2. Primary fascial repair: the advantage of this approach is that it does not require abdominal entry and should be reserved only for patients unable to tolerate laparotomy. This option is associated with predictably high recurrence rates (up to 76%) and is not generally recommended.[91,92]
3. Mesh reinforcement: first described by Sugarbaker in 1980, this option is associated with the lowest recurrence rate, especially with underlay mesh placement.[93,94] An additional consideration is whether to pass the stoma through the mesh via a keyhole incision or lateral to it (ie, the Sugarbaker technique) (**Fig. 8**).
   a. Prosthetic: despite concerns about mesh infection, studies have reported a surprisingly low rate of mesh-related complications (<5%) when used under elective conditions.[92] There have been occasional reports of mesh erosion into adjacent bowel.[95] Under emergent conditions, mesh selection should be

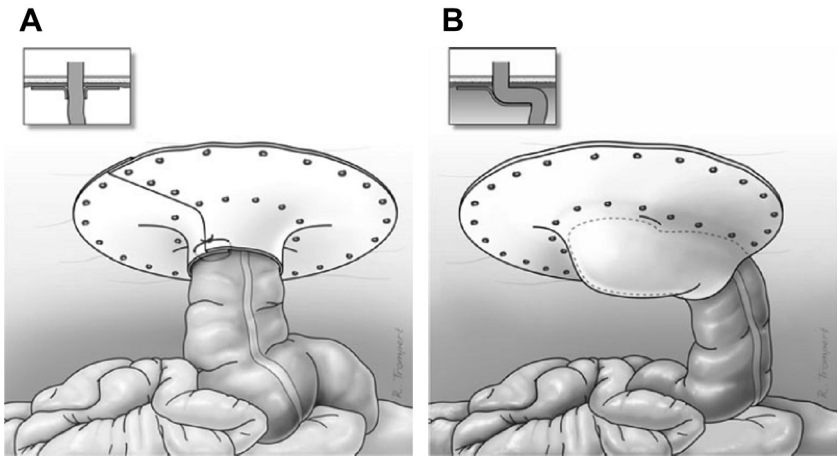


**Fig. 8.** (*A*) Keyhole technique for parastomal mesh placement. (*B*) Sugarbaker technique for parastomal mesh placement. (*From* Hansson BM, Slater NJ, van der Velden AS, et al. Surgical techniques for parastomal hernia repair: a systematic review of the literature. Ann Surg 2012;255(4):685–95; with permission.)

dictated by the degree of contamination. The prosthetic may be placed via a separate peritoneal incision, or directly, without laparotomy.[96–98]

b. Biological: there have been reports of use of porcine and human biological grafts to reinforce parastomal hernia repairs, but it is unclear how durable or cost-effective this approach is.[99,100]

***Unusual hernias***

**Spigelian hernia** Also known as spontaneous lateral VHs, hernia of the semilunar line, or hernias of the conjoint tendon, these hernias are rare, comprising approximately 1% of all abdominal wall hernias. They usually occur in the sixth or seventh decade of life, and both sexes are equally affected.[101] This eponymous hernia is named after the Belgian anatomist Adriaan van der Spiegal, who first described the semilunar line, where these hernias occur. Most (90%) spigelian hernias (SH) occur within the spigelian belt of Spangen, a transverse zone between the umbilicus and a line connecting the anterior superior iliac spines.[102]

The most common presenting symptom is localized pain, and diagnosis by physical examination is difficult, given the overlying external oblique muscle (ie, interparietal hernia). Point tenderness is often the only sign suggestive of the diagnosis. More than half are diagnosed intraoperatively. Ultrasonography or CT scan can help establish the diagnosis (**Fig. 9**). Because of the narrow neck, the risk of incarceration is high and it is recommended to electively repair all SH, because 20% to 30% require emergent operation.

The usual surgical approach is via a transverse incision directly overlying the hernia. Primary repair by suture repair of the internal oblique and transversus abdominis muscle may be accompanied with plug or mesh reinforcement.[103]

**Lumbar hernias** With less than 300 cases reported worldwide, spontaneous lumbar hernias are rare. Most hernias in this body region (80%) are acquired or incisional. Incarceration rarely occurs (<10%) because of the wide neck of the hernia orifice.[104–106] Both superior (Grynfeltt) lumbar triangle and inferior (Petit) lumbar triangle hernias show wide anatomic variation.[107,108] Operative repair is usually via an

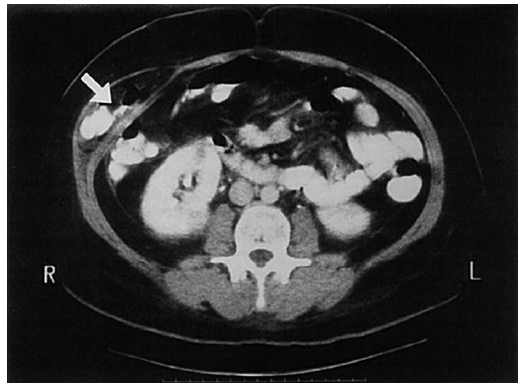


**Fig. 9.** Spigelian Hernia. (*From* Mukherjee K, Wise PE. Internal hernia through the gastrohepatic ligament after laparoscopic restorative proctocolectomy. Am Surg 2013;79(6):236–7.)

incision directly overlying the hernia. Although evidence is sparse, it is assumed that mesh repair is associated with lower recurrence rates than primary repair.

***Obstructing diaphragmatic and internal hernia***

**Diaphragmatic hernia** Diaphragmatic hernias (DH) occur through the diaphragm, the thin muscle separating the thoracic and abdominal cavities. Their natural history is to progressively enlarge over time, given the driving force of negative intra-thoracic pressure combined with positive intra-abdominal pressure. DH most commonly occur at the esophageal hiatus (hiatal DH), though congenital DH may occur elsewhere and traumatic DH may occur anywhere (**Fig. 10**).

DH may be classified as traumatic or nontraumatic. Nontraumatic hernias may be further subdivided as congenital or acquired. Congenital hernias are central, Bochdalek, and Morgagni. Central diaphragmatic defects (absence of the central tendon) are rare in adults and usually presents in infants.[109] Bochdalek hernias account for 90% of DH and occur through a defect in embryonic development. They occur more commonly on the left and have equal incidence in men and women. The most common presenting symptoms are pain and obstruction.[110] A foramen of Morgagni hernia is a

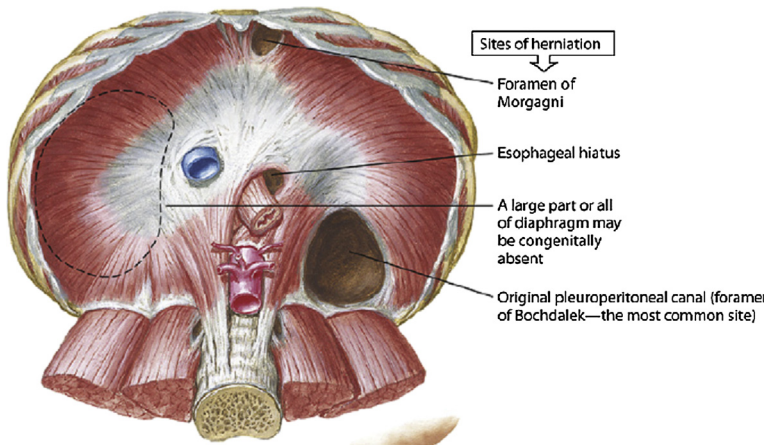


**Fig. 10.** Congenital DH sites. (Netter illustration from www.netterimages.com. © Elsevier Inc. All rights reserved.)

herniation through the space of Larrey, the area between the xiphoid process and the costal attachments of the diaphragm. Morgagni hernias account for <5% of nontraumatic DH in adults and the majority occur on the right side. The hernia sac most commonly contains omentum, transverse colon, or stomach.[111] Most are symptomatic and the condition affects women 3 times more commonly than men. Recurrence after repair is rare.[112]

Acquired DH are usually in the region of the esophageal hiatus.

**Paraesophageal hernia** The prototypical patient with paraesophageal hernia (PH) is frail and elderly, with significant comorbid medical illnesses, and perioperative morbidity and mortality are high, especially for emergent operations.[113] Untreated, approximately 30% of patients present with life-threatening complications.[114] There are 4 recognized types of PH, with type 1, or sliding hiatal hernia, predominating (>95%) (**Fig. 11**). In type 2 and 3 PH, the fundus and potentially other parts of the stomach have herniated through the diaphragmatic hiatus, with a combined sliding hiatal hernia distinguishing type 3. A type 4 PH is defined as any PH that includes an additional intra-abdominal organ, such as spleen or colon.

Most patients report an antecedent history of symptoms, such as epigastric or substernal discomfort, dyspnea, nausea, or postprandial distress. Rarely, a patient may present with syncope or acute chest pain symptoms.[115] The estimated risk of requiring emergent operation for untreated PH is estimated at 1.16% per year, and a lifetime risk of 18% for patients older than 65 years.[116]

Obstructive symptoms, severe pulmonary dysfunction, and bleeding from ischemic or mechanical ulceration are the most common indications for emergent repair. The workup for a patient presenting with these symptoms is different from for a patient being considered for elective repair and generally includes plain films and CT of the chest and abdomen. Barium contrast studies, esophageal manometry, and 24-hour pH monitoring are not appropriate for acutely ill patients.

The steps for repair are identical for all DH: reduction of hernia contents, excision of hernia sac, and hernioplasty or herniorrhaphy (with or without mesh). For hiatal DH, additional considerations are whether to perform an antireflux procedure, or gastropexy. When performing surgery on the diaphragm, it is imperative to be aware of the course of the phrenic nerve and avoid division if possible. If primary repair is not possible, mesh selection is similar to VH repair: microporous prosthetic is preferred, followed by biological grafts in contaminated fields. Absorbable prosthetic mesh is never appropriate for DH repair. As with other external and internal hernias of the abdomen, the top priority is to correct the life-threatening problem; durable hiatal hernia repair is secondary. Because of the extensive vascular supply of the stomach,

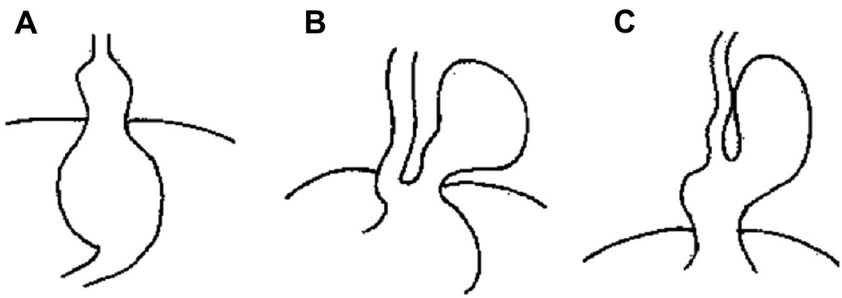


**Fig. 11.** Types of hiatal hernia. (*A*) Type 1, (*B*) Type 2, (*C*) Type 3. (*From* Oddsdottir M. Paraesophageal hernia. Surg Clin North Am 2000;80(4):1243–52; with permission.)

ischemia leading to necrosis is rare. The approach is usually transabdominal, although a transthoracic approach is advocated by some to permit additional esophageal mobilization and improve visualization during adhesiolysis. Rather than compromise exposure, the surgeon should not hesitate to perform a combined approach if necessary. The decision to attempt this operation laparoscopically should be determined on a case-by-case basis and should take into account the patient's physiologic status and experience of the surgeon. The peritoneal covering of the diaphragmatic crus should be preserved during dissection.

Once the hernia contents have been reduced and the hernia sac resected, attention is then directed toward repairing the diaphragmatic defect. Traditionally, this repair is accomplished via primary suture (nonabsorbable) reapproximation of the right and left diaphragmatic crura posterior to the esophagus, although 1 or 2 anterior sutures may be required in especially large defects. A tension-free repair is crucial. Autologous flap reinforcement with falciform ligament has been described (**Fig. 12**).[117]

Mesh reinforcement is recommended by some investigators, but robust evidence supporting its routine use is lacking. If it is considered, macroporous prosthetic should be avoided. Even with microporous prosthetics, erosion and stricture have been reported. The use of biological graft may be considered in certain cases, but this application is poorly studied.

The decision to perform an esophageal lengthening procedure, such as a Collis gastroplasty, should not be taken lightly, and every effort should be made to mobilize the esophagus transhiatally. Assuming that the gastroesophageal junction lies adequately below the hiatus, 1 final decision to consider is the addition of an antireflux procedure (such as a Nissen or Toupet fundoplication) or gastropexy to prevent recurrence.[118] Routine fundoplication in the absence of preoperative esophageal reflux symptoms is controversial.[119,120] Gastrostomy may be added as necessary for further intraperitoneal fixation of the stomach.

**Internal hernia** Internal hernias are rare, representing 2% of all hernias and less than 1% of all cases of bowel obstruction.[121] Delays in presentation, diagnosis, and treatment are common because of the vague nature of symptoms and difficulty in diagnosis. Overall mortality is estimated at 20%.[122] The 6 main types of internal

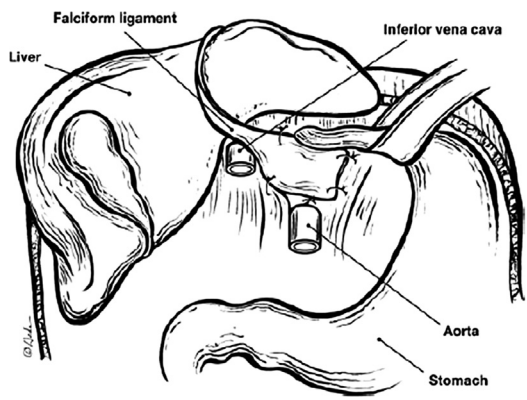


**Fig. 12.** Falciform ligament flap for crucal closure of hiatal hernia. (*From* Park AE, Hoogerboord CM, Sutton E. Use of the falciform ligament flap for closure of the esophageal hiatus in giant paraesophageal hernia. J Gastrointest Surg 2012;16(7):1417–21; with permission.)

abdominal hernias are, in order of decreasing frequency: paraduodenal, foramen of Winslow, transmesenteric, paracecal, intersigmoid, and paravesical (Fig. 13).[123]

**Paraduodenal hernia** Also known as Treitz hernia, paraduodenal hernia (PDH) accounts for more than 50% of internal hernias.[124] PDH are 3 times more common in men and occur most commonly on the left (75%), through the Landzert fossa.[124] The average age of presentation is between the third and fourth decades. The cause of PDH is unclear, but it is thought to be caused by either enlargement of a preexisting fossa or abnormal intestinal malrotation during embryonic development.

PDH most commonly presents as an acute bowel obstruction superimposed on a background of chronic, vague abdominal pain. Because of the rarity of the entity and the difficulty of diagnosis, a high level of suspicion must be maintained. It is estimated that the lifetime risk of bowel incarceration approaches 50%, and thus, these hernias should be repaired if discovered incidentally. Bowel necrosis occurs in 20% of emergent cases.[124]

Operative exploration may show the pathognomic empty abdomen sign, whereby only a segment of ileum is found in the peritoneal cavity, the remainder of the intestines being found within the hernia sac (Fig. 14). In right-sided PDH, the intestines herniate through the fossa of Waldeyer and are noted to lie posterior to the superior mesenteric artery (SMA).[125] For left-sided PDH, the border of the hernia sac contains the inferior mesenteric vein (IMV), and the anterior sac wall contains branches of the left colic artery.[126] As with all emergency hernia repairs, the first step is to reduce the intestine back into the peritoneal cavity, incising the constricting hernia ring if necessary, or opening the entire hernia sac. Because the hernia sac is formed by the mesocolon, in this case, the sac should be left in situ rather than excised. Extreme care should

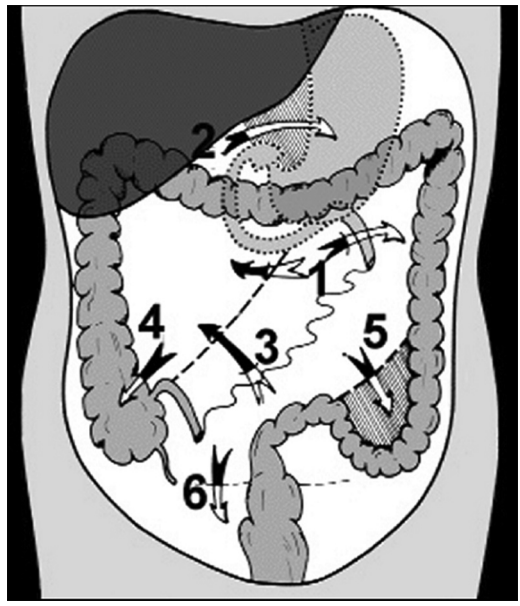


**Fig. 13.** Potential sites of internal herniation. 1, Paraduodenal; 2, Foramen of Winslow; 3, Transmesenteric; 4, Paracecal, 5, Para sigmoid; 6, Paravesical (pelvic). (*From* Ghahremani GG, Meyers MA. Internal abdominal hernias. Curr Probl Radiol 1975;5:1–30; with permission.)

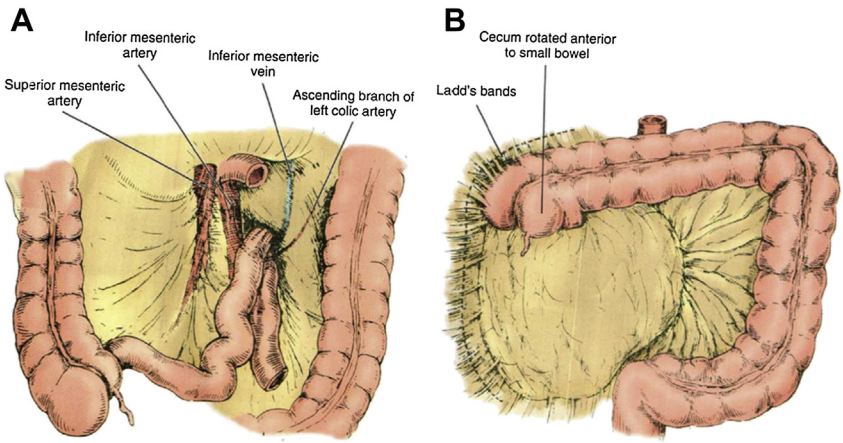


**Fig. 14.** (*A*) Left PDH. (*B*) Right PDH. (*From* Newsom BD, Kukora JS. Congenital and acquired internal hernias: unusual causes of small bowel obstruction. Am J Surg 1986;152(3):279–85; with permission.)

be taken to avoid injury to the IMV and SMA. The final step is to carefully close the hernia defect.

**Foramen of Winslow hernia** These hernias are rare, representing less than 10% of internal hernias.[127] Less than 200 cases have been reported worldwide (**Figs. 15** and **16**). The usual hernia contents are cecum and intestine, although a case of gallbladder herniation has been reported.[128] Because of delay in treatment, mortality can be as high as 49%.[129] The principles of treatment are identical to those for other internal hernias. Suture closure of the foramen is left to the discretion of the surgeon. There have been no reports of recurrence and injury to the portal triad structures is extremely morbid.

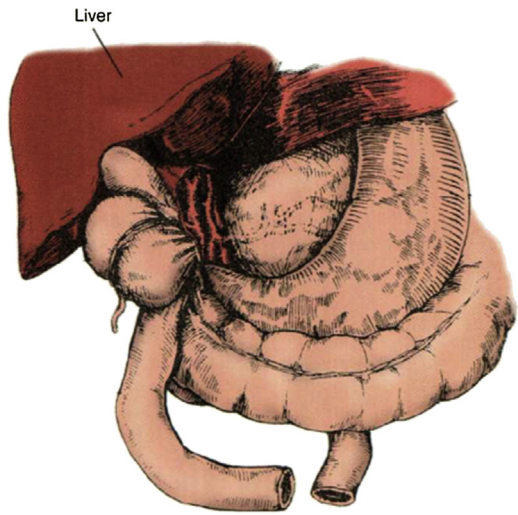


**Fig. 15.** Foramen of Winslow hernia. (*From* Newsom BD, Kukora JS. Congenital and acquired internal hernias: unusual causes of small bowel obstruction. Am J Surg 1986;152(3):279–85; with permission.)

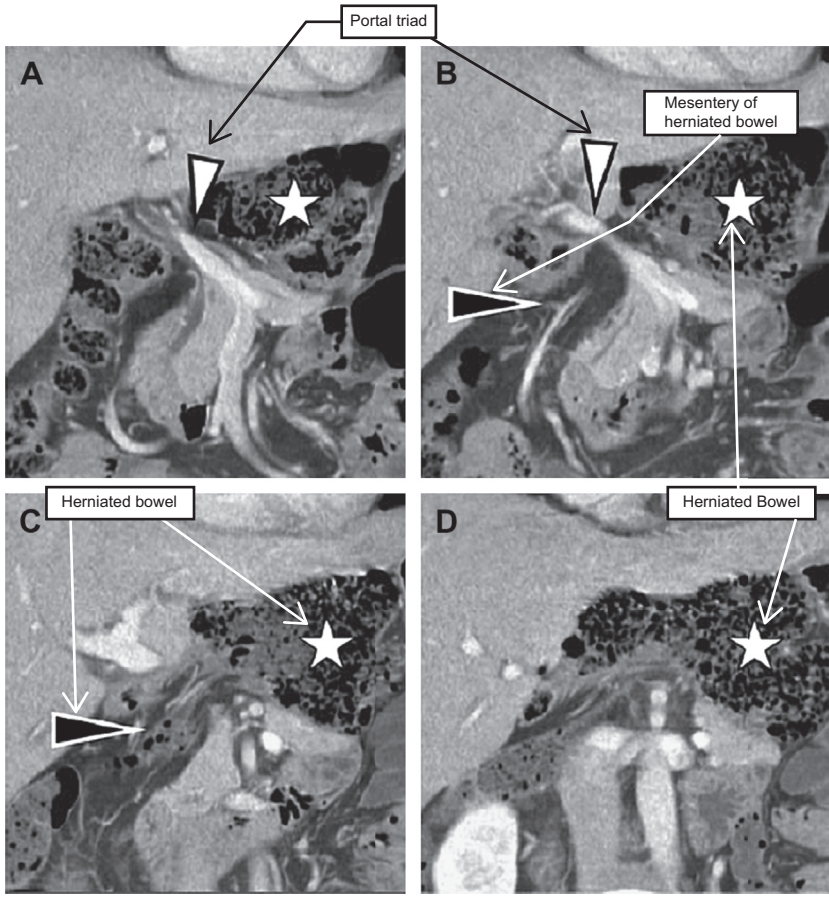


**Fig. 16.** (*A–D*), Sequential coronal images of Foramen of Winslow hernia. (*From* Azar AR, Abraham C, Coulier B, et al. Ileocecal herniation through the foramen of Winslow: MDCT diagnosis. Abdom Imaging 2010;35(5):574–7; with permission.)

**Transmesenteric hernia** Transmesenteric hernia (TMH) may be congenital or acquired, the former most commonly encountered in children.[130] They account for between 5% and 10% of internal hernias, and, in adults, are usually acquired after previous abdominal operations, trauma, or peritonitis. As in other internal hernias, palpable external defect is absent and the most common presenting symptoms are those suggestive of bowel obstruction. One interesting feature of TMH is that the bowel herniating through the mesenteric defect may exert such lateral pressure as to compress the vasculature in that mesentery, causing infarction of the unherniated bowel supplied by the mesentery (**Fig. 17**). Exploration is usually undertaken for a clinical condition, because CT scan is inaccurate in the preoperative diagnosis of TMH. The small bowel mesentery is usually involved, most commonly in the ileocecal region, although mesoappendiceal herniation has been reported.[127,131]

**Paracecal hernia** These hernias account for approximately 13% of internal hernias. A paracecal hernia is diagnosed preoperatively on CT by the presence of fluid-filled small intestine loops lateral to the cecum and posterior to the ascending colon

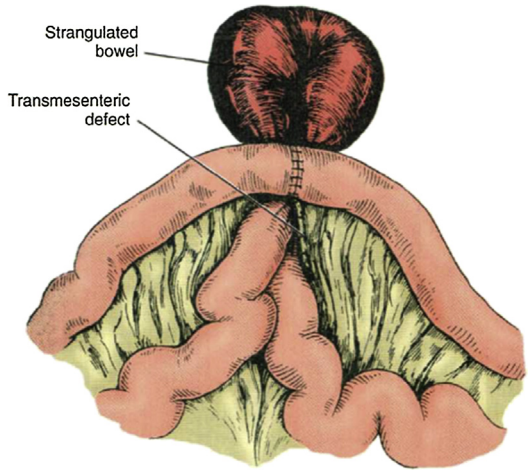


**Fig. 17.** Transmesenteric hernia. (*From* Newsom BD, Kukora JS. Congenital and acquired internal hernias: unusual causes of small bowel obstruction. Am J Surg 1986;152(3):279–85; with permission.)

(**Fig. 18**).[123,132] The principles of repair are similar to other internal and external hernias.

**Intersigmoid hernia** These hernias occur when intestines have herniated between adjacent segments of sigmoid colon and mesentery. The principles of repair are similar to other internal and external hernias.

**Paravesical hernia** These hernias are rare, with only about 60 cases reported worldwide. The principles of repair are similar to other internal and external hernias.[123]

***Internal hernia after bariatric surgery***

Special mention must be made of internal herniation after bariatric surgery, specifically Roux-en-Y gastric bypass, the most popular bariatric operation in the United

**Fig. 18.** Paracecal hernia (*arrow*). (*From* Choh NA, Rasheed M, Jehangir M. The computed tomography diagnosis of paracecal hernia. Hernia 2010;14(5):527–9; with permission.)

States. These internal hernias are the result of herniation through iatrogenic mesenteric defects and occur after 2.5% of bariatric operations. With increasing rates of weight-reduction operations being performed, the corresponding rates of internal hernia through mesenteric defects created as a result of gastrointestinal anastomosis have increased. Nonbariatric acute care surgeons may be called on to operate emergently on these patients, and a thorough understanding of the anatomy and potential sites of herniation is required (**Fig. 19**). These internal hernias most commonly present within the first postoperative month, but up to 25% can present after more than 1 year. Almost 90% occur within the first 2 years postoperatively.[133–136] Clinical diagnosis is difficult, with pain (usually upper quadrants) the most consistent symptom. Nausea and vomiting are frequent, but not universal. Diagnosis is usually made by CT scan or direct operative exploration. A mesenteric swirl has been reported as highly specific for internal herniation after gastric bypass.[137] Treatment consists of reduction, resection of necrotic intestine, and repair of the mesenteric defect with nonabsorbable suture to prevent future reherniation. Most are amenable to laparoscopic repair.[136,138]

Several technical factors have been found to increase the likelihood of postoperative internal herniation. Laparoscopic operations, compared with open operations, are associated with higher internal hernia rates, likely secondary to decreased adhesions, allowing for increased bowel mobility.[138,139] The retrocolic approach, by virtue of creation of an additional mesenteric defect, results in higher (up to 4-fold) internal herniation rates compared with antecolic.[134,135] Rapid postoperative excess weight loss has been associated with higher internal herniation risk.[133,135] The use of nonabsorbable suture for mesenteric closure at the index operation is associated with lower herniation rates compared with absorbable suture.[140]

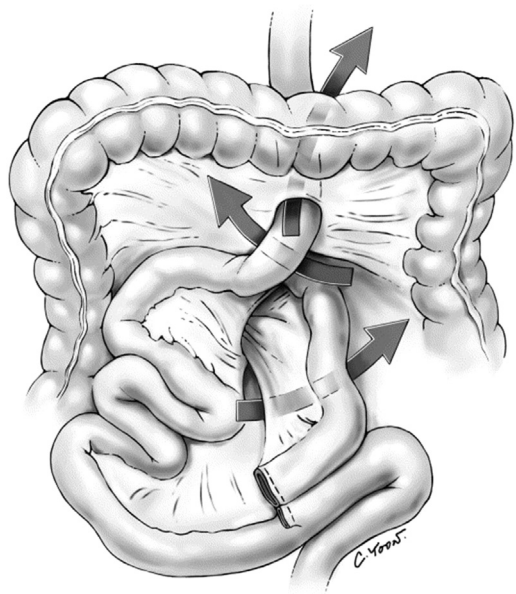

**Fig. 19.** Potential internal hernias after retrocolic Roux-en-Y gastric bypass. (*From* Carmody B, DeMaria E, Jamal M. Internal hernia after laparoscopic Roux-en-Y gastric bypass. Surg Obes Relat Dis 2005;1:543–8; with permission.)

***Other internal hernias***

**Transomental hernia** This rare entity involves herniation of small intestines through the gastrocolic greater omentum. An even rarer variant, the internal double omental hernia, involves further herniation of intestines through the gastrohepatic lesser omentum (**Fig. 20**). Intraoperatively, the omental defect is usually described as a constricting ring of stiff, fibrous tissue.[127] There is no hernia sac proper to limit the amount of bowel herniation, and this may account for the rapid develop of gangrene. The principles of repair are similar to other internal and external hernias.

**Arcuate line hernia** Although the presence of an ascending peritoneal fold between the posterior rectus sheath and the posterior aspect of the rectus abdominis muscle has been estimated to be present in up to 8% of the population, these internal hernias are rarely symptomatic, and only 7 cases have ever been reported (**Fig. 21**).[141,142] Misdiagnosis as the more lateral SH occurs in 50%.[143] Described repair techniques include incising the posterior rectus sheath to obliterate the internal hernia defect, and preperitoneal mesh repair.[144]

**Broad ligament hernia** This rare internal hernia in women has been reported less than 100 times in the world literature and is believed to result from trauma associated with previous pregnancy, because most occur in parous women.[145,146] After hernia reduction, treatment consists of either hernia defect repair or division of the fallopian tube and broad ligament.

***Pelvic floor hernias***

The 3 main pelvic floor hernias, in order of decreasing frequency, are: obturator, perineal, and sciatic.

**Obturator hernia** Obturator hernias (OH) are rare, representing less than 1% of abdominal wall hernias. They most commonly afflict thin, frail, elderly women.[147] Herniation of intestines through the obturator foramen of the bony pelvis presents a diagnostic challenge, because physical examination is highly insensitive because of the overlying pectineus muscle. Before the era of CT scanning, only 10% were diagnosed preoperatively. Occasionally, a palpable mass is evident on rectal or vaginal

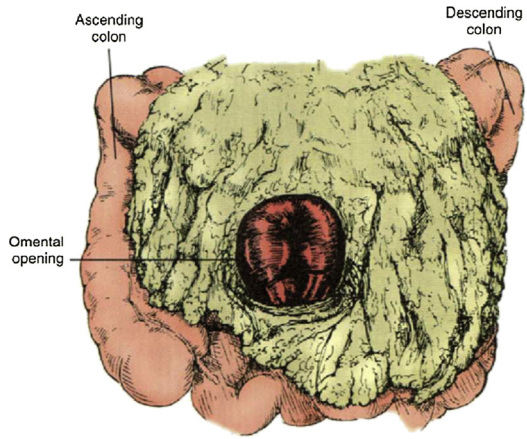


**Fig. 20.** Transomental hernia. (*From* Newsom BD, Kukora JS. Congenital and acquired internal hernias: unusual causes of small bowel obstruction. Am J Surg 1986;152(3):279–85; with permission.)

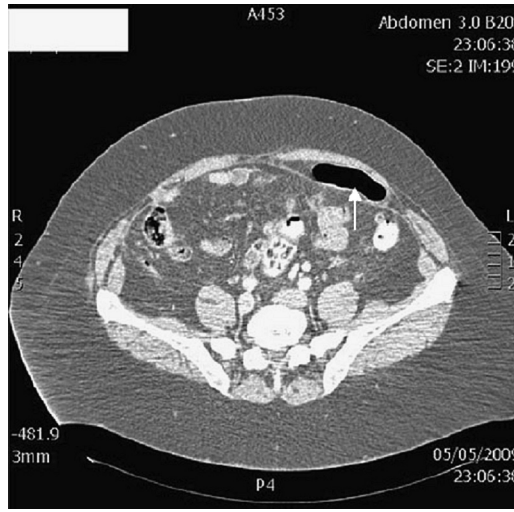


**Fig. 21.** Arcuate line hernia (*arrow*). (*From* Abasbassi M, Hendrickx T, Caluwé G, et al. Symptomatic linea arcuata hernia. Hernia 2011;15(2):229–31; with permission.)

examination. The pathognomonic Howship-Romberg sign (medial thigh pain on leg extension, adduction, or medial rotation) is specific for obturator nerve compression but is present in only one-third of patients.[147–149] The Hannington-Kiff sign (absence of the thigh adductor reflex) is more specific, but less well known and rarely tested.[150] In most patients (>90%), the presenting symptoms are abdominal pain and mechanical intestinal obstruction.[26] Because of delays in diagnosis, up to 75% of OH repairs require resection of infarcted bowel; morbidity and mortality are understandably high.[148] CT scan may show the lesion if the intestines are incarcerated (**Fig. 22**).[151]

Recently, a maneuver has been described to facilitate reduction of an incarcerated obturator hernia. With the patient lying supine, the leg is repeatedly flexed, externally rotated, and slightly adducted. Shigemitsu and colleagues[152] reported an 80% success rate with their technique, reducing an otherwise incarcerated OH and allowing for subsequent elective laparoscopic repair.

Although it is theoretically feasible to repair a known OH via an inguinal or thigh incision, full assessment of bowel viability may be limited, and therefore, laparotomy or laparoscopy is recommended. If the intestine cannot be reduced and the ring must be incised, care must be taken to avoid the obturator neurovascular bundle, which lies lateral to the sac in 50% of patients.[153] Primary repair may be difficult, because of the surrounding fixed bony structures, and a variety of repair techniques have been described, including plug,[154] prosthetic reinforcement, and autologous flap reinforcement.[155–157]

**Perineal hernia** Perineal hernia is a herniation through the pelvic diaphragm and is usually diagnosed in older, multiparous women. They may be repaired transabdominally, transperineally, or through a combined approach. Only approximately 100 cases have been reported in the literature. Repair is challenging, because of the complex anatomy of the pelvic floor, and may be accomplished via direct repair, autologous flap reconstruction, or mesh reinforcement.[158]

**Sciatic hernia** Sciatic hernia is defined as a herniation through the greater (suprapiriform or infrapiriform) or lesser sciatic foramen. Only about 100 cases have been

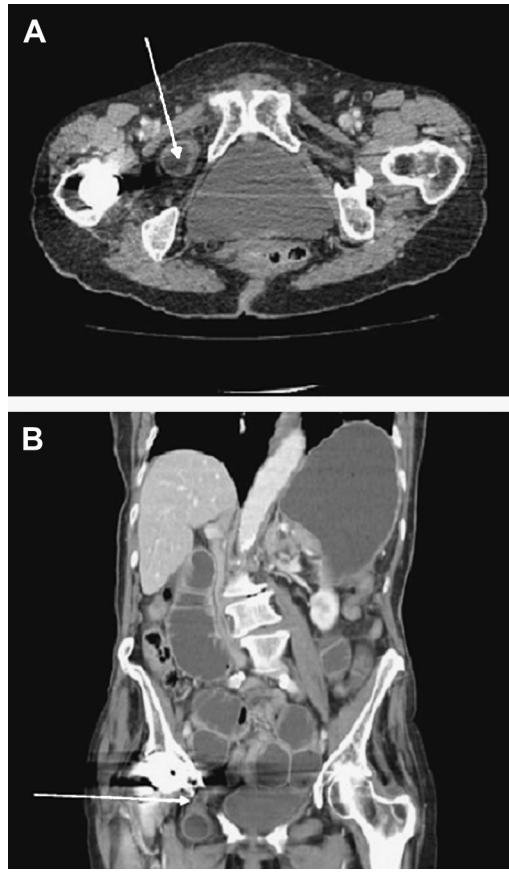


**Fig. 22.** (*A*) Axial image, (*B*) Coronal image. Obturator hernia (*arrows*). (*From* Galketiya K, Sakrepatna S, Gananadha S. Obturator hernia–an uncommon cause of small bowel obstruction. J Gastrointest Surg 2013;17(4):840–1; with permission.)

reported in the literature.[159] Most are acquired presumably secondary to increased intra-abdominal pressure. Presenting symptoms may include abdominal pain, a palpable buttock mass, or symptoms of sciatic nerve compression, and diagnosis is made via CT scan or operative exploration. Mesh repair (prosthetic or biological) is recommended.[160]

## SUMMARY

Hernia emergencies are commonly encountered by the acute care surgeon. Although the location and contents may vary, the basic principles are constant: address the life-threatening problem first, then perform the safest and most durable hernia repair possible. Mesh reinforcement provides the most durable long-term results. Underlay positioning is associated with the best outcomes. CS is a useful technique to achieve tension-free primary fascial reapproximation. The choice of mesh is dictated by the degree of contamination. Internal herniation is rare, and preoperative diagnosis remains difficult. In all hernia emergencies, morbidity is high, and postoperative wound complications should be anticipated.

## REFERENCES


1. Kingsnorth A, LeBlanc K. Hernias: inguinal and incisional. Lancet 2003; 362(9395):1561–71.
2. Dabbas N, Adams K, Pearson K, et al. Frequency of abdominal wall hernias: is classical teaching out of date? JRSM Short Rep 2011;2(1):5.
3. Kark AE, Kurzer M. Groin hernias in women. Hernia 2008;12(3):267–70.
4. Gallegos NC, Dawson J, Jarvis M, et al. Risk of strangulation in groin hernias. Br J Surg 1991;78(10):1171–3.
5. Fitzgibbons RJ, Giobbie-Hurder A, Gibbs JO. Watchful waiting vs. repair of inguinal hernia in minimally symptomatic men: a randomized clinical trial. JAMA 2006;295(3):285–92.
6. Fitzgibbons RJ Jr, Ramanan B, Arya S, et al. Long-term results of a randomized controlled trial of a nonoperative strategy (watchful waiting) for men with minimally symptomatic inguinal hernias. Ann Surg 2013;258:508–15.
7. Dahlstrand U, Wollert S, Nordin P, et al. Emergency femoral hernia repair: a study based on a national register. Ann Surg 2009;249(4):672–6.
8. Neumayer L, Giobbie-Hurder A, Jonasson O, et al. Open mesh versus laparoscopic mesh repair of inguinal hernia. N Engl J Med 2004;350(18):1819–27.
9. Hynes DM, Stroupe KT, Luo P, et al. Cost effectiveness of laparoscopic versus open mesh hernia operation: results of a Department of Veterans Affairs randomized clinical trial. J Am Coll Surg 2006;203(4):447–57.
10. Eklund AS, Montgomery AK, Rasmussen IC, et al. Low recurrence rate after laparoscopic (TEP) and open (Lichtenstein) inguinal hernia repair: a randomized, multicenter trial with 5-year follow-up. Ann Surg 2009;249(1):33–8.
11. Scott NW, McCormack K, Graham P, et al. Open mesh versus non-mesh for repair of femoral and inguinal hernia. Cochrane Database Syst Rev 2002;(4):CD002197.
12. Oida T, Kawasaki A, Mimatsu K, et al. Mesh vs. non-mesh repair for inguinal hernias in emergency operations. Hepatogastroenterology 2012;59(119):2112–4.
13. Nieuwenhuizen J, van Ramshorst GH, ten Brinke JG, et al. The use of mesh in acute hernia: frequency and outcome in 99 cases. Hernia 2011;15(3):297–300.
14. Rosen MJ, Krpata DM, Ermlich B, et al. A 5-year clinical experience with single-staged repairs of infected and contaminated abdominal wall defects utilizing biologic mesh. Ann Surg 2013;257(6):991–6.
15. Kouhia ST, Huttunen R, Silvasti SO, et al. Lichtenstein hernioplasty versus totally extraperitoneal laparoscopic hernioplasty in treatment of recurrent inguinal hernia–a prospective randomized trial. Ann Surg 2009;249(3):384–7.
16. Helgstrand F, Rosenberg J, Kehlet H, et al. Outcomes after emergency versus elective ventral hernia repair: a prospective nationwide study. World J Surg 2013;37(10):2273–9.
17. Muschaweck U. Umbilical and epigastric hernia repair. Surg Clin North Am 2003;83(5):1207–21.
18. Mudge MH, Hughes LE. Incisional hernia: a 10 year prospective study of incidence and attitude. Br J Surg 1985;72(1):70–1.
19. Bensley RP, Schermerhorn ML, Hurks R, et al. Risk of late-onset adhesions and incisional hernia repairs after surgery. J Am Coll Surg 2013;216(6):1159–67, 1167.e1–12.
20. Llaguna OH, Avgerinos DV, Lugo JZ, et al. Incidence and risk factors for the development of incisional hernia following elective laparoscopic versus open colon resections. Am J Surg 2010;200(2):265–9.

21. George CD, Ellis H. The results of incisional hernia repair: a twelve year review. Ann R Coll Surg Engl 1986;68(4):185–7.
22. Carlson MA, Ludwig KA, Condon RE. Ventral hernia and other complications of 1,000 midline incisions. South Med J 1995;88(4):450–3.
23. Read RC, Yoder G. Recent trends in the management of incisional herniation. Arch Surg 1989;124(4):485–8.
24. Derici H, Unalp HR, Bozdag AD, et al. Factors affecting morbidity and mortality in incarcerated abdominal wall hernias. Hernia 2007;11(4):341–6.
25. Nassar AH, Ashkar KA, Rashed AA, et al. Laparoscopic cholecystectomy and the umbilicus. Br J Surg 1997;84(5):630–3.
26. Salameh JR. Primary and unusual abdominal wall hernias. Surg Clin North Am 2008;88(1):45–60, viii.
27. Velasco M, Garcia-Ureña MA, Hidalgo M, et al. Current concepts on adult umbilical hernia. Hernia 1999;3:233–9.
28. Maniatis AG, Hunt CM. Therapy for spontaneous umbilical hernia rupture. Am J Gastroenterol 1995;90(2):310–2.
29. Chapman CS, Snell AM, Rowntree LG. Decompensated portal cirrhosis: report of one hundred and twelve cases. JAMA 1931;97(4):237–44.
30. O'Hara ET, Oliai A, Patek AJ Jr, et al. Management of umbilical hernias associated with hepatic cirrhosis and ascites. Ann Surg 1975;181(1):85–7.
31. Baron HC. Umbilical hernia secondary to cirrhosis of the liver. Complications of surgical correction. N Engl J Med 1960;263:824–8.
32. Pescovitz MD. Umbilical hernia repair in patients with cirrhosis. No evidence for increased incidence of variceal bleeding. Ann Surg 1984;199(3):325–7.
33. Gray SH, Vick CC, Graham LA, et al. Umbilical herniorrhapy in cirrhosis: improved outcomes with elective repair. J Gastrointest Surg 2008;12(4):675–81.
34. Choi SB, Hong KD, Lee JS, et al. Management of umbilical hernia complicated with liver cirrhosis: an advocate of early and elective herniorrhaphy. Dig Liver Dis 2011;43(12):991–5.
35. Choo EK, McElroy S. Spontaneous bowel evisceration in a patient with alcoholic cirrhosis and an umbilical hernia. J Emerg Med 2008;34(1):41–3.
36. Triantos CK, Kehagias I, Nikolopoulou V, et al. Incarcerated umbilical hernia after large volume paracentesis for refractory ascites. J Gastrointestin Liver Dis 2010;19(3):245.
37. Chu KM, McCaughan GW. Iatrogenic incarceration of umbilical hernia in cirrhotic patients with ascites. Am J Gastroenterol 1995;90(11):2058–9.
38. Lemmer JH, Strodel WE, Knol JA, et al. Management of spontaneous umbilical hernia disruption in the cirrhotic patient. Ann Surg 1983;198(1):30–4.
39. Runyon BA, Juler GL. Natural history of repaired umbilical hernias in patients with and without ascites. Am J Gastroenterol 1985;80(1):38–9.
40. O'Connor M, Allen JI, Schwartz ML. Peritoneovenous shunt therapy for leaking ascites in the cirrhotic patient. Ann Surg 1984;200(1):66–9.
41. Belghiti J, Durand F. Abdominal wall hernias in the setting of cirrhosis. Semin Liver Dis 1997;17(3):219–26.
42. Telem DA, Schiano T, Divino CM. Complicated hernia presentation in patients with advanced cirrhosis and refractory ascites: management and outcome. Surgery 2010;148(3):538–43.
43. Fagan SP, Awad SS, Berger DH. Management of complicated umbilical hernias in patients with end-stage liver disease and refractory ascites. Surgery 2004;135(6):679–82.

44. Slakey DP, Benz CC, Joshi S, et al. Umbilical hernia repair in cirrhotic patients: utility of temporary peritoneal dialysis catheter. Am Surg 2005;71(1):58–61.
45. Bachman S, Ramshaw B. Prosthetic material in ventral hernia repair: how do I choose? Surg Clin North Am 2008;88(1):101–12, ix.
46. Jin J, Rosen MJ, Blatnik J, et al. Use of acellular dermal matrix for complicated ventral hernia repair: does technique affect outcomes? J Am Coll Surg 2007;205(5):654–60.
47. Kim H, Bruen K, Vargo D. Acellular dermal matrix in the management of high-risk abdominal wall defects. Am J Surg 2006;192(6):705–9.
48. Patton JH Jr, Berry S, Kralovich KA. Use of human acellular dermal matrix in complex and contaminated abdominal wall reconstructions. Am J Surg 2007; 193(3):360–3 [discussion: 363].
49. Slater NJ, Hansson BM, Buyne OR, et al. Repair of parastomal hernias with biologic grafts: a systematic review. J Gastrointest Surg 2011;15(7):1252–8.
50. Shah BC, Tiwari MM, Goede MR, et al. Not all biologics are equal! Hernia 2011; 15(2):165–71.
51. de Castro Bras LE, Shurey S, Sibbons PD. Evaluation of crosslinked and non-crosslinked biologic prostheses for abdominal hernia repair. Hernia 2012; 16(1):77–89.
52. Primus FE, Harris HW. A critical review of biologic mesh use in ventral hernia repairs under contaminated conditions. Hernia 2013;17(1):21–30.
53. Ramirez OM, Ruas E, Dellon AL. "Components separation" method for closure of abdominal-wall defects: an anatomic and clinical study. Plast Reconstr Surg 1990;86(3):519–26.
54. de Vries Reilingh TS, van Goor H, Rosman C, et al. "Components separation technique" for the repair of large abdominal wall hernias. J Am Coll Surg 2003;196(1):32–7.
55. Yegiyants S, Tam M, Lee DJ, et al. Outcome of components separation for contaminated complex abdominal wall defects. Hernia 2012;16(1):41–5.
56. Morris LM, LeBlanc KA. Components separation technique utilizing an intraperitoneal biologic and an onlay lightweight polypropylene mesh: "a sandwich technique". Hernia 2013;17(1):45–51.
57. de Vries Reilingh TS, van Goor H, Charbon JA, et al. Repair of giant midline abdominal wall hernias: "components separation technique" versus prosthetic repair: interim analysis of a randomized controlled trial. World J Surg 2007; 31(4):756–63.
58. Breuing K, Butler CE, Ferzoco S, et al. Incisional ventral hernias: review of the literature and recommendations regarding the grading and technique of repair. Surgery 2010;148(3):544–58.
59. Espinosa-de-los-Monteros A, Dominguez I, Zamora-Valdes D, et al. Closure of midline contaminated and recurrent incisional hernias with components separation technique reinforced with plication of the rectus muscles. Hernia 2013;17(1):75–9.
60. Rosen MJ, Jin J, McGee MF, et al. Laparoscopic component separation in the single-stage treatment of infected abdominal wall prosthetic removal. Hernia 2007;11(5):435–40.
61. Giurgius M, Bendure L, Davenport DL, et al. The endoscopic component separation technique for hernia repair results in reduced morbidity compared to the open component separation technique. Hernia 2012;16(1):47–51.
62. Lowe JB, Garza JR, Bowman JL, et al. Endoscopically assisted "components separation" for closure of abdominal wall defects. Plast Reconstr Surg 2000; 105(2):720–9 [quiz: 730].

63. Milburn ML, Shah PK, Friedman EB, et al. Laparoscopically assisted components separation technique for ventral incisional hernia repair. Hernia 2007; 11(2):157–61.
64. Krpata DM, Blatnik JA, Novitsky YW, et al. Posterior and open anterior components separations: a comparative analysis. Am J Surg 2012;203(3):318–22.
65. van Geffen HJ, Simmermacher RK, Bosscha K, et al. Anatomical considerations for surgery of the anterolateral abdominal wall. Hernia 2004;8(2):93–7.
66. Carbonell AM, Cobb WS, Chen SM. Posterior components separation during retromuscular hernia repair. Hernia 2008;12(4):359–62.
67. Mayo WJ. VI. An operation for the radical cure of umbilical hernia. Ann Surg 1901;34(2):276–80.
68. Luijendijk RW, Lemmen MH, Hop WC, et al. Incisional hernia recurrence following "vest-over-pants" or vertical Mayo repair of primary hernias of the midline. World J Surg 1997;21(1):62–5 [discussion: 66].
69. Paul A, Korenkov M, Peters S, et al. Unacceptable results of the Mayo procedure for repair of abdominal incisional hernias. Eur J Surg 1998;164(5):361–7.
70. Arroyo A, Garcia P, Perez F, et al. Randomized clinical trial comparing suture and mesh repair of umbilical hernia in adults. Br J Surg 2001;88(10):1321–3.
71. Ammar SA. Management of complicated umbilical hernias in cirrhotic patients using permanent mesh: randomized clinical trial. Hernia 2010;14(1):35–8.
72. Perrakis E, Velimezis G, Vezakis A, et al. A new tension-free technique for the repair of umbilical hernia, using the Prolene hernia system–early results from 48 cases. Hernia 2003;7(4):178–80.
73. Khera G, Berstock DA. Incisional, epigastric and umbilical hernia repair using the Prolene hernia system: describing a novel technique. Hernia 2006;10(4): 367–9.
74. Luijendijk RW, Hop WC, van den Tol MP, et al. A comparison of suture repair with mesh repair for incisional hernia. N Engl J Med 2000;343(6):392–8.
75. Burger JW, Luijendijk RW, Hop WC, et al. Long-term follow-up of a randomized controlled trial of suture versus mesh repair of incisional hernia. Ann Surg 2004; 240(4):578–83 [discussion: 583–5].
76. Sauerland S, Schmedt CG, Lein S, et al. Primary incisional hernia repair with or without polypropylene mesh: a report on 384 patients with 5-year follow-up. Langenbecks Arch Surg 2005;390(5):408–12.
77. Voeller GR, Ramshaw B, Park AE, et al. Incisional hernia. J Am Coll Surg 1999; 189(6):635–7.
78. Duce AM, Mugüerza JM, Villeta R, et al. The Rives operation for the repair of incisional hernias. Hernia 1997;1:175–7.
79. Stoppa RE. The treatment of complicated groin and incisional hernias. World J Surg 1989;13(5):545–54.
80. Binnebosel M, Rosch R, Junge K, et al. Biomechanical analyses of overlap and mesh dislocation in an incisional hernia model in vitro. Surgery 2007;142(3): 365–71.
81. Shell DH, de la Torre J, Andrades P, et al. Open repair of ventral incisional hernias. Surg Clin North Am 2008;88(1):61–83, viii.
82. Petersen S, Henke G, Zimmermann L, et al. Ventral rectus fascia closure on top of mesh hernia repair in the sublay technique. Plast Reconstr Surg 2004;114(7): 1754–60.
83. Satterwhite TS, Miri S, Chung C, et al. Abdominal wall reconstruction with dual layer cross-linked porcine dermal xenograft: the "pork sandwich" herniorraphy. J Plast Reconstr Aesthet Surg 2012;65(3):333–41.

84. Kolker AR, Brown DJ, Redstone JS, et al. Multilayer reconstruction of abdominal wall defects with acellular dermal allograft (AlloDerm) and component separation. Ann Plast Surg 2005;55(1):36–41 [discussion: 41–2].
85. Londono-Schimmer EE, Leong AP, Phillips RK. Life table analysis of stomal complications following colostomy. Dis Colon Rectum 1994;37(9):916–20.
86. Leong AP, Londono-Schimmer EE, Phillips RK. Life-table analysis of stomal complications following ileostomy. Br J Surg 1994;81(5):727–9.
87. Sjodahl R, Anderberg B, Bolin T. Parastomal hernia in relation to site of the abdominal stoma. Br J Surg 1988;75(4):339–41.
88. Pilgrim CH, McIntyre R, Bailey M. Prospective audit of parastomal hernia: prevalence and associated comorbidities. Dis Colon Rectum 2010;53(1):71–6.
89. Garcia RM, Brody F, Miller J, et al. Parastomal herniation of the gallbladder. Hernia 2005;9(4):397–9.
90. Carne PW, Robertson GM, Frizelle FA. Parastomal hernia. Br J Surg 2003;90(7):784–93.
91. Rubin MS, Schoetz DJ Jr, Matthews JB. Parastomal hernia. Is stoma relocation superior to fascial repair? Arch Surg 1994;129(4):413–8 [discussion: 418–9].
92. Hansson BM, Slater NJ, van der Velden AS, et al. Surgical techniques for parastomal hernia repair: a systematic review of the literature. Ann Surg 2012;255(4):685–95.
93. Sugarbaker PH. Prosthetic mesh repair of large hernias at the site of colonic stomas. Surg Gynecol Obstet 1980;150(4):576–8.
94. Janes A, Cengiz Y, Israelsson LA. Preventing parastomal hernia with a prosthetic mesh: a 5-year follow-up of a randomized study. World J Surg 2009;33(1):118–21 [discussion: 122–3].
95. Aldridge AJ, Simson JN. Erosion and perforation of colon by synthetic mesh in a recurrent paracolostomy hernia. Hernia 2001;5(2):110–2.
96. Sugarbaker PH. Peritoneal approach to prosthetic mesh repair of paraostomy hernias. Ann Surg 1985;201(3):344–6.
97. Meyer C, de Manzini N, Rohr S, et al. A direct approach for the treatment of parastomal hernias using a prosthesis. A report of 15 cases. Hernia 1997;1:89–92.
98. Martinez-Munive A, Medina-Ramirez Llaca O, Quijano-Orvananos F, et al. Intraparietal mesh repair for parastomal hernias. Hernia 2000;4:272–4.
99. Smart NJ, Velineni R, Khan D, et al. Parastomal hernia repair outcomes in relation to stoma site with diisocyanate cross-linked acellular porcine dermal collagen mesh. Hernia 2011;15(4):433–7.
100. Taner T, Cima RR, Larson DW, et al. The use of human acellular dermal matrix for parastomal hernia repair in patients with inflammatory bowel disease: a novel technique to repair fascial defects. Dis Colon Rectum 2009;52(2):349–54.
101. Montes IS, Deysine M. Spigelian and other uncommon hernia repairs. Surg Clin North Am 2003;83(5):1235–53, viii.
102. Spangen L. Spigelian hernia. World J Surg 1989;13(5):573–80.
103. Tsalis K, Zacharakis E, Lambrou I, et al. Incarcerated small bowel in a spigelian hernia. Hernia 2004;8(4):384–6.
104. Teo KA, Burns E, Garcea G, et al. Incarcerated small bowel within a spontaneous lumbar hernia. Hernia 2010;14(5):539–41.
105. Moreno-Egea A, Baena EG, Calle MC, et al. Controversies in the current management of lumbar hernias. Arch Surg 2007;142(1):82–8.
106. Astarcioglu H, Sokmen S, Atila K, et al. Incarcerated inferior lumbar (Petit's) hernia. Hernia 2003;7(3):158–60.

107. Loukas M, El-Zammar D, Shoja MM, et al. The clinical anatomy of the triangle of Grynfeltt. Hernia 2008;12(3):227–31.
108. Loukas M, Tubbs RS, El-Sedfy A, et al. The clinical anatomy of the triangle of Petit. Hernia 2007;11(5):441–4.
109. Jagad RB, Kamani P. Central diaphragmatic hernia in an adult: a rare presentation. Hernia 2012;16(5):607–9.
110. Brown SR, Horton JD, Trivette E, et al. Bochdalek hernia in the adult: demographics, presentation, and surgical management. Hernia 2011;15(1):23–30.
111. Altinkaya N, Parlakgumus A, Koc Z, et al. Morgagni hernia: diagnosis with multidetector computed tomography and treatment. Hernia 2010;14(3): 277–81.
112. Iso Y, Sawada T, Rokkaku K, et al. A case of symptomatic Morgagni's hernia and a review of Morgagni's hernia in Japan (263 reported cases). Hernia 2006;10(6): 521–4.
113. Poulose BK, Gosen C, Marks JM, et al. Inpatient mortality analysis of paraesophageal hernia repair in octogenarians. J Gastrointest Surg 2008;12(11): 1888–92.
114. Oddsdottir M. Paraesophageal hernia. Surg Clin North Am 2000;80(4):1243–52.
115. Maekawa T, Suematsu M, Shimada T, et al. Unusual swallow syncope caused by huge hiatal hernia. Intern Med 2002;41(3):199–201.
116. Stylopoulos N, Gazelle GS, Rattner DW. Paraesophageal hernias: operation or observation? Ann Surg 2002;236(4):492–500 [discussion: 500–1].
117. Park AE, Hoogerboord CM, Sutton E. Use of the falciform ligament flap for closure of the esophageal hiatus in giant paraesophageal hernia. J Gastrointest Surg 2012;16(7):1417–21.
118. Fuller CB, Hagen JA, DeMeester TR, et al. The role of fundoplication in the treatment of type II paraesophageal hernia. J Thorac Cardiovasc Surg 1996;111(3): 655–61.
119. Rakic S, Pesko P, Dunjic MS, et al. Paraoesophageal hernia repair with and without concomitant fundoplication. Br J Surg 1994;81(8):1162–3.
120. Williamson WA, Ellis FH Jr, Streitz JM Jr, et al. Paraesophageal hiatal hernia: is an antireflux procedure necessary? Ann Thorac Surg 1993;56(3):447–51 [discussion: 451–2].
121. Martin LC, Merkle EM, Thompson WM. Review of internal hernias: radiographic and clinical findings. AJR Am J Roentgenol 2006;186(3):703–17.
122. Fan HP, Yang AD, Chang YJ, et al. Clinical spectrum of internal hernia: a surgical emergency. Surg Today 2008;38(10):899–904.
123. Mathieu D, Luciani A. Internal abdominal herniations. AJR Am J Roentgenol 2004;183(2):397–404.
124. Zonca P, Maly T, Mole DJ, et al. Treitz's hernia. Hernia 2008;12(5):531–4.
125. Hong SS, Kim AY, Kim PN, et al. Current diagnostic role of CT in evaluating internal hernia. J Comput Assist Tomogr 2005;29(5):604–9.
126. Davis R. Surgery of left paraduodenal hernia. Am J Surg 1975;129(5):570–3.
127. Newsom BD, Kukora JS. Congenital and acquired internal hernias: unusual causes of small bowel obstruction. Am J Surg 1986;152(3):279–85.
128. Dardik H, Cowen R. Herniation of the gallbladder through the epiploic foramen into the lesser sac. Ann Surg 1967;165(4):644–6.
129. Osvaldt AB, Mossmann DF, Bersch VP, et al. Intestinal obstruction caused by a foramen of Winslow hernia. Am J Surg 2008;196(2):242–4.
130. Gomes R, Rodrigues J. Spontaneous adult transmesentric hernia with bowel gangrene. Hernia 2011;15(3):343–5.

131. Rooney JA, Carroll JP, Keeley JL. Internal hernias due to defects in the mesoappendix and mesentery of small bowel, and probable Ivemark syndrome: report of two cases. Ann Surg 1963;157(2):254–8.
132. Choh NA, Rasheed M, Jehangir M. The computed tomography diagnosis of paracecal hernia. Hernia 2010;14(5):527–9.
133. Schneider C, Cobb W, Scott J, et al. Rapid excess weight loss following laparoscopic gastric bypass leads to increased risk of internal hernia. Surg Endosc 2011;25(5):1594–8.
134. Champion JK, Williams M. Small bowel obstruction and internal hernias after laparoscopic Roux-en-Y gastric bypass. Obes Surg 2003;13(4):596–600.
135. Ahmed AR, Rickards G, Husain S, et al. Trends in internal hernia incidence after laparoscopic Roux-en-Y gastric bypass. Obes Surg 2007;17(12):1563–6.
136. Garza E Jr, Kuhn J, Arnold D, et al. Internal hernias after laparoscopic Roux-en-Y gastric bypass. Am J Surg 2004;188(6):796–800.
137. Lockhart ME, Tessler FN, Canon CL, et al. Internal hernia after gastric bypass: sensitivity and specificity of seven CT signs with surgical correlation and controls. AJR Am J Roentgenol 2007;188(3):745–50.
138. Iannelli A, Facchiano E, Gugenheim J. Internal hernia after laparoscopic Roux-en-Y gastric bypass for morbid obesity. Obes Surg 2006;16:1265–71.
139. Higa KD, Ho T, Boone KB. Internal hernias after laparoscopic Roux-en-Y gastric bypass: incidence, treatment and prevention. Obes Surg 2003;13(3):350–4.
140. Paroz A, Calmes JM, Giusti V, et al. Internal hernia after laparoscopic Roux-en-Y gastric bypass for morbid obesity: a continuous challenge in bariatric surgery. Obes Surg 2006;16(11):1482–7.
141. Montgomery A, Petersson U, Austrums E. The arcuate line hernia: operative treatment and a review of the literature. Hernia 2013;17(3):391–6.
142. Coulier B. Multidetector computed tomography features of linea arcuata (arcuate-line of Douglas) and linea arcuata hernias. Surg Radiol Anat 2007; 29(5):397–403.
143. von Meyenfeldt EM, van Keulen EM, Eerenberg JP, et al. The linea arcuata hernia: a report of two cases. Hernia 2010;14(2):207–9.
144. Abasbassi M, Hendrickx T, Caluwe G, et al. Symptomatic linea arcuata hernia. Hernia 2011;15(2):229–31.
145. Chapman VM, Rhea JT, Novelline RA. Internal hernia through a defect in the broad ligament: a rare cause of intestinal obstruction. Emerg Radiol 2003; 10(2):94–5.
146. Langan RC, Holzman K, Coblentz M. Strangulated hernia through a defect in the broad ligament: a sheep in wolf's clothing. Hernia 2012;16(4):481–3.
147. Nasir BS, Zendejas B, Ali SM, et al. Obturator hernia: the Mayo Clinic experience. Hernia 2012;16(3):315–9.
148. Rodriguez-Hermosa JI, Codina-Cazador A, Maroto-Genover A, et al. Obturator hernia: clinical analysis of 16 cases and algorithm for its diagnosis and treatment. Hernia 2008;12(3):289–97.
149. Skandalakis LJ, Skandalakis PN, Colborn GL, et al. Obturator hernia: embryology, anatomy, surgery. Hernia 2000;4:121–8.
150. Hannington-Kiff JG. Absent thigh adductor reflex in obturator hernia. Lancet 1980;1(8161):180.
151. Galketiya K, Sakrepatna S, Gananadha S. Obturator hernia–an uncommon cause of small bowel obstruction. J Gastrointest Surg 2013;17(4):840–1.
152. Shigemitsu Y, Akagi T, Morimoto A, et al. The maneuver to release an incarcerated obturator hernia. Hernia 2012;16(6):715–7.

153. Skandalakis LJ, Androulakis J, Colborn GL, et al. Obturator hernia. Embryology, anatomy, and surgical applications. Surg Clin North Am 2000;80(1):71–84.
154. Martinez Insua C, Costa Pereira JM, Cardoso de Oliveira M. Obturator hernia: the plug technique. Hernia 2001;6:161–3.
155. Tchanque CN, Virmani S, Teklehaimanot N, et al. Bilateral obturator hernia with intestinal obstruction: repair with a cigar roll technique. Hernia 2010;14(5): 543–5.
156. Maharaj D, Maharaj S, Young L, et al. Obturator hernia repair–a new technique. Hernia 2002;6(1):45–7.
157. Shipkov CD, Uchikov AP, Grigoriadis E. The obturator hernia: difficult to diagnose, easy to repair. Hernia 2004;8(2):155–7.
158. Preiss A, Herbig B, Dorner A. Primary perineal hernia: a case report and review of the literature. Hernia 2006;10(5):430–3.
159. Losanoff JE, Basson MD, Gruber SA, et al. Sciatic hernia: a comprehensive review of the world literature (1900-2008). Am J Surg 2010;199(1):52–9.
160. Chaudhuri A, Chye KK, Marsh SK. Sciatic hernias: choice of optimal prosthetic repair material in preventing long-term morbidity. Hernia 1999;4:229–31.