106 Mesentery, Omentum, Peritoneum: Internal Hernias and Abdominal Wall Hernias

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Introduction

Abdominal hernias are a common clinical problem. They are classified as internal hernias and external or abdominal wall hernias. Abdominal wall hernias involve protrusion of abdominal contents through a defect in the abdominal wall. In internal hernias, bowel or viscera protrude through a natural opening or a defect in the peritoneum or mesentery into a compartment within the abdominal cavity. Diaphragmatic hernias are a special subtype of hernia in which abdominal contents protrude into the thoracic cavity (Miller et al. 1995). Internal hernias (IH) may develop based on congenital anomalies of the peritoneum or mesentery or secondary to trauma, surgery, inflammation, or circulation disorders.

Understanding the anatomy of the peritoneal cavity and the predestined anatomic locations for IH and the recognition of characteristic radiologic imaging findings helps to consider and identify internal hernias in most cases (Takeyama et al. 2005; Mathieu and Luciani 2004). Therefore, it is crucial for every radiologist to be aware of these imaging findings particularly on CT, since CT is a mainstay in the workup of acute abdominal pain.

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Internal Hernias

Epidemiology

The overall incidence of internal abdominal hernias is rare; they are reported to account for 0.2–0.9 % in autopsies and for 0.5–4.1 % in cases with intestinal obstruction (Mathieu and Luciani 2004).

Over the past decade, the incidence of IH has increased, presumably due to a number of new surgical procedures being performed, including gastric bypass surgery and liver transplantation. Since IH are associated with a high mortality rate of up to 50 % in some series (Newsom and Kukora 1986), they deserve special attention and a sound understanding of the underlying anatomy and pathomechanism.

Classification

Internal abdominal hernias are defined as protrusion of an abdominal hollow or solid organ through a normal or abnormal mesenteric or peritoneal aperture within the confines of the peritoneal cavity. According to the classification of Welch, they can be categorized based on their topographic location within the peritoneal cavity in the following types: left and right paraduodenal hernia, pericecal hernia, foramen of Winslow hernia, transmesenteric, intersigmoid,

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transomental, supravesical, and pelvic hernias as well as retroanastomotic hernias (Takeyama et al. 2005). The relative frequency and characteristics of each of these types of IH are summarized in Table 106.1.

IH which are related to congenital predispositions occur spontaneously through hernial orifices. These orifices are defined by preexisting anatomic structures, such as foramina, recesses, and fossae. Malrotation of the large or small bowel may be associated with these preexisting defects. Additional predisposing factors for the formation of IH are pathologic defects of the mesentery and the visceral peritoneum secondary to surgery, trauma, inflammation, and circulation disorders.

Clinical Presentation

Internal abdominal hernias are rarely correctly diagnosed preoperatively because they lack specific clinical symptoms. The most common clinical presentation of an IH is that of an acute intestinal obstruction. Most of the time, however, the diagnosis is more challenging due to a wide range of symptoms from intermittent and mild digestive complaints to acute-onset intestinal obstruction. If hernias are easily reducible, the clinical presentation may be intermittent or transient and less severe. During asymptomatic intervals, clinical or radiologic studies may not reveal any abnormality.

General Imaging Findings in Internal Hernias

Because the clinical diagnosis of IH is difficult, imaging plays a central role. The imaging modalities relevant for diagnosing IH include plain radiography, ultrasound, and CT. In most cases, accurate and reliable findings can be obtained to make a correct diagnosis. CT has become the first-line imaging technique in these patients. It is mostly readily available, fast, and little operator dependant. Multidetector row CT (MDCT) technology and 3D postprocessing capabilities with multiplanar reformation (MPR) help to ease the diagnosis through multidirectional display. Radiographic studies with barium or iodinated contrast have lost importance in view of the availability and capabilities of cross-sectional imaging.

Typical imaging features of IH on plain radiography include a cluster of distended gas-containing bowel loops which may be appreciated in abnormal locations, and loculated fluid-fluid levels indicating obstruction. The absence of normal gas distribution patterns in the abdomen is an additional indirect sign of dislocated bowel loops (Figs. 106.8a, 106.9).

Barium studies will confirm apparent encapsulation of distended bowel loops in an abnormal location and abnormal arrangement or crowding of small bowel loops within a hernial sac. Segmental dilatation and stasis are key features of obstruction. Furthermore, the pattern of propulsion of the luminal contrast agent provides functional information which helps in the diagnosis: reversed peristalsis during fluoroscopy may indicate apparent fixation of the hernial sac. The abrupt discontinuation of intraluminal contrast material at the hernial orifice due to strangulation may point at the hernial orifice in the suspicion of IH (Fig. 106.8b).

Ultrasound may identify distended bowel loops and secondary free fluid, yet it is limited in providing full anatomic overview in the presence of abundant gas collections.

In CT, as a general rule, there are mainly two findings which are characteristic for IH: (1) abnormal bowel configuration and arrangement of the mesentery and (2) pathologic course of the mesenteric vasculature. Abnormal bowel configuration consists of a group of dilated bowel loops which are clustered and crowded or encapsulated as a saclike mass. Additionally, other bowel segments may be displaced, especially the transverse colon and the fourth portion of the duodenum.

The mesenteric vascular pedicle may be engorged, stretched, and displaced. The vessels to the dilated bowel loops typically converge at the entrance of the hernial orifice. Impaired venous drainage and maintained continuous influx of the arterial flow may result in bowel wall ischemia due to the engorgement (Miller et al. 1995).

Specific Hernia Types

Paraduodenal Hernia

Paraduodenal hernias are the most common type of IH and constitute approximately 53 % of all IH. They are more frequent in men than in women. There are two types of paraduodenal hernias: left and right. Approximately 3/4 of all paraduodenal hernias occur to the left (Fig. 106.1). Paraduodenal hernias form within

Table 106.1 Pathologic cluster of small bowel loops (CSB)

Type of hernia	Origin	Incidence (%)	Anatomic location	Hernial sac formation	Key imaging finding: X-ray	Key imaging finding: Fluoroscopy/ barium study	Key imaging finding: Computed tomography	Landmark	Comments
Internal Hernia	See below	0.5–4.1[a]	See below		Abnormal bowel loop arrangement; vascular distortion; dilated bowel loops with fluid-fluid levels				
Paraduodenal hernia (1)	Congenital	53[b]	Paraduodenal fossa						Most common type of IH
Right paraduodenal IH		25/53	Fossa of Landzert	Yes				Right colic vein lies anteriorly and the superior mesenteric artery is located at the anterior-medial border	
Left paraduodenal IH		75/53	Fossa of Waldeyer	Yes			CSB between pancreas and stomach	inferior mesenteric vein and left colic artery in the anterior wall of the sac	
Pericecal hernia (2)		13[b]					CSB in right paracolic gutter		Second most common type of IH; often misdiagnosed as appendicitis, appendiceal disorder, IBD
Transmesenteric hernia (4)	Congenital	8	Defect within mesentery close to ligament of Treitz or ileocecal valve	No					1/3 occurs during pediatric period
Foramen of Winslow hernia (3)	Congenital	8		No					
Perisigmoid hernia (6)	Congenital	6							
Intersigmoid			Lateral aspect of the sigmoid mesocolon				Loopsbehind and beyond the left posterolatral aspect of the sigmoid colon		Most common type of sigmoid hernia
Intermesosigmoid									
Intramesosigmoid									
Transomental hernia (5)	Congenital	1–4		no					

(*continued*)

Table 106.1 (continued)

Type of hernia	Origin	Incidence (%)	Anatomic location	Hernial sac formation	Key imaging finding			Landmark	Comments
					X-ray	Fluoroscopy/ barium study	Computed tomography		
Supravesical hernia		6		yes				They appear close to the abdominal wall or around the bladder	common clinicalpresentation is that of intestinal obstruction
Direct supravesical hernia									
Indirect supravesical hernia									
Pelvic hernias									
Through broad ligament	Congenital or acquired	4–5	Caudal or cephalad to the round ligament				Bowel loops dispalcing the uterus ventrally		“Fenestra” or “pouch” type
Perirectal		Extremely rare							
Postoperative hernia	Acquired			Yes			Swirled appearance of fat and vessels, loops touching the abdominal wall	Displacement of the suture line cephalad into the left upper quadrant	After treatment of morbid obesity or liver trasplant
Transmesocolic		Most common							
Retroanastomotic									During the first postoperative month, after Roux en Y reconstruction
Peterson defect (behind Roux-Y)									
External hernia (abdominal wall)									
Spighelian hernia	Congenital	Uncommon	Semilunar line				Fascial defect in the apprpriate location		Herniation of only fat misinterpreted as lipoma
Incisional hernias	Acquired, iatrogenic	5 % of patients after abdominal surgery		Yes				Most common type of anterior abdominal hernia	Manifest in the first year after surgery

Umbilical hernia	Acquired	Common	Midline hernia	Yes				Most common type of ventral hernia, strangulation and incarceration are common
Inguinal hernia		Most common type of AWH	Inguinal canal	Yes		May be easily overlooked in the supine position	Herniating bowel loops in the inguinal canal	
Indirect	Congenital			Yes			Lateral to the inferior epigastric vessels	Most common of all abdominal hernias
Direct	Acquired			Yes			Medial to the inferior epigastric vessels	Rarely icarcerate
Littre hernia								The inguinal hernia contains a Meckel diverticulum
Femoral hernia	Congenital		Inferior and lateral to the pubic tubercle					Prone to strangulation and incarceration
Obturator hernia	Acquired	Uncommon	Obturator canal	Yes		Hernial sac between the internal and external obturator muscles		Elderly women, incarceration
Sciatic hernias	Acquired	Uncommon	Greater or lesser sciatic notch	Yes		Hernia emerges above or below piriform muscle		Involves the distal ureter or a loop of small bowel
Perineal hernia	Acquired	Very rare		Yes		Perineal or gluteal mass formed by bowel loops		Elderly women
Traumatic hernia	Acquired		Lumbar region and lower abdomen			Associated with intraabdominal injuries		Incarceration and strangulation

Inflammatory bowel disease (IBD)
AWH abdominal wall hernia
(x) means chapter
[a]overall %
[b]of all IH

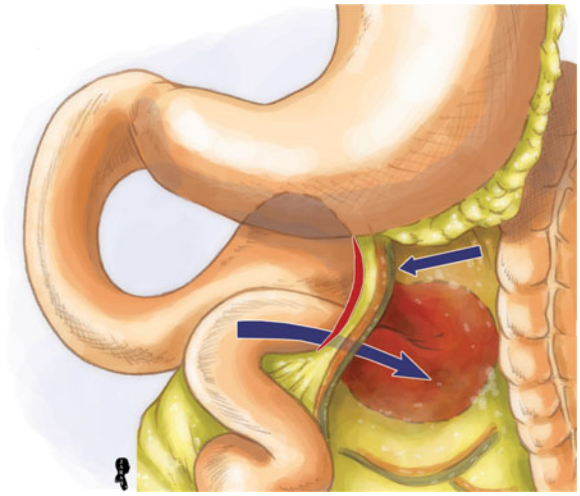

Fig. 106.1 Schema: left paraduodenal hernia

paraduodenal fossae which are congenital peritoneal anomalies. Paraduodenal fossae persist if the mesentery fails to fuse with the parietal peritoneum. There is an associated abnormal rotation with imprisonment of the small intestine beneath the developing colon.

Five types of paraduodenal fossae are clinically relevant: the superior duodenal fossa, inferior duodenal fossa (fossa of Treitz), paraduodenal fossa (fossa of Landzert), intermesocolic fossa (fossa of Broesike), and mesentericoparietal fossa (fossa of Waldeyer). The fossa of Landzert, present in about 2 % of autopsies, is recognized as predisposing for left paraduodenal hernia and the fossa of Waldeyer, present in about 1 % of autopsies, as predisposing for right paraduodenal hernia. The fossa of Landzert is located at the duodenojejunal junction, which is a zone of confluence of the descending mesocolon, transverse mesocolon, and small bowel mesentery. The herniated small bowel loops may become entrapped within this mesenteric sac.

Imaging

The key imaging feature of a ***left paraduodenal hernia*** is an abnormal cluster or saclike mass of dilated small bowel loops lying ***between the pancreas and stomach*** and to the left of the ligament of Treitz (Fig. 106.2). There is usually mass effect displacing the posterior wall of the stomach anteriorly, the duodenal flexure inferiorly, and the transverse colon inferiorly. The mesenteric vessels supplying the herniated bowel segments are crowded, engorged, and stretched at the entrance of the hernial sac.

As a landmark for a left paraduodenal hernia, the ***anterior wall*** of the sac with the encapsulated bowel loops contains the ***inferior mesenteric vein and left colic artery***. These conditions are best appreciated on CT.

Right paraduodenal hernias (Fig. 106.3) involve the fossa of Waldeyer which is located immediately behind the course of the superior mesenteric artery and inferior to the transverse segment of the duodenum. Right paraduodenal hernias may be associated with rotation anomaly of the bowel; they are more frequent in individuals with non-rotated small intestine and a normal or incompletely rotated colon. Depending on the extent of malrotation, the superior mesenteric vein is displaced to the left of and ventral to the superior mesenteric artery. A normal horizontal duodenum may also be absent.

Because the fossa of Waldeyer extends to the right and downward directly in front of the posterior parietal peritoneum, right paraduodenal hernias develop ***into the ascending mesocolon***. As a landmark for a right paraduodenal hernia (Fig. 106.4a, b), **the *right colic vein lies anteriorly, and the superior mesenteric artery is located at the anterior-medial border*** of the encapsulated small bowel loops (Mathieu and Luciani 2004; Zarvan et al. 1995).

Pericecal Hernia

Pericecal hernia (Fig. 106.5) is the second most common type of IH; it accounts for approximately 13 % of all cases with IH. Embryologically, the anatomy of the cecal and pericecal peritoneum is not determined until the 5th fetal month when the migration of the midgut is complete and the cecum fixed in the right colic fossa.

Four different pericecal recesses may be formed by folds of the peritoneum: the superior and inferior ileocecal recess, the retrocecal recess which is the largest of the four recesses, and the paracolic sulci (Takeyama et al. 2005). The paracolic sulci are lateral depressions of the peritoneum investing the cecum. These recesses may be absent or rarely extend posterior to the cecum, forming pockets large enough to admit several fingers. Supplementary recesses and fossae may develop in the ileocecal area because of individual variations in the processes of bowel rotation and peritoneal fusion; these structures may also become hernial orifices.

In pericecal hernia (Fig. 106.6), typically ileal loops herniate through the defect and occupy ***the right***

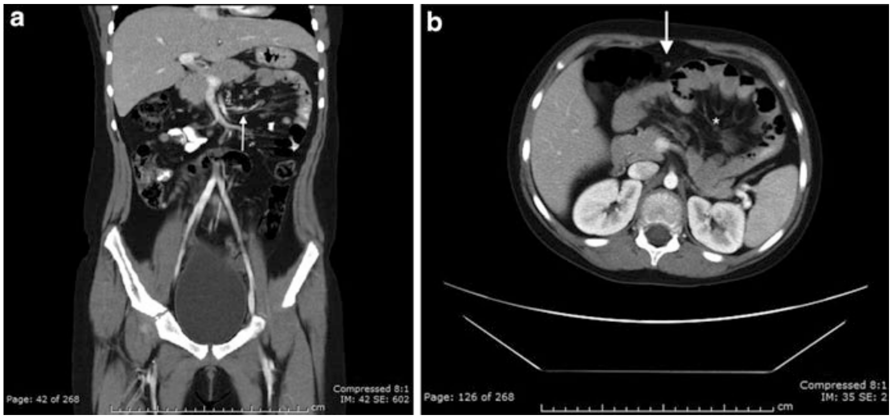

Fig. 106.2 (**a**, **b**): Left Paraduodenal Hernia. Coronal CT reformation (**a**) showing mesenteric vessels (*arrow*) entering hernia sac through Landzert's fossa. Axial image of the same patient shows a key feature of left paraduodenal hernia which is anterior displacement of inferior mesenteric vein (*arrow*) by the hernia sac (*)

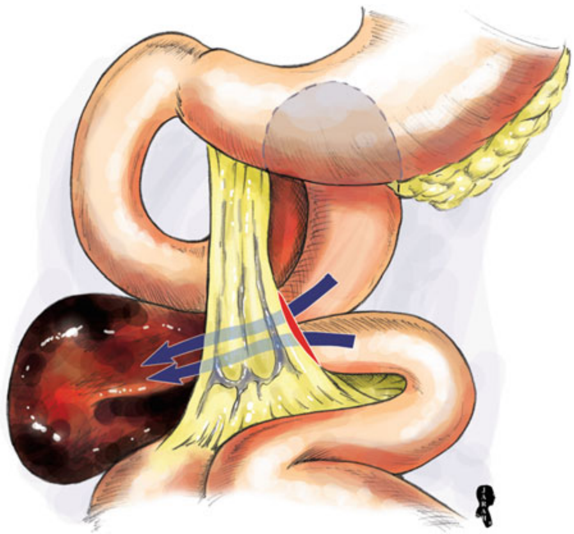

Fig. 106.3 Schema: right paraduodenal hernia

paracolic gutter. Clinical diagnosis is again difficult, especially in chronic incarceration, since pericecal hernia owing to their location easily mimic inflammatory bowel disease, appendiceal disorders, or other causes of SBO.

Imaging

Again, CT is the most conclusive imaging modality and demonstrates a cluster of fluid-filled small bowel ***loops located lateral to the cecum and posterior to the ascending colon***. A ***beaking appearance*** of the mesentery and corresponding vessels, tethering at the aperture of the peritoneal recess and dilatation of small bowel loops are indicative signs of this disorder (Pessaux et al. 1999; Zissin et al. 2005).

On plain films, small bowel loops may be appreciated lateral to the ascending colon. Delayed radiographs from a small bowel series or barium enema examination may be helpful if the patient's condition permits these examinations.

Foramen of Winslow Hernia

The lesser sac and the greater peritoneal cavity communicate through the epiploic foramen of Winslow. This opening is a 3-cm vertical slit situated beneath the right border of the lesser sac, cephalad to the duodenal bulb, and deep to the liver. This foramen is located anterior to the inferior vena cava and posterior to the hepatoduodenal ligament, which carries the portal vein, common bile duct, and hepatic artery.

IH through the foramen of Winslow (Fig. 106.7) represent approximately 8 % of all IH. Predisposing factors for this type of IH include an enlarged foramen of Winslow, excessively mobile intestinal loops due to a long mesentery and persistence of an ascending mesocolon where the ascending colon has not fused to the parietal peritoneum (Rajeswaran et al. 2010).

The intestinal segment which is herniating into the Foramen of Winslow most commonly is the small intestine (60–70 %); the terminal ileum, cecum, and ascending colon are involved in about 25–30 %. Hernias involving the transverse colon, omentum, and gallbladder are rare.

Imaging

Characteristic plain radiographic findings of Foramen of Winslow hernias are gas-containing intestinal loops high in the abdomen, medial and posterior to the stomach if the small bowel loops are involved in the hernia (Fig. 106.2).

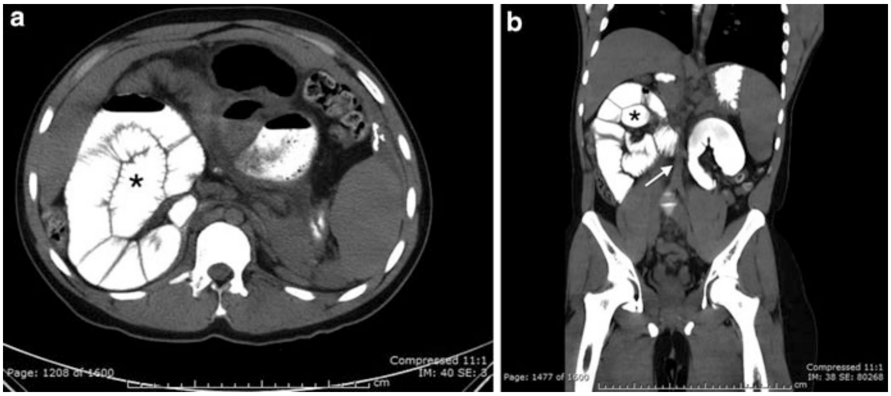

Fig. 106.4 Right paraduodenal hernia. 22 y/o male with a complex history of pelvic renal transplant, recurrent abdominal abscesses and recurrent bowel obstruction. Axial (**a**) and coronal (**b**) images from CT enteroclysis revealing small bowel loop (*) entering the hernia sac via Waldeyer's fossa. Mesenteric vessels (*arrow*) coursing over small bowel loops as they pass through Waldeyer's fossa into the hernia sac (*)

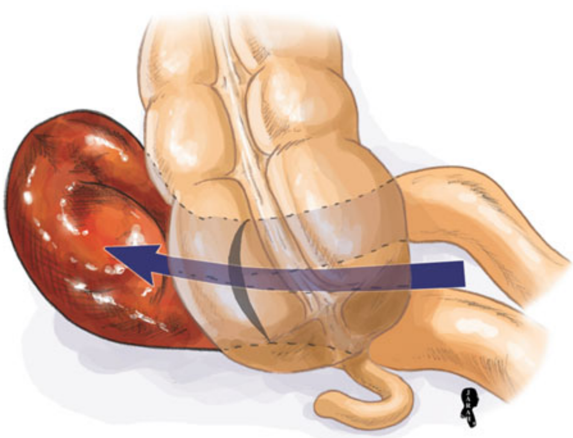

Fig. 106.5 Schema: pericecal hernia

The cecum and ascending colon may be absent from their usual locations if they are part of the herniated viscera.

The typical CT appearance includes the presence of ***mesentery between the inferior vena cava and main portal vein***, an air-fluid collection in the lesser sac with a beak directed toward the foramen of Winslow. The ***absence of the ascending colon in the right gutter*** and two *or* ***more bowel loops in the high subhepatic spaces*** are further signs (Zarvan et al. 1995; Azar et al. 2012).

Transmesenteric Hernia (Fig. 106.9)

The small bowel mesentery is a broad, fan-shaped fold of peritoneum suspending the small intestine from the posterior abdominal wall. The two layers of peritoneal reflection extend from its origin at the ligament of Treitz in the mid upper abdomen to the right and downward toward the ileocecal valve.

Overall, transmesenteric hernias account for 8 % of all IH. Nearly 35 % of transmesenteric hernias occur during the pediatric period and are most likely caused by a congenital mechanism. Mesenteric defects are usually 2–5 cm in diameter and are located close to the ligament of Treitz or the ileocecal valve. Three etiologic hypotheses have been proposed for congenital mesenteric defects: (1) partial regression of the dorsal mesentery, (2) fenestration of an inadequately vascularized area during the developmental enlargement of the mesentery, and (3) considerable and rapid lengthening of the ileocecal mesentery in fetal life. In adults, most mesenteric defects result from surgery, trauma, or inflammation and may occur anywhere along the mesenteric course.

The incidence of transmesenteric and transmesocolic hernia is increasing in frequency as a result of abdominal surgery involving Roux-en-Y reconstructions (such as in gastric bypass for obesity control or liver transplantation) (Blachar et al. 2001; Blachar and Federle 2001). Among those, IH are more common after laparoscopic Roux-en-Y gastric bypass than after open Roux-en-Y gastric bypass. Actually, IH are reported to be the most common cause of small bowel obstruction after laparoscopic Roux-en-Y gastric bypass (Husain et al. 2007) (see postsurgical IH).

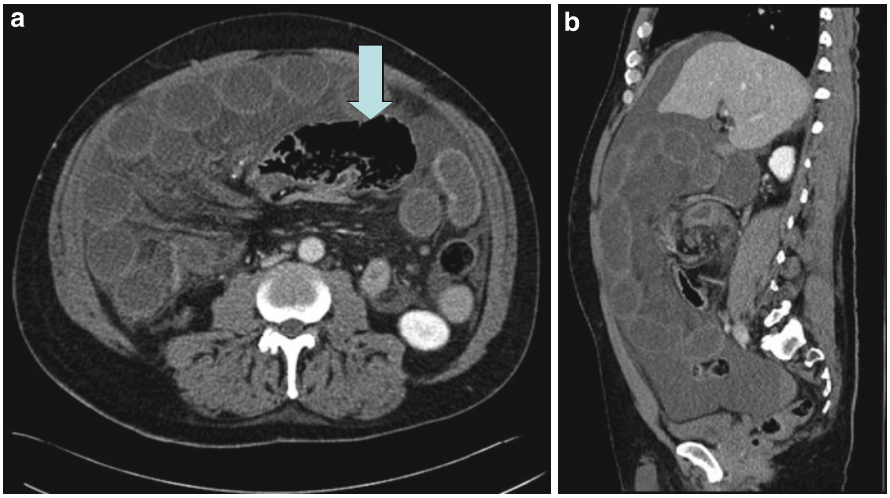

Fig. 106.6 The cecum is high in the abdomen and displaced to the midline lying horizontally placed in the mid abdomen (**a**, *arrow*). Behind the cecum there is a 'beaking' of small bowel indicating the point of herniation (**a**). Note that the vessels radiate into the right flank (sagittal, **b**).

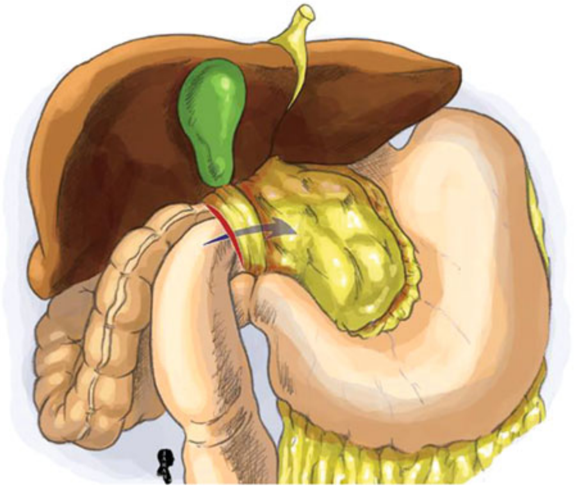

Fig. 106.7 Schema: Foramen Winslow hernia

Imaging

A transmesenteric hernia usually manifests with proximal small bowel dilatation followed by a transitional zone to normal or collapsed intestine. Because the mesenteric defect itself is generally not visualized, the ***clustering of small bowel loops*** and ***abnormal course of the mesenteric vessels*** are key findings in the diagnosis of transmesenteric and transmesocolic hernia (Figs. 106.9, 106.10). On plain film, a persistent cluster of distended air-containing bowel loops and abnormal gas pattern in the remaining abdomen are indicative of this condition (Fig. 106.9). In the absence of a limiting hernial sac, mechanical small bowel obstruction occurs easily and might rapidly complicate into a volvulus with hernial strangulation and intestinal gangrene. It is impossible to differentiate closed-loop obstruction by herniation through the mesenteric defect from those caused by adhesive bands.

Transomental Hernia

Transomental hernias constitute approximately 1–4 % of all IH. Two types can be distinguished: in the first type, bowel herniates through a bare area in the greater omentum. This type is more common, and no hernial sac is present. The hernial orifice is typically located in the periphery near the free edge of the greater omentum; it is usually slitlike and 2–10 cm wide (Fig. 106.11). In the second type, which is rare, herniation occurs into the lesser sac through a defect in the gastrocolic ligament. Small bowel loops, the cecum, and the sigmoid colon may be involved in these hernias.

The cause of omental defects has not been identified. It has been suggested that most have a congenital origin, although inflammation, trauma, and circulation disorders may also result in omental perforations. The clinical and radiological findings are very similar to those of transmesenteric hernias.

Sigmoid Mesocolon Hernia

IH through the sigmoid mesocolon account for 6 % of all IH. The sigmoid mesocolon is a peritoneal fold attaching the sigmoid colon to the pelvic wall. At the tip of its course near the left common iliac artery, it splits up to form a V-shaped parietal attachment embracing the intersigmoid fossa. This pocket is

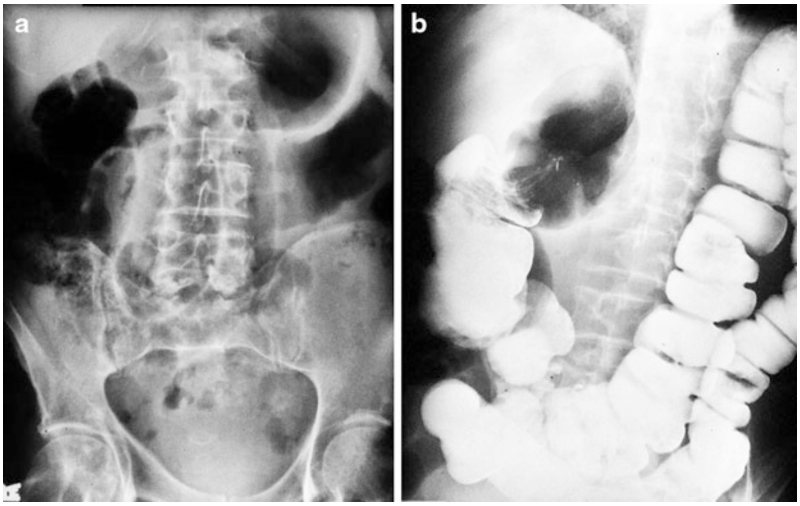

Fig. 106.8 (**a**, **b**) Winslow hernia: The cecal pole is herniated into the lesser sac in the *right upper* quadrant. There is air distension of the ascending colon and cecum which is trapped in the lesser sac in the upper abdomen. The colonic frame distal to this shows no air pattern. During rectal barium enema the stop of contrast progress can be demonstrated at the entrance into the lesser sac, the foramen of Winslow in the *right* upper quadrant

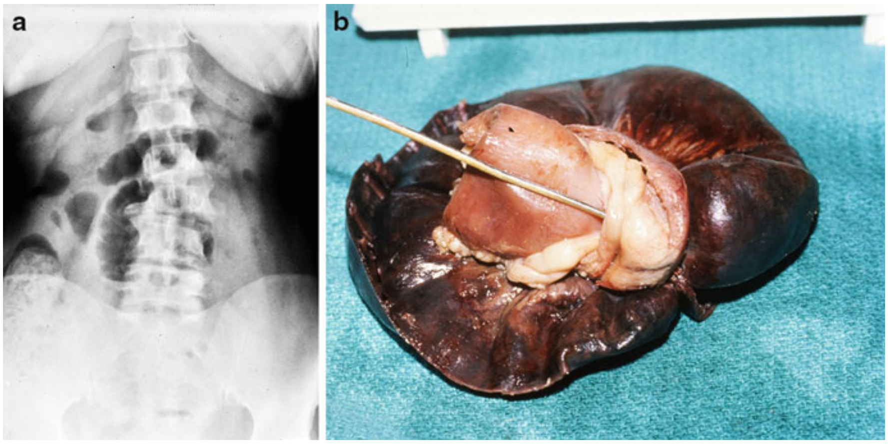

Fig. 106.9 *Transmesenteric hernia:* Conventional abdominal x-ray in supine position (**a**) and macroscopic specimen (**b**) of a resected bowel segment after strangulation and incarceration

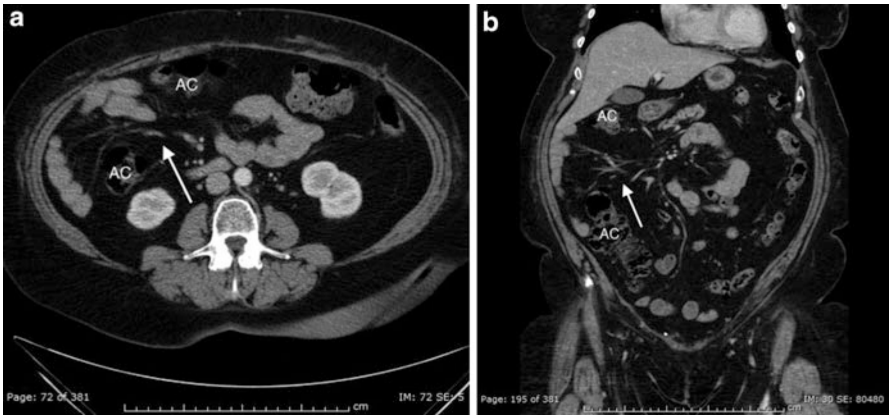

Fig. 106.10 Transmesocolic hernia: ascending mesocolon hernia. Axial and sagittal CT images of the ascending mesocolonic hernia. Small bowel mesentery (*arrow*) seen herniating through the ascending mesocolon. There was no acute obstruction in this case. Clustered bowel loops in abnormal position and an abnormal course of mesenteric vessels are key findings. (**a**) *AC* ascending colon

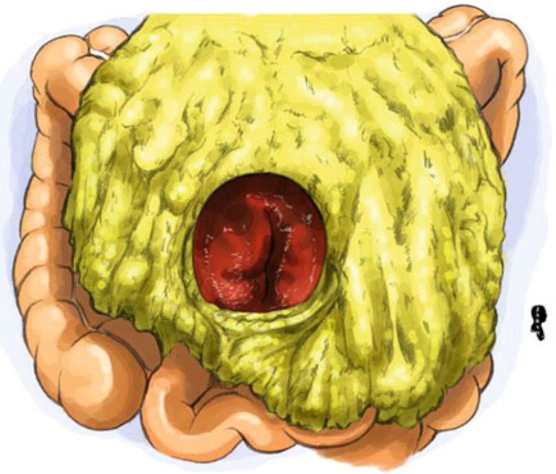

Fig. 106.11 Schema: transomental hernia

found in 65 % of autopsies and varies in size from a dimple to a true fossa admitting the fifth finger. This intersigmoid fossa is a congenital precondition with potential for IH formation.

Sigmoid mesocolon hernias are divided into three subtypes: intersigmoid hernia, intermesosigmoid hernia, and transmesosigmoid hernia.

The *intersigmoid hernia* is the most common type. Intersigmoid hernias develop when herniating viscera protrude into a peritoneal pocket formed between two adjacent sigmoid segments and their mesentery, the intersigmoid fossa (Mathieu and Luciani 2004). The herniated portion is situated at the ***lateral aspect of the attachment of the sigmoid mesocolon***.

Intramesosigmoid hernia implies a small bowel prolapse through a congenital defect in only one of the constituent leaves of the sigmoid mesocolon. This condition is associated with the formation of a hernial sac. Incarceration may complicate it.

In *transmesosigmoid* hernia small bowel loops herniate through a complete defect in the sigmoid mesocolon involving both layers of peritoneal leaves forming the sigmoid mesentery; this defect is oval and ranges in diameter from 2 to 4 cm. (Fig. 106.12). In transmesosigmoid hernia, there is no hernial sac as small bowel loops descend toward the left lower abdomen into the space posterior-lateral to the sigmoid colon (Mathieu and Luciani 2004).

Imaging

In the absence of signs of obstruction, these hernias can be diagnosed with post-evacuation barium enema radiographs, which will show sacculated ileal loops occupying the left lower quadrant. The sigmoid colon will be elevated and displaced to the right toward the mid-abdomen.

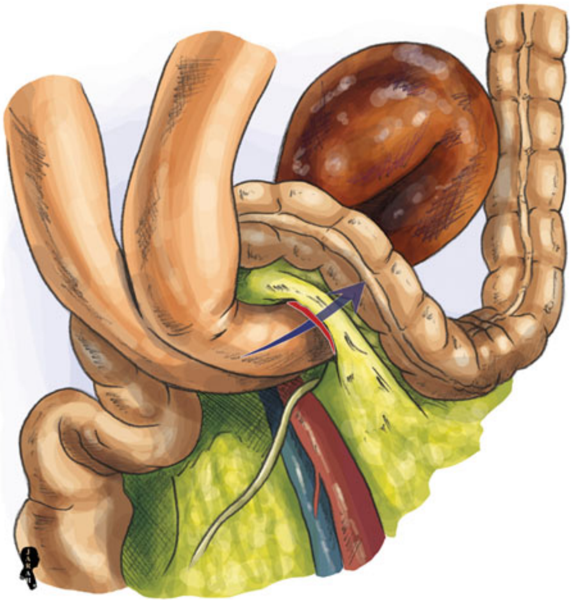

Fig. 106.12 Schema: transmesosigmoidal hernia

In the presence of obstruction, CT findings include a cluster of dilated small bowel loops entrapped ***behind and beyond the left posterolateral aspect of the sigmoid colon***. The defect is most commonly located between the sigmoid colon and the left psoas muscle or between the two mesosigmoid folds of two sigmoid segments if it is an intersigmoid type. The entrapped bowel often causes a mass effect, displacing the sigmoid colon anteromedially. In addition, congestion of the mesenteric vessels and stranding of the mesenteric fat may be seen, suggesting strangulation (Yu et al. 2004; Martin et al. 2006).

Supravesical and Pelvic Hernias

Anatomy: In order to evaluate IH in the pelvis, profound knowledge of the peritoneal lining, folds, recesses, and fossae of the pelvic cavity is of paramount importance. The pelvic peritoneum covers to a large extend the surfaces of the pelvic viscera and the pelvic walls. Some gender differences have to be memorized.

In the male, the peritoneum covers the upper two-thirds of the anterior rectal surface. At the junction of the middle and lower third of the rectum, it passes anteriorly to cover the upper poles of the seminal vesicles and the dome of the urinary bladder. The peritoneal space between the rectum and urinary bladder is deemed the retrovesical pouch. Lateral to the rectum, the peritoneum forms the right and left perirectal fossae. The most anterior parts of the pelvic peritoneum cover the superior surface of the urinary bladder and form a paravesical fossa on each side.

In the female, perirectal and paravesical fossae also exist. Lateral to each paravesical fossa, the peritoneum encompasses the Fallopian tubes, the round and the broad ligaments of the uterus. The rectovesical pouch in the female is further subdivided by the uterus and vagina into the vesicouterine pouch and rectouterine pouch (pouch of Douglas). The broad ligaments extend from each side of the uterus to the lateral pelvic walls. The superior extent of the broad ligaments contains the fallopian tubes. Immediately below the fallopian tubes, the anterior and posterior peritoneal layers condense to form the mesosalpinx. The mesosalpinx extends downward to the ovarian ligament and is flanked by the uterus medially and the ovary laterally. The lateral extent of the broad ligament covers the ovarian vessels, forming the infundibulopelvic ligament, which suspends the ovary. The anterior portion of the broad ligament covers the round ligament of the uterus and forms the mesoligamentum teres.

From the dome of the urinary bladder, the peritoneal coverage passes anteriorly to eventually reach the anterior abdominal wall and extend upward. In this region, it forms a triangular-shaped area bound by the median and the right and left medial umbilical ligaments, called the supravesical fossa. This fossa predisposes to the formation of supravesical hernia.

Supravesical and pelvic hernia account for up to 6 % of all IH.

Supravesical Hernia

Supravesical hernias are extremely rare; fewer than 100 cases are reported in the literature. Supravesical hernias form in the area of the supravesical fossa which extends between the median and right or left umbilical ligaments. Supravesical hernia can be categorized as external and internal. In external supravesical hernia, the hernial sac remains above the level of the pelvis and protrudes anteriorly through the anterior abdominal wall as a direct hernia. Clinically it may impress as an inguinal hernia. Internal supravesical hernia direct inward into the pelvic cavity and pass through spaces around the urinary bladder, beside or behind. The common clinical presentation is that of intestinal obstruction. CT is currently the best imaging technique for detecting this particular hernias (Mathieu and Luciani 2004; Sasaya et al. 2001).

Imaging

In imaging, these hernias appear close to the abdominal wall or around the bladder. Signs of bowel irritation may be indicative, yet imaging is not specific.

Hernia Through the Broad Ligament

Hernias through a defect of the broad ligament account for 4–5 % of all IH. In over 85 % this type of hernia affects women of middle age who had given birth but had no history of abdominal surgery. In more than 90 %, the herniating structure is the small bowel.

Broad ligament defects are either congenital or acquired. Congenital defects have their origin in a hampered embryologic development of the peritoneum around the uterus. Acquired defects result from surgical trauma, pregnancy and birth trauma, perforations following vaginal manipulation, and prior pelvic inflammatory disease. A classification according to the location of the defect has been proposed describing type 1 as caudal to the round ligament, type 2 as cephalad to the round ligament, and type 3 as between the round ligament and the remaining broad ligament through the mesoligamentum teres.

In addition to this classification, hernias through the broad ligament can be of “fenestra” type or “pouch” type. The “fenestra” type is a complete defect in both layers of the broad ligament allowing passage and potential hernial strangulation of the herniating element. In the “pouch” type, the herniating viscus penetrates only one single layer of peritoneum of the broad ligament and becomes entrapped in the parametrium.

Imaging

CT imaging shows a cluster of dilated small bowel loops with air-fluid levels in the pelvic cavity and bowel loops ***compressing the rectosigmoid dorsolaterally and displacing the uterus ventrally***.

Hernia in the Perirectal Fossa

Hernias in the perirectal fossa are extremely rare. They are believed to occur in the presence of congenital defects within the peritoneum of the pouch of Douglas or the perirectal fossa but without any abnormalities of the pouch itself or the pelvic floor musculature. The depth of the pouch of Douglas varies extensively; an abnormally deep pouch of Douglas may also lead to a posterior perineal hernia. All of these are extremely rare (Takeyama et al. 2005).

Imaging

CT shows dilated and fluid-filled small bowel ***loops clustered in the immediate vicinity of the rectum*** and posterior to the cervix and vagina in females.

Postsurgical Internal Hernia

The overall incidence of IH has risen as more surgical procedures with transmesenteric and transmesocolic approaches for anatomical reconstruction are performed. This creates a shift from congenital to iatrogenic causes of IH (Martin et al. 2006). Postsurgical hernias are also referred to as "acquired type" of IH. One major cause for iatrogenic IH formation is gastric bypass surgery for treatment of morbid obesity (Blachar and Federle 2002; Chandler et al. 2008). In this technique, a small gastric pouch is created to exclude the remainder of the stomach, duodenum, and proximal jejunum from the path of food. The gastric pouch is anastomosed to a Roux jejunal limb; the Roux limb is brought to the gastric pouch either through a surgically created opening in the transverse mesocolon (retrocolic approach) or anterior to transverse colon (antecolic approach). The jejuno-jejunal anastomosis of the Roux-en-Y reconstruction is typically located in the left mid-abdomen. While IH can form through any defect, the most frequent sites of bowel herniation are the defect in the transverse mesocolon (transmesocolic IH, following retrocolic technique), the space posterior to the jejuno-jejunal anastomosis (retroanastomotic IH), and the space posterior to the Roux limb (so-called Peterson defect) (Carucci et al. 2009) (Fig. 106.13).

An increased incidence of transmesenteric hernias has also been described in patients who had undergone liver transplantation; this can probably be attributed to the fact that the Roux-en-Y anastomosis is also performed in those patients (Blachar et al. 2001).

Imaging

In small bowel follow-through series, the relevant signs of postoperative hernias are clustered bowel loops displacing other bowel, the displacement of the jejuno-jejunal suture line, the visualization of the entrance and exit limbs into the clustered segment, and a change in bowel configuration compared to prior images (Carucci et al. 2009). The ***displacement of the radiopaque suture line cephalad into the left upper quadrant*** is a very specific sign and can be considered highly indicative.

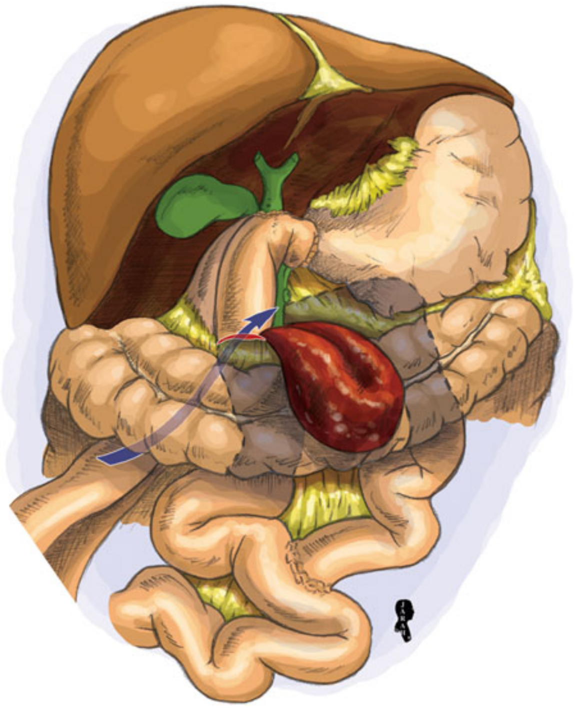

Fig. 106.13 Peterson defect

The CT imaging findings in patients with IH complicating gastric bypass surgery **include *clustered small bowel loops directly touching the abdominal wall***, without overlying omental fat, and central displacement of colon (Fig. 106.14 a, b). The mesenteric fat and *vessels* may have a ***swirled appearance***, and the hernia may adopt the shape of a ***mushroom***.

These types of IH tend to be more often complicated by small bowel volvulus and ischemia with intestinal gangrene (Fig. 106.14a, b) (Blachar et al. 2001; Lockhart et al. 2007; Reddy et al. 2007). Ischemic and gangrenous small bowel may be recognized on CT as lacking contrast enhancement and including gas in the intestinal wall.

In *retroanastomotic hernias*, the small bowel loops herniate posteriorly through a defect created by the surgical anastomosis; they are by definition of acquired type. These hernias have been most commonly described in association with the Roux-en-Y reconstruction and are more common with the

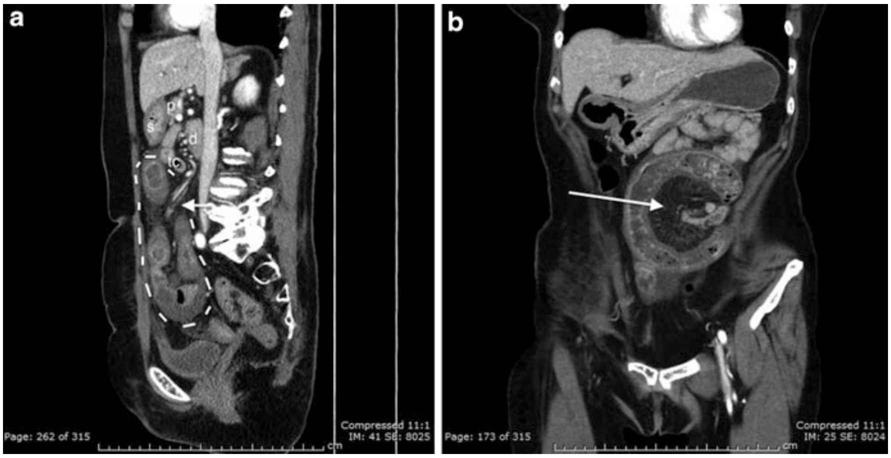

Fig. 106.14 Transmesocolic hernia: transverse Mesocolon hernia. Forty-four years old patient who is status post Roux-en-Y gastric bypass. Sagittal reformation (**a**) shows the orifice (*arrow*) of the hernia sac (*dashed* outline) crossing the through the transverse mesocolon. Coronal image shows the distended small bowel loops within the hernia sac. There is bowel wall thickening, free fluid, engorgement of the mesenteric veins and mesenteric edema secondary to obstruction *S* stomach, *P* pancreas, *d* duodenum, *tc* transverse mesocolon

antecolic form of the surgery. In the case of an antecolic approach, the borders of the artificial surgical aperture consist of the transverse mesocolon superiorly, the ligament of Treitz inferiorly, and the gastrojejunostomy and afferent limb of the jejunum anteriorly, hence the term "retroanastomotic." The most common herniated bowel segment is the efferent jejunal limb in approximately 75 % of cases.

As opposed to the transmesenteric type of IH related to the Roux-en-Y surgery, the retroanastomotic type tends to occur most commonly during the first postoperative month, 50 % of all cases present during this time (Blachar and Federle 2001; Martin et al. 2006).

Another category of postsurgical hernia represents the retrostomal hernia. In this case, small or large bowel herniates through the abdominal wall defect created for the passage of the bowel loop which is brought up to the skin. Herniation occurs next to the stoma carrying bowel loop, and incarceration and obstruction are complications of this condition.

Abdominal Wall Hernias: External Hernias

Abdominal wall hernias (AWH) are a frequent clinical problem, one of the most common indications for major surgery and a common finding in abdominal imaging. CT scans and barium-enhanced radiographs allow for confident diagnosis of this disorder. Since CT has a dominant role in the radiological assessment of the abdomen, special focus is attributed to this imaging modality in the description of characteristic imaging findings for AWH.

Definition and Origin

Hernias involving the abdominal wall are considered external hernias (EH). They occur at areas of congenital or acquired weakness in the abdominal wall. Various abdominal contents may be subject to herniation through these abdominal wall defects depending on the location of the defect. They may include preperitoneal fat, the greater omentum, the different segments of small or large bowel including the appendix and viscera, and solid organs surrounded by peritoneum.

Classification

Abdominal wall hernias (AWH) can be further subdivided into **ventral hernias** and **hernias in the groin**. Obturator hernia, sciatic hernia, and perineal hernia are special manifestations of EH in the pelvis. They are determined by the anatomic site of the hernial protrusion.

Hernias which involve only part of the bowel wall but not the entire circumference of the intestinal wall and lumen are termed **Richter hernias**. This term refers to a herniation which is limited to the antimesenteric wall of the bowel. Since only a portion of the intestinal wall is incorporated into the hernia, the lumen remains patent and there is no obstruction. Incarceration is uncommon.

In children, there are mainly two specific forms of abdominal wall defects, both congenital: gastroschisis and omphalocele. In **gastroschisis**, the abdominal wall fails to close, probably related to cutaneous ischemia. Usually, gastroschisis is not associated with chromosomal anomalies. **Omphalocele** is a herniation of the intestinal content at the base of the umbilical cord, with or without rupture of the peritoneal membrane.

Clinical Presentation

The **clinical presentation** of EH may encompass a wide spectrum of symptoms ranging from intermittent or permanent pain at the site of herniation to signs of small bowel obstruction. AWH can be clinically diagnosed when a physical examination reveals a bulge that is visualized or palpated with or without a Valsalva maneuver. Obesity or abdominal pain may limit the physical examination and abdominal palpation (Zafar et al. 2006).

The most common **complications** of AWH include bowel obstruction, bowel incarceration, and strangulation (Aguirre et al. 2005). AWH are the second leading cause of small bowel obstruction (10–15 % of cases) after adhesions. Colonic obstruction is uncommon.

Incarceration: Incarceration refers to an irreducible hernia. In this case, clinically, the hernia cannot be reduced or pushed back manually. Immediate and correct diagnosis is essential because incarceration may complicate rapidly with obstruction, inflammation, or ischemia. Incarcerated bowel requires immediate surgery to prevent bowel necrosis and subsequent resection of the affected bowel loop (Rettenbacher et al. 2001).

Strangulation refers to ischemia caused by a compromised blood supply to a herniated segment. It usually occurs when the hernial defect obstructs the afferent and efferent bowel loops, creating a closed loop within the herniated bowel.

Imaging Abdominal Wall Hernias

Imaging studies are required when the clinical manifestation is misleading or inconclusive, or preoperative assessment of the hernia or secondary obstruction is required.

Imaging Techniques

In the past, conventional radiographs and barium studies, especially small bowel follow-through examinations, were the key imaging modalities to diagnose AWH; conventional radiography has preserved its role in the initial evaluation of suspected small bowel obstruction until today. To assess small bowel obstruction, it is also possible to administer Gastrografin orally and obtain sequential spot images at 2, 6, and 12 h.

Cross-sectional imaging techniques have widely gained importance as they have become the mainstay in the assessment of acute abdominal pain nowadays. Multidetector CT with 3D reconstructions is essential for a state-of-the-art assessment of abdominal wall hernias and their complications. This calls for the need to familiarize with typical imaging findings in both conventional and cross-sectional imaging techniques.

Ultrasound has a predominant role in infants and children. It is an important add-on to the clinical evaluation and may help to avoid radiation exposure.

In adults, its role is complementary to conventional and cross-sectional imaging modalities. Here, ultrasound is mainly used for functional aspects assessing the mobility and reducibility of hernias.

- Conventional Radiographs and Barium Small Bowel Follow-Through Studies

  Conventional radiographs are performed in supine position; additional views such as left lateral decubitus, standing upright, profile, and lateral spot images may be obtained. Anterior AWH are best recognized in profile on lateral spot images. One or more bowel loops extend beyond the fascial planes of the abdominal wall. A luminal narrowing may exist at the entry or exit of the hernial orifice or at both sites. Small anterior abdominal wall hernias may pass unnoticed in asymptomatic patients due to the lack of clinical evidence. In patients with suspicion of hernias and a history of abdominal surgery, it may be required to provoke the protrusion of a hernia in either changing the patient position or increasing the intra-abdominal pressure (e.g., Valsalva maneuver). In these patients, the abdomen should routinely be imaged under fluoroscopy with the patient in the lateral position (Zafar et al. 2006).

Fluoroscopy is useful to detect and characterize anterior AWH and to evaluate for the reducibility of the herniated bowel. Manual palpation of the abdominal wall during fluoroscopy with the patient in the lateral position helps to determine whether the bowel loops can be easily returned into their proper location in the abdominal cavity or whether they are fixed within a hernial sac. This observation is crucial since the risk of obstruction or strangulation is higher in fixed, incarcerated bowel (Zafar et al. 2006).

A specific technique to identify occult inguinal hernia is herniography which involves injection of nonionic iodinated contrast agent into the peritoneal cavity (see inguinal hernia).

- Cross-Sectional Imaging Techniques: CT

  Cross-sectional imaging techniques are distinctly useful in evaluating AWH due to their multiplanar capabilities and virtual reconstructions. This considerably eases the visualization and comprehension of the underlying anatomy and pathology. CT is the modality of choice in the assessment of unrepaired AWH and surgically treated hernias and their complications. Generally, it is readily available, little operator dependant, and highly accurate and are of specific value in the treatment planning.

  Intravenous administration of contrast material is necessary for characterization of the vascular supply. Positive contrast material or water may be used to better visualize bowel loops. A standard CT protocol includes supine images after bolus injection of ~125 ml of iodinated contrast material (table speed 10 mm/s, collimation 2,5 mm). MPR images are of routine use. Postural maneuvers (prone or lateral decubitus) and maneuvers to increase intra-abdominal pressure (Valsalva) can be useful to depict subtle hernias that would otherwise be missed (Aguirre et al. 2005).

  Despite its eminent role in the identification of wall hernias, multidetector row CT has some limitations: the functional assessment with CT is limited; some type of hernias (groin hernias) may be resolved in supine position, and the CT may appear normal; radiation exposure is critical in children.

- Cross-Sectional Imaging Techniques: MRI

  The role of MRI in the assessment of AWH is minor, and experience is limited. Nonetheless, it offers a number of advantages over CT: radiation exposure is not an issue. The multiplanar capabilities of MRI are comparable in anatomic detail and display of pathology. MRI is equally efficacious in the depiction of fascial defects or even superior due to inherently high soft tissue contrast; additional contrast is typically not required. Unlike CT, MRI can provide functional information using fast imaging and CINE techniques. SSFP sequences at rest and during Valsalva maneuvers allow the evaluation of functional aspects of reducibility, motility, and peristalsis. However, the availability of MRI is limited. The necessity of experienced interpretation and its high cost remain on the downside of this potent imaging modality (van den Berg et al. 1997).

- Ultrasound

  Ultrasound is an efficacious tool to evaluate the anterior abdominal wall and groin for hernias. Its strengths lay in its real-time capabilities to assess functional motility aspects of the hernial content, to visualize bowel peristalsis, and to evaluate bowel vascularity with Doppler and duplex ultrasound. The muscular and fascial layers of the abdominal wall are best depicted with high-frequency transducers (>10 MHz). Comparison with the asymptomatic and normal contralateral side of the abdominal wall eases the detection of pathology since there is great variability in the sonographic appearances in the structures of the groin due to differences in muscle thickness and in fat echogenicity (Harrison et al. 1995). It is the modality of choice in infants and children.

General Imaging Findings in Abdominal Wall Hernia

Occasionally, an abdominal wall hernia can be recognized indirectly on a frontal view of an abdominal X-ray when herniated bowel loops appear displaced and deformed by extrinsic compression.

The role of CT is to confirm or rule out the diagnosis of AWH, to determine the hernial content, to identify the location and extent of the hernial orifice, and, most importantly, to depict signs of complication. The major task is to identify the fascial defect through which the hernia protrudes. The diagnosis is obvious when bowel is herniated but more challenging when only mesenteric or omental fat is herniated. As CT is also a very sensitive technique for detecting ischemic bowel, it remains the diagnostic test of choice to confirm or rule out bowel incarceration, strangulation, and ischemia when clinically suspected.

Imaging Signs of Bowel Obstruction

Key findings on CT for bowel obstruction are dilated bowel loops proximal to the hernia and normal, reduced caliper or collapsed bowel distal to the obstruction. The degree of change in caliper helps predict the grade of obstruction. Other findings may include tapering of the afferent and efferent limbs at the hernial defect, dilatation of herniated bowel loops, and fecalization of small bowel contents proximal to the obstruction (Boudiaf et al. 2001). In these cases, bowel obstruction occurs with the *transition point at the level of the hernia*.

Imaging Signs of Incarceration

The diagnosis of incarceration cannot be made with imaging alone but can be suggested when herniation occurs through a small defect and the hernial sac has a very narrow neck. Impending strangulation of a hernia should be suspected when there is free fluid within the hernia sac, bowel wall thickening, or luminal dilatation (Fig. 106.14a, b) (Rettenbacher et al. 2001).

Imaging Signs of Strangulation

Findings in closed-loop obstruction include dilated, fluid-filled U- or C-shaped loops of bowel entrapped within the hernia sac and proximal obstruction. Findings in ischemia include wall thickening, abnormal mural hypo- or hyperattenuation and enhancement, mesenteric vessel engorgement, fat obliteration, mesenteric haziness, and ascites. Strangulated abdominal wall hernias are associated with a high surgical fatality rate (6–23 %) secondary to the strangulated viscus.

Specific Hernia Types

Hernias of the Groin

Hernias of the groin refer to **inguinal** hernias and **femoral hernias** (Wechsler et al. 1989).

Inguinal Hernias

Inguinal hernias are the most common type of AWH: approximately 75 % of all hernias occur in the groin (inguinal hernia). They are caused by acquired weakness and dilatation of the internal inguinal ring. Inguinal hernias are described as either direct or indirect depending on the location and orifice by which abdominal contents leave the abdominal cavity to protrude outward (Katz 2001). Two-thirds of inguinal hernias are indirect and one-third direct. They may occur bilaterally in about 8–10 % of cases.

The inferior epigastric vessels are a landmark to identify inguinal hernias as direct or indirect. Indirect inguinal hernias penetrate the abdominal wall lateral to the inferior epigastric vessels and direct inguinal hernia penetrates medial to them. Regardless of age, inguinal hernias are most common in males (ratio male to female 10–25:1). In adults, both direct and indirect types are found. Indirect inguinal hernias are the most common type in both men and women; a right-sided predominance exists.

In **children**, the most common type is the umbilical hernia followed by the indirect inguinal hernia. The incidence of inguinal hernias in children ranges up to 4.4 %, while umbilical hernias occur in approximately 1 out of every 6 children. The incidence of incarcerated or strangulated hernias in pediatric patients is 10–20 %; 50 % of these occur in infants younger than 6 months.

A **Littre hernia** is a very distinct situation in which the inguinal hernia contains a Meckel diverticulum.

- Indirect Inguinal Hernia: Anatomy and Embryology

  Before birth, a peritoneal outpouching called processus vaginalis exists in the region of the inguinal canal which is formed by layers of the peritoneum and spermatic fascia. This processus vaginalis typically closes at birth; in one-third of infants and one-sixth of adults, however, it remains patent, a condition which predisposes to inguinal hernia formation. In this case, a peritoneal sac containing bowel loops protrudes through the deep inguinal ring into the inguinal canal and emerges at the external inguinal ring. This condition is named indirect inguinal hernia. In men, the hernia can extend further along the spermatic cord into the scrotum and form a scrotal hernia; in women, the hernia may follow the course of the round ligament into the labia majora. Retroperitoneal organs such as the urinary bladder, distal ureters, and ascending or descending colon may be incorporated into the hernia.
- Direct Inguinal Hernias: Anatomy and Embryology

Direct inguinal hernias are believed to be acquired. The respective area of weakness in the abdominal wall is called the Hesselbach triangle in the posterior wall of the inguinal canal. Direct inguinal hernias protrude directly through the lower abdominal wall medial to the inferior epigastric vessels; they rarely incarcerate (Zarvan et al. 1995). It is not uncommon to find synchronous direct and indirect inguinal hernias in the same patient, either ipsilaterally or contralaterally. Bilateral hernia occurs in 8–10 % of cases.

Imaging of Inguinal Hernias

- X-Ray and Radiographic Studies

  In symptomatic patients with chronic groin pain (inguinodynia) but without definite clinical signs of hernia, a herniography may be performed to investigate for an occult inguinal hernia. A herniography (or peritoneography) is a seldom-used X-ray procedure where nonionic iodinated contrast agent is injected into the abdominal peritoneal cavity and radiographs are obtained in various patient positions (Harrison et al. 1995). This technique is no applied on a routine basis but may be helpful in obese patients where clinical physical examination is limited. Interpretation of herniographs requires distinct experience.
- Ultrasound

  The inguinal region can be successfully explored with ultrasound techniques. A high-frequency transducer (10 MHz or more) is recommended; individuals with large body habitus and adipositas may require a transducer of 7 MHz. During the examination, it is essential to ask the patient to increase abdominal pressure (Valsalva maneuver) at each of the sonographic steps to identify transient hernias. The Valsalva maneuver is a critical component of the examination, because in many patients the hernia may be completely reduced at rest (Jamadar et al. 2006). Reexamination with the patient standing is recommended if supine evaluation does not reveal herniation. This is an advantage over CT and other cross-sectional imaging techniques. Herniated bowel contents may show peristalsis, and herniated fat will appear hyperechoic. It is important to evaluate for reducibility and bowel viability identified by peristalsis or mucosal blood flow (Jamadar et al. 2006).
- CT and Other Cross-Sectional Imaging (MRI)

Fig. 106.15 Inguinal hernia (with fat, with bowel). CT of the abdomen and pelvis with oral contrast demonstrates bilateral inguinal hernia which extend into the scrotum bilaterally In the *right* side, there is small bowel involved, in the *left* side mesentery and a segment of large bowel. There are no signs of incarceration

The diagnosis of groin hernias is evident on CT scans in the presence of herniating bowel loops. However, groin hernia may easily be overlooked when containing only fat (Fig. 106.15) or when repositioned in the abdomen during scanning in supine position. Scanning patients in lateral decubitus and during Valsalva maneuver has been proposed and reported to be more accurate (Aguirre et al. 2005).

Femoral Hernias

Femoral hernias are less common than inguinal hernias and represent only 3 % of all hernia. They are thought to be congenital, arising from a defect in the attachment of the transverse fascia to the pubis. The herniation pathway in femoral hernia is medial to the femoral vein, below the inguinal ligament and lateral to the pelvic tubercle. Because of their deep location in the femoral canal, they are difficult to diagnose by clinical examination; however, they are more prone to incarceration and strangulation than inguinal hernias. This type or hernia occurs more commonly in women.

Imaging

The appropriate imaging techniques are the same as for inguinal hernia, and their imaging appearance is similar. Femoral hernia can be distinguished from inguinal hernias primarily by their location inferior and lateral to the pubic tubercle.

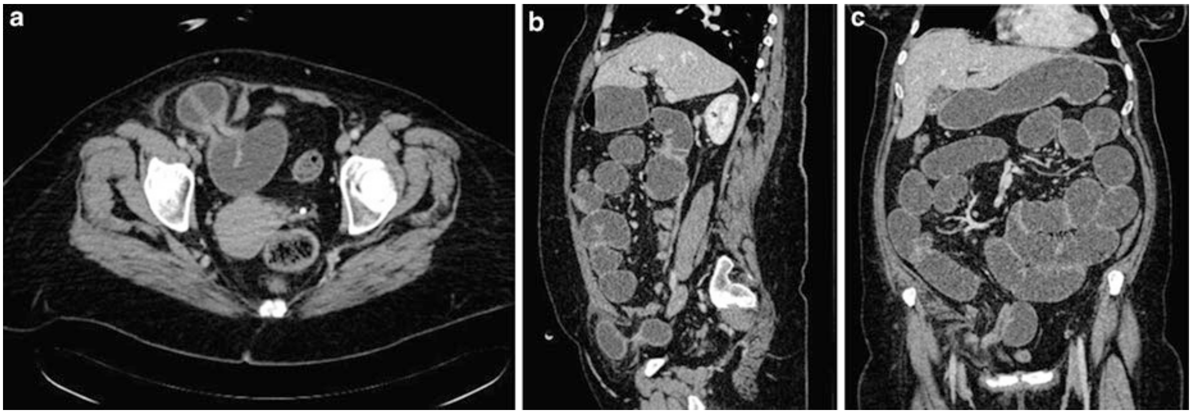

Fig. 106.16 Low Spigelian hernia: In axial images there is a defect in the right lower abdominal wall lateral to the border of the rectus abdominis muscle sheath. A small bowel loop is herniating into the tight defect (axial image, **a**). The entire small bowel loops proximal to this transition point are dilated indicating obstruction (coronal, **b**). The defect and the herniating sac are well seen on sagittal images (**c**).

Ventral Hernias

Ventral hernias involve the anterior or lateral abdominal wall. The majority of them occur in the midline through a defect in the aponeurosis of the linea alba. Those located superior to the umbilicus are called epigastric hernias; those inferior to the umbilicus are called hypogastric hernias. Hypogastric hernias are less common. Umbilical, Spigelian, and incisional hernias are specific forms of ventral hernias.

Umbilical Hernia

The umbilical hernia is by far the most common type of ventral hernia. It is usually small and particularly common in women. A **paraumbilical hernia** results from large abdominal wall defect in the linea alba around the umbilicus and is usually related to a diastasis of the rectus abdominis muscles. Strangulation and incarceration are common in all midline hernias.

Spigelian Hernia

The Spigelian hernia is caused by a congenital weakness in the posterior layer of the transverse fascia. This defect allows viscera to herniate between the lateral abdominal wall muscles and form an interstitial hernia. These uncommon hernias occur along the semilunar line formed by fibrous union of the rectus sheath with the aponeurosis of the transverse abdominal and oblique abdominal muscles. Clinical diagnosis is difficult.

Imaging

Ultrasound and CT are the most appropriate imaging modalities to detect a fascial defect in the appropriate location which will help to establish correct diagnosis of a Spigelian hernia (Fig. 106.16). When moving inferiorly from the level of the umbilicus along the lateral margin of the rectus abdominis muscle (the linea semilunaris), the inferior epigastric artery can be identified as a landmark to the site where Spigelian hernias may occur (Jamadar et al. 2006). Herniation of only fat may be misinterpreted as lipoma or as normally lobulated subcutaneous abdominal fat. Findings of a Spigelian hernia may be subtle if the herniated content is small. In rare cases, the appendix may herniate into the defect (Fig. 106.17).

Incisional Hernias

Incisional hernias occur in up to 5 % of patients who undergo abdominal surgery. These iatrogenic hernias are usually ventral and occur at the site of a midline or paramedian incision, but they may also be peristomal or located at other sites of surgical interruption of soft tissue layers. These hernias commonly manifest in the 1st year after surgery; a small percentage may remain clinically silent. Incisional hernias are more frequently encountered after transverse incisions. With the increasing frequency of abdominal surgery, incisional hernias have become one of the most common types of anterior abdominal hernia.

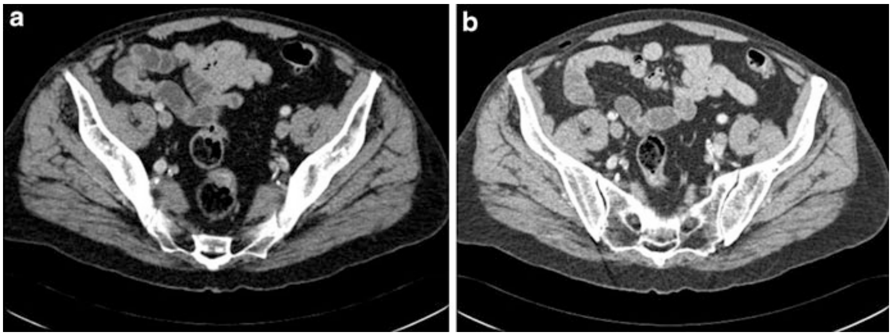

Fig. 106.17 Spigelian Hernia with herniated appendix: A Spigelian hernia forms in a defect at the lteral border of the rectus sheath. In this case, the appendix is herniated in this space between the fascias. There is no gross edema or stranding in the adjacent fat to suggest inflammation

Flank Herniation

Rarely, hernias occur in the superior and inferior lumbar spaces; they are then referred to as flank herniation. The Grynfeltt-Lesshaft and Petit triangles, respectively, are rare sites of flank herniation. The Grynfeltt-Lesshaft triangle is bordered by the 12th rib superiorly, the internal oblique muscle anteriorly, and the erector spinae muscle posteriorly. The Petit triangle is bordered by the external oblique muscle anteriorly, the latissimus dorsi muscle posteriorly, and the iliac crest inferiorly. While these are "natural" points of low resistance predisposing for hernia formation, lumbar hernias may also occur at the site of prior flank incisions for kidney surgery. Those hernias may contain bowel loops, retroperitoneal fat, kidneys, or other viscera (Killeen et al. 2000).

Imaging of Ventral and Flank Hernias

Ultrasound and CT are the most relevant imaging modalities to detect a fascial defect in the respective locations (Killeen et al. 2000).

Hernias in the Pelvis

Obturator Hernias

Obturator hernias are uncommon and thought to constitute fewer than 1 % of all hernias worldwide (Lobo et al. 1998; Bjork et al. 1988). They result from an acquired defect in the obturator membrane. The peritoneal sac and its contents herniate through the obturator canal in the superolateral aspect of the obturator foramen, alongside the obturator vessels and nerves, and protrude between the external obturator and pectineal muscles or between the layers of the obturator membrane. Obturator hernia poses a diagnostic challenge as signs and symptoms are often nonspecific, and generally no external lumps are visible or clinically palpable. The Howship-Romberg sign which is due to compression of the obturator nerve by the hernia sac and its contents is present in about 50 % of cases.

Obturator hernia occurs primarily in elderly women or patients with chronically raised intra-abdominal pressure (e.g., ascites, COPD, chronic cough). An obturator hernia may contain any or all female genital organs, urinary bladder, segments of large or small bowel, appendix, and omentum. Incarceration occurs in most cases (Fig. 106.18). The mortality rate of obturator hernia is highest among all abdominal wall hernias (range 13 %–40 %) (Mantoo et al. 2009).

Imaging

CT is the gold standard in imaging for this disorder; ultrasonography, contrast studies, herniography, and plain films are less specific (Stamatiou et al. 2011). Multiplanar reformats in coronal and sagittal planes are of particular value to illustrate the anatomic pathway of the hernia and establish the diagnosis. On CT, obturator hernias project through the obturator canal. The hernial sac is visualized between the internal and external obturator muscles.

Occasionally, on conventional X-ray, an air bubble or fluid levels below the pubic bone and in the obturator fossa may be a hint toward this distinct condition.

Sciatic Hernias

Sciatic hernias pass through the greater or lesser sciatic notch. The hernia may emerge above or below the piriform muscle and under the inferior border of the gluteus maximus muscle. The majority of cases involve the distal ureter or a loop of small bowel.

Imaging

Transgluteal ultrasound and abdominopelvic CT are the most conclusive imaging techniques. Plain abdominal

Fig. 106.18 Obturator hernia: Sagittal (**a**), oblique coronal (**b**) and axial images (**c**) are provided of a CT of the abdomen in a 75 year old patient. Along the right sided pelvic wall there is a small defect (**a**, **b** *arrows*) which allows a small bowel loop to pass in the space lateral to the obturator muscle. Upstream small bowel dilatation again indicates obstruction (**c**)

radiography is diagnostic in about 50–60 % of cases of SBO, equivocal in about 20–30 % of cases, and normal or misleading in 10–20 % of cases, regardless of etiology (Yu et al. 2002). Identification of sciatic hernia on plain radiography is difficult. Barium studies may demonstrate persistent outpouching of bowel loops through the sciatic foramen. However, barium filling of the close loop, as in incarcerated or strangulated sciatic hernias, is hampered. In addition, barium studies of SBO are time consuming, and the barium column may be diluted by intraluminal fluid obscuring the detail of obstruction. Sciatic hernia diagnosed by herniography has been reported, but this method is invasive (Yu et al. 2002).

Transgluteal US may show a segment of fluid-filled bowel loop entrapped between the iliac bone and sacrum. Fluid accumulation and edema in the adjacent tissue may accompany the condition. Color Doppler studies of the bowel wall can help assess the blood flow to the intestinal wall to rule out bowel ischemia.

Besides US, CT is the most useful technique in diagnosing sciatic hernia. It may be limited in low-grade small bowel obstruction, but it is reliable for diagnosing high-grade SBO and incarceration which is often seen in these patients.

Perineal Hernias

Perineal hernia in humans is an extremely rare condition and is usually caused by prior pelvic operation or trauma or secondary to an acquired weakness of the pelvic floor, e.g., in the urogenital diaphragm, levator ani muscle, or coccygeal muscle. They are most common in elderly women. Clinically they manifest as a perineal or gluteal mass formed by bowel loops (Miller et al. 1995).

Imaging

Imaging of perineal hernias is similar to the conditions of an obturator or sciatic hernias. Ultrasound and abdominopelvic CT are the most conclusive imaging techniques.

Trauma and Abdominal Wall Hernias

Abdominal wall hernias can be trauma related in two ways: (1) they may be caused by trauma or (2) a preexisting hernia may be exposed to trauma.

Traumatic Hernia

Abdominal trauma can result in a wide variety of abdominal wall hernias, ranging from small defects caused by direct injury to more extensive defects after a compression injury to the abdomen. Most traumatic hernias result from a high-impact blunt trauma in which the intra-abdominal pressure was increased sufficiently to disrupt the abdominal wall musculature. Up to 60 % of all cases with traumatic hernias are associated with intra-abdominal injuries. The most common locations are areas of relative anatomic weakness: the lumbar region and the lower abdomen. In more severe cases, diaphragmatic rupture may occur, and herniation of abdominal contents into the chest may be seen (Fig. 106.19). Seat belt use, which exposes the wall musculature to full deceleration forces, increases the risk for traumatic hernias. Typically, the location of the defect is unrelated to the site of the impact (Aguirre et al. 2005; Esposito and Fedorak 1994). Traumatic AWH are easily overlooked at initial physical examination. Incarceration and strangulation of hernia contents are also common. For these reasons, traumatic abdominal wall hernias require emergent laparotomy, even in the absence of other imaging findings (Killeen et al. 2000).

Trauma to Preexisting Hernia

Patients with known abdominal wall hernia who present following high-impact trauma should be scrutinized for the presence of fluid within the hernia sac, bowel wall thickening, asymmetric bowel wall enhancement, vessel engorgement, and fat stranding within the hernia sac or in surrounding soft tissues. These findings should alert the radiologist to traumatic injury of a preexisting abdominal wall hernia, which usually require surgical management.

Imaging After Surgical Repair

Various surgical procedures are commonly applied to repair AWH including open suture, laparoscopic suture, and the use of mesh. To date, tension-free mesh repair has been accepted as the standard surgical technique for the majority of abdominal wall hernias, regardless of defect size.

Complications after surgical hernia repair may occur in up to 50 % of cases, depending on surgical technique and the quality of the hernia sac vasculature. Approximately one-half of these complications may require surgical re-intervention (Aguirre et al. 2005; Bendavid 1998).

- Hernia Recurrence

  Hernia recurrence constitutes the most common complication after hernia repair, usually occurring 2–3 years after surgery. Clinical evaluation of recurrent hernias is typically hampered due to the existence of nonabsorbable mesh and accompanying fibrosis or to obesity; CT plays an important role in the diagnosis of recurrence.
- Fluid Collections

  Fluid collections occur frequently in the immediate postoperative period after hernia repair (17 % of cases). These collections usually contain a serous fluid, seromas, or blood products, hematomas. Most seromas resolve without manipulation within 30 days. Aspiration may be indicated if the collection persists for more than 6 weeks, produce symptoms, or is suspected to be infected. Imaging-guided aspiration or drainage may be problematic for large collections located under the mesh due to infolding of the mesh layers. CT again is the most effective diagnostic imaging modality for this condition.
- Infection

  Infected postoperative fluid collections occur in 1–5 % of patients after hernia repair. These complications tend to occur more frequently in older female patients, especially after surgical repair of strangulated and incarcerated hernias. Infected fluid collections may involve subcutaneous or mesh-surrounding deep tissues. Differentiation is important because superficial infections are managed conservatively, whereas deep infections require intervention such as percutaneous drainage or prosthesis removal. Imaging – mostly CT imaging – is used to confirm the presence and define the location

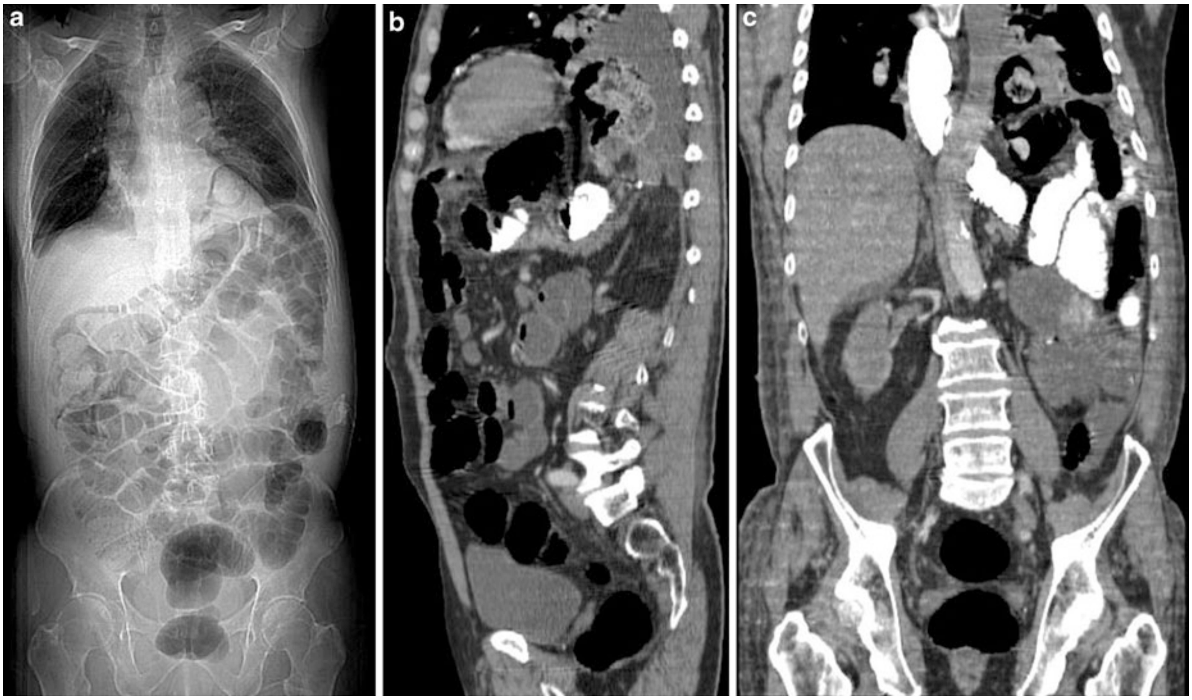

Fig. 106.19 Diaphragmatic hernia: Computed tomography scout view of a CT of the chest, abdomen and pelvis (**a**) with sagittal (**b**) and coronal (**c**) reconstructions: The scout view demonstrates a ring like lucency overlying the cardiac silhouette; on the left suggesting the presence of somehow loculated air in this area (**a**). The coronal reconstruction (**c**) shows a bowel loop correlating with this finding on the scout image. Sagittal reconstruction (**b**) discloses best the herniation of small and large bowel above the level of the left diaphragm in the posterior aspect and posterior to the left ventricle consistent with a diaphragmatic hernia.

and volume of collections, to guide aspiration, and to monitor treatment (Gossios et al. 2003).

- Mesh-Related Complications

  Inflammatory reactions may lead to fibrosis of tissues surrounding the mesh. This condition may be suspected if the mesh has an asymmetric or irregular shape at CT. Intraperitoneal adhesions may develop, predisposing to small bowel obstruction. Less frequently, meshes may detach from supporting tissues and migrate within the abdominal wall (Aguirre et al. 2005).

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