Review of Internal Hernias: Radiographic and Clinical Findings

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OBJECTIVE. Internal hernias, including paraduodenal (traditionally the most common), pericecal, foramen of Winslow, and intersigmoid hernias, account for approximately 0.5–5.8% of all cases of intestinal obstruction and are associated with a high mortality rate, exceeding 50% in some series. To complicate matters, the incidence of internal hernias is increasing because of a number of relatively new surgical procedures now being performed, including liver transplantation and gastric bypass surgery. A significant increase in hernias is occurring in patients undergoing transmesenteric, transmesocolic, and retroanastomotic surgical procedures. It is important for radiologists to be familiar with and to understand the various types of internal hernias and their imaging features so that prompt and accurate diagnosis of these conditions can be made.

CONCLUSION. This article illustrates the imaging findings of internal hernias, with emphasis placed on the CT findings, especially in transmesenteric, transmesocolic, and retroanastomotic types of internal hernias.

Although internal hernias have an overall incidence of less than 1%, they constitute up to 5.8% of all small-bowel obstructions, which, if left untreated, have been reported to have an overall mortality exceeding 50% if strangulation is present [1, 2]. Over the past decade, their incidence has been increasing because of the more frequent performance of liver transplantations and gastric bypass surgery for bariatric treatment. In this subset of patients, internal hernias account for just over half of all cases of small-bowel obstruction, almost equal to those caused by adhesions in one study [3, 4]. Without a heightened awareness and understanding of these hernias, they can often be misdiagnosed, with subsequent significant morbidity and mortality. The purpose of this article is therefore not only to review the definition and types of internal hernias, but also to describe the clinical and radiographic findings, with an emphasis placed on the CT features, because CT is rapidly becoming the first-line imaging technique in these patients.

Definition

Hernias are of two main types, external and internal [1]. External hernias refer to prolapse of intestinal loops through a defect in the wall of the abdomen or pelvis, and internal hernias are defined by the protrusion of a viscus through a normal or abnormal peritoneal or mesenteric aperture within the confines of the peritoneal cavity. The orifice can be either acquired, such as a postsurgical, traumatic, or postinflammatory defect, or congenital, including both normal apertures, such as the foramen of Winslow, and abnormal apertures arising from anomalies of internal rotation and peritoneal attachment.

In the broad category of internal hernias are several main types, as traditionally described by Meyers [5], based on location. Specifically, using historical data, these consist of paraduodenal (53%), pericecal (13%), foramen of Winslow (8%), transmesenteric and transmesocolic (8%), intersigmoid (6%), and retroanastomotic (5%) (Fig. 1), with the overall incidence of internal hernias being 0.2–0.9%. The other 7% described by Meyers included paravesical hernias, which are not true internal hernias and thus are not described in this article. In general, internal hernias have no age or sex predilection. With more new surgical procedures being performed using a Roux loop, the number of transmesenteric, transmesocolic, and retroanastomotic internal hernias

Keywords: colon, CT, gastrointestinal radiology, hernia, small bowel

DOI:10.2214/AJR.05.0644

Received April 14, 2005; accepted after revision August 9, 2005.

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AJR 2006; 186:703–717

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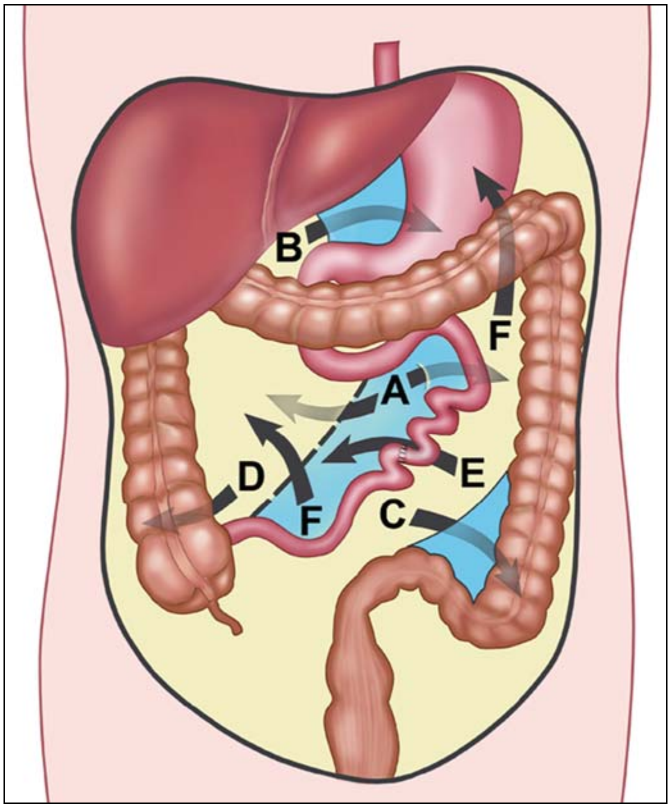


Fig. 1—Diagrammatic illustration shows various types of internal hernias:
A = paraduodenal,
B = foramen of Winslow,
C = intersigmoid,
D = pericecal,
E = transmesenteric, and
F = retroanastomotic.

has been increasing. These are probably more common than the traditional incidence of the various types of internal hernias reported by Meyers (Table 1).

General Clinical Findings

Clinically, internal hernias can be asymptomatic or cause significant discomfort ranging from constant vague epigastric pain to intermittent colicky periumbilical pain [1, 5] (Table 1). Additional symptoms include nausea, vomiting (especially after a large meal), and recurrent intestinal obstruction [1, 2, 5–7]. Symptom severity relates to the duration and reducibility of the hernia and the presence or absence of incarceration and strangulation [6]. These symptoms may be altered or relieved by changes in patient position [5, 7]. Because of the propensity of these hernias to spontaneously reduce, patients are best imaged when they are symptomatic [5, 7].

General Imaging Findings on Radiography and CT

Imaging studies often play an important role in the diagnosis of internal hernias because they are often difficult to identify clinically. In the past, these hernias were most frequently assessed with small-bowel oral contrast studies. However, CT has become the first-line imaging technique in these patients because of its availability, speed, and multiplanar reformatting capabilities. General radiographic features with barium studies include apparent encapsulation of distended bowel loops with an abnormal location, arrangement or crowding of small-bowel loops within the hernial sac, evidence of obstruction with segmental dilatation and stasis, with additional features of apparent fixation and reversed peristalsis during fluoroscopic evaluation [1, 5] (Table 1). On CT, additional findings include mesenteric vessel abnormalities, with engorgement, crowding, twisting, and stretching of these vessels commonly found and providing an important clue to the underlying diagnosis [6].

Paraduodenal Hernias

In the classic older literature, paraduodenal hernias were the most common type of internal hernia, accounting for approximately 53% of all cases [1]. Unlike most types of internal hernias, this subtype does have a sex predilection, being found more commonly in men by a ratio of 3:1 [1, 2, 6]. There are two main types, left and right, with the former consisting of most (75%) cases [1, 6–8].

Left Paraduodenal Hernia

Left paraduodenal hernias have an overall incidence of approximately 40% of all internal hernias. They occur when bowel prolapses through Landzert's fossa, an aperture present in approximately 2% of the population (Fig. 1). These hernias therefore can be classified as a congenital type, normal aperture subtype. Landzert's fossa is located behind the ascending or fourth part of the duodenum and is formed by the lifting up of a peritoneal fold by the inferior mesenteric vein and ascending left colic artery as they run along the lateral side of the fossa. Small-bowel loops prolapse posteroinferiorly through the fossa to the left of the fourth part of the duodenum into the left portion of the transverse mesocolon and descending mesocolon (Fig. 2).

Clinically, in addition to the aforementioned symptomatology, these patients will also often present with postprandial pain, typically chronic in nature, with symptoms dating back to childhood [5].

On radiography or oral contrast studies, these hernias will present as an encapsulated circumscribed mass of a few loops of small bowel (usually jejunal) in the left upper quadrant, lateral to the ascending duodenum [1, 5, 9] (Fig. 3A). These loops may have mass effect, depressing the distal transverse colon and indenting the posterior wall of the stomach [1, 5] (Figs. 3B and 3C). Mild duodenal dilatation often occurs, and the efferent loop often shows an abrupt caliber change [5]. With CT, similar findings of encapsulated bowel loops are noted, either at the duodenojejunal junction between the stomach and pancreas to the left of the ligament of Treitz; behind the pancreatic tail itself, displacing the inferior mesenteric vein to the left; or between the transverse colon and the left adrenal gland [5–7, 9–12] (Figs. 4A–4D). Evidence of small-bowel obstruction with dilated loops and air–fluid levels is also commonly seen [5] (Fig. 4E). There is associated mass effect with displacement of the posterior stomach wall anteriorly, the duodenojejunal junction inferomedially, and the transverse colon inferiorly [6, 7, 10]. Mesenteric vessel abnormalities, including enlargement, stretching, and anterior displacement of the main mesenteric

TABLE 1: Clinical and Imaging Findings for Internal Hernias

Hernia Type	Subtype	Incidence[a]	Characteristic Clinical Findings	Radiography and Barium Studies	CT Findings	Key Vessel
Left paraduodenal	Congenital, normal aperture	40% of all hernias, 75% of paraduodenal hernias	Postprandial pain, may date back to childhood	Encapsulated cluster of jejunum in LUQ, lateral to the ascending duodenum; may have mass effect indenting posterior wall of stomach or displacing transverse colon inferiorly	Clustered dilated small-bowel loops between stomach and pancreas, behind pancreas itself, or between transverse colon and left adrenal gland	IMV in neck of hernial sac with anterior and upward displacement of IMV
Right paraduodenal	Congenital, normal aperture	13% of all hernias, 25% of paraduodenal hernias	Postprandial pain, may date back to childhood	Encapsulated loops lateral and inferior to the descending duodenum; associated with small-bowel nonrotation	Encapsulated loops lateral and inferior to the descending duodenum; associated with small-bowel nonrotation	SMA displaced anteriorly
Pericecal	Congenital or acquired, abnormal aperture	13%	RLQ pain, differential diagnosis of appendicitis; high incidence of occlusive symptoms	Clustered small-bowel loops (usually distal) posterior and lateral to the cecum in right paracolic gutter	Clustered small-bowel loops (usually distal) posterior and lateral to the cecum in right paracolic gutter	None
Foramen of Winslow	Congenital, normal aperture	8%	Symptoms of proximal obstruction because of mass effect on stomach; symptom onset often preceded by changes in intraabdominal pressure (i.e., parturition, straining); relief of symptoms with forward bending	Circumscribed loops medial and posterior to the stomach; differential diagnosis of cecal volvulus	Loops in lesser sac between liver hilum and IVC	None; vessels stretched through foramen of Winslow
Intersigmoid	Type 1: congenital, normal aperture; types 2 and 3: acquired, abnormal aperture	6%	None	U- or C-shaped cluster of small bowel posterior and lateral to the sigmoid colon	U- or C-shaped cluster of small bowel posterior and lateral to the sigmoid colon	None
Transmesenteric[b]	In children: congenital, abnormal aperture; in adults: usually acquired, abnormal aperture	8%	Two typical patient populations: children and postsurgical adults; in adults, less vomiting because fewer secretions in proximal gastric pouch, onset more acute	Variable, air within gastric remnant; may simulate a left paraduodenal hernia	Small bowel lateral to colon; displaced omental fat with small bowel directly abutting abdominal wall	None
Retroanastomotic[b]	Acquired, abnormal aperture	5%	Usually within the first postoperative month; less vomiting because fewer secretions in the proximal gastric pouch	Variable	Variable	None

Note—LUQ = left upper quadrant, IMV = inferior mesenteric vein, SMA = superior mesenteric artery, RLQ = right lower quadrant, IVC = inferior vena cava.

[a]Incidence for first six types from Meyers [5], which are historic data but only major source currently available. Incidence for these first six types of internal hernias totals only 93% because perivesical hernias reported [5] are not true internal hernias, so they were not included in this review.

[b]Probably more transmesenteric and retroanastomotic internal hernias currently because of number of liver transplant and gastric bypass operations being performed throughout the United States during past decade. The 5% refers to the incidence after Roux loops used during surgery for reasons other than liver transplantation or gastric bypass.

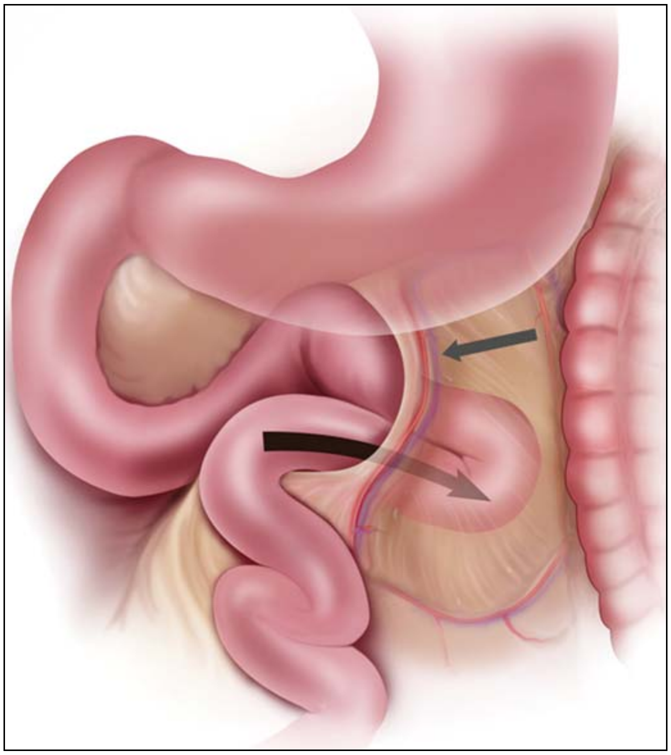


Fig. 2—Graphic illustration of a left paraduodenal hernia depicts loop of small bowel prolapsing (*curved arrow*) through Landzert's fossa, located behind inferior mesenteric vein and ascending left colic artery (*straight arrow*). Herniated bowel loops are therefore located lateral to fourth portion of duodenum.

trunks, especially the inferior mesenteric vein, to the left, are also helpful findings [10, 11]. If the vasculature is optimally visualized, one can often see additional findings of engorged vessels grouped together at the entrance of the hernia sac, with the proximal jejunal arteries showing an abrupt change of direction posteriorly behind the inferior mesenteric artery [6, 7] (Fig. 4F). The inferior mesenteric vein and ascending left colic artery lie in the anterior and medial border of the left paraduodenal hernia and may be displaced laterally (Figs. 2 and 4C).

Right Paraduodenal Hernia

Right paraduodenal hernias have an overall incidence of approximately 13% and occur when bowel herniates through Waldeyer's fossa (representing a defect in the first part of the jejunal mesentery), behind the superior mesenteric artery and inferior to the transverse or third portion of the duodenum (Fig. 5). This normal yet uncommon recess is found in less than 1% of the population and, like left paraduodenal hernias, the right paraduodenal hernia can be classified as congenital type, normal aperture subtype [1, 9]. In these situations, the herniated contents are located in the right half of the transverse mesocolon and behind the ascending mesocolon. This type of hernia occurs more frequently in the setting of nonrotated small bowel [6, 8]. When compared with the left paraduodenal hernias, those on the right are usually larger and are more often fixed [5].

Clinically, these hernias present in a similar manner to the left paraduodenal hernias with chronic postprandial pain [5].

On a standard barium gastrointestinal examination, a larger and more fixed, encapsulated, ovoid collection of bowel loops is noted lateral and inferior to the descending duodenum, in the right half of the transverse mesocolon, or behind the ascending mesocolon [1, 5, 9] (Fig. 6A). As opposed to the left paraduodenal hernias, both the afferent and efferent loops of bowel are closely opposed and narrowed [1, 5]. With CT, an encapsulated cluster of small-bowel loops is noted in the right mid abdomen, with looping of the small bowel around the superior mesenteric artery and vein at the root of the small-bowel mesentery being seen occasionally [5, 8] (Fig. 6B). Small-bowel obstruction may be present with dilated loops containing air–fluid levels. Because right-sided paraduodenal hernias are thought to be congenital, related to abnormalities of embryologic midgut rotation, there may be additional clues such as small-bowel nonrotation, as evidenced by the superior mesenteric vein occupying a more ventral and leftward position and the absence of a normal horizontal duodenum [5, 8, 9]. The cecum, however, remains in its normal position. Vascular findings include jejunal branches of the superior mesenteric artery and superior mesenteric vein looping posteriorly and to the right of the parent vessel to supply the herniated loops [1, 5, 8, 9]. Additional vascular findings include the presence of the superior mesenteric artery, ileocolic artery, and right colic vein in the anterior margin of the neck of the hernial sac, displaced anteriorly if there is sufficient mass effect by the encased small-bowel loops [8]. Again, vessel engorgement may also be present and provide a clue to the diagnosis.

Pericecal Hernias

Historically, pericecal hernias account for 13% of all internal hernias. The pericecal fossa is located behind the cecum and ascending colon and is limited by the parietocecal fold outward and the mesentericocecal fold inward [9]. Although there are actually four subtypes (ileocolic, retrocecal, ileocecal, and paracecal) of pericecal hernias, most commonly the herniated loop consists of an ileal segment protruding through a defect in the cecal mesentery and extending into the right paracolic gutter [1, 9] (Fig. 7). These hernias can therefore be subcategorized as either acquired or congenital defects in the cecal mesentery.

Clinically, patients with pericecal hernias present in a similar manner to those with all other types of internal hernias except for the location of symptoms, which tends to be in the right lower quadrant, so that pericecal hernias are sometimes mistaken for appendiceal abnormalities [1, 9]. A higher incidence of occlusive symptoms with rapid progression to strangulation is also commonly found, with a mortality rate reported to be as high as 75% [9, 13].

Imaging studies, including both barium and CT, show similar findings. These hernias can often be confidently diagnosed as a cluster of bowel loops (usually ileal) located posteriorly and laterally to the normal cecum, occasionally extending into the right paracolic gutter [1, 9] (Fig. 8). Again, there will be evidence of small-bowel obstruction and mass effect displacing the cecum anteriorly and medially.

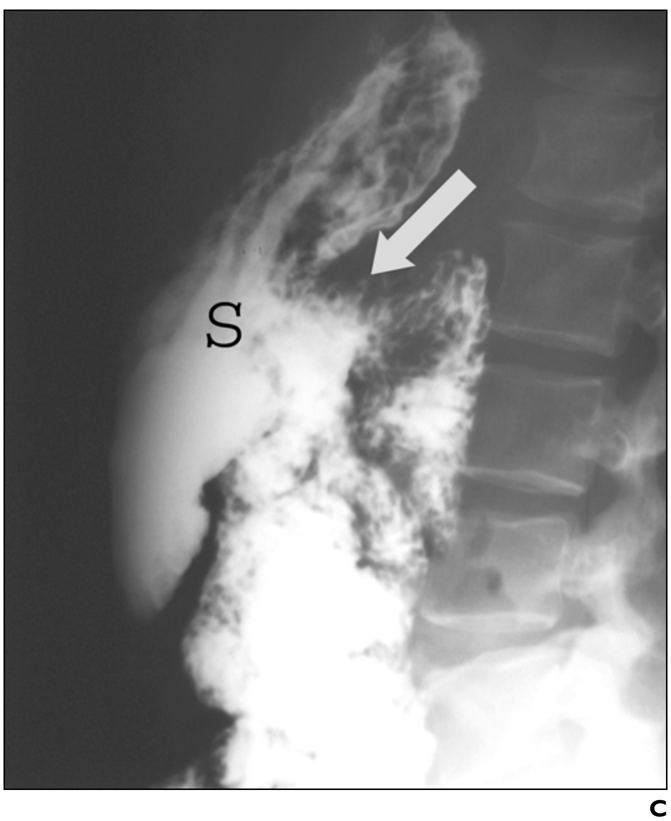


Fig. 3—Left paraduodenal hernias shown on upper gastrointestinal series, and barium enema in one patient and lateral view of upper gastrointestinal series from different patients.
A, 55-year-old man with gastrointestinal bleeding. Anteroposterior projection of oral contrast small-bowel study shows cluster of small-bowel loops in left upper quadrant, lateral to fourth portion of duodenum (*arrow*).
B, Barium enema study (anteroposterior projection) from same patient as in **A** depicts inferior displacement of distal transverse colon and splenic flexure (*arrow*) caused by mass in left upper quadrant that was later revealed to be left paraduodenal hernia.
C, Lateral radiograph from upper gastrointestinal series in 35-year-old woman with abdominal pain shows small-bowel loops (*arrow*) causing mass effect and indentation on posterior aspect of stomach (S), displacing it anteriorly.

Foramen of Winslow

The foramen of Winslow is a normal communication between the greater and lesser peritoneal cavities, located beneath the free edge of the lesser omentum, the hepatoduodenal ligament (Fig. 9). The posterior, superior, and inferior boundaries of this foramen include the inferior vena cava, caudate lobe, and duodenum, respectively [14]. This hernia can therefore be subcategorized as a congenital type, normal aperture subtype. It constitutes 8% of all internal hernias,

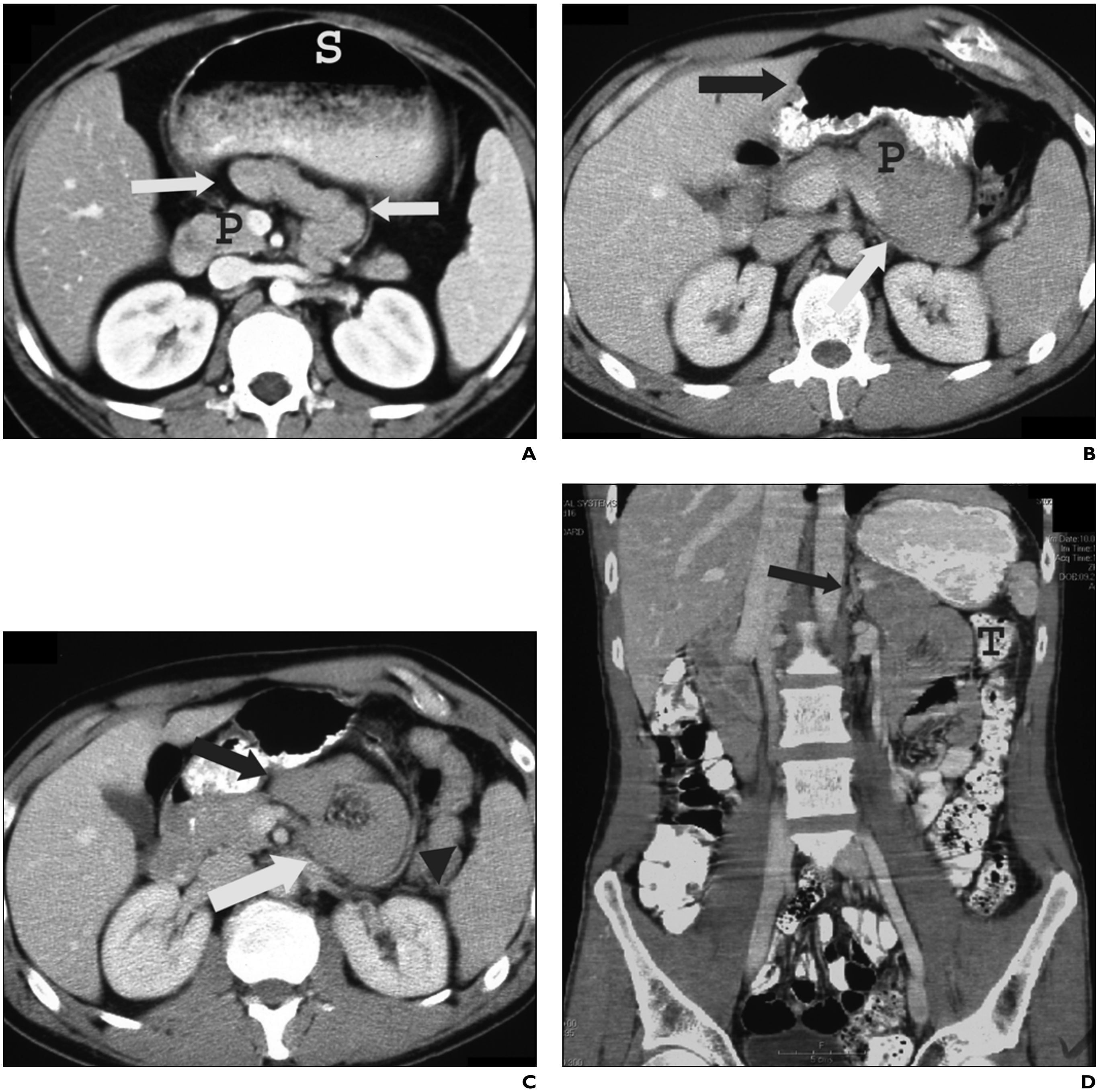
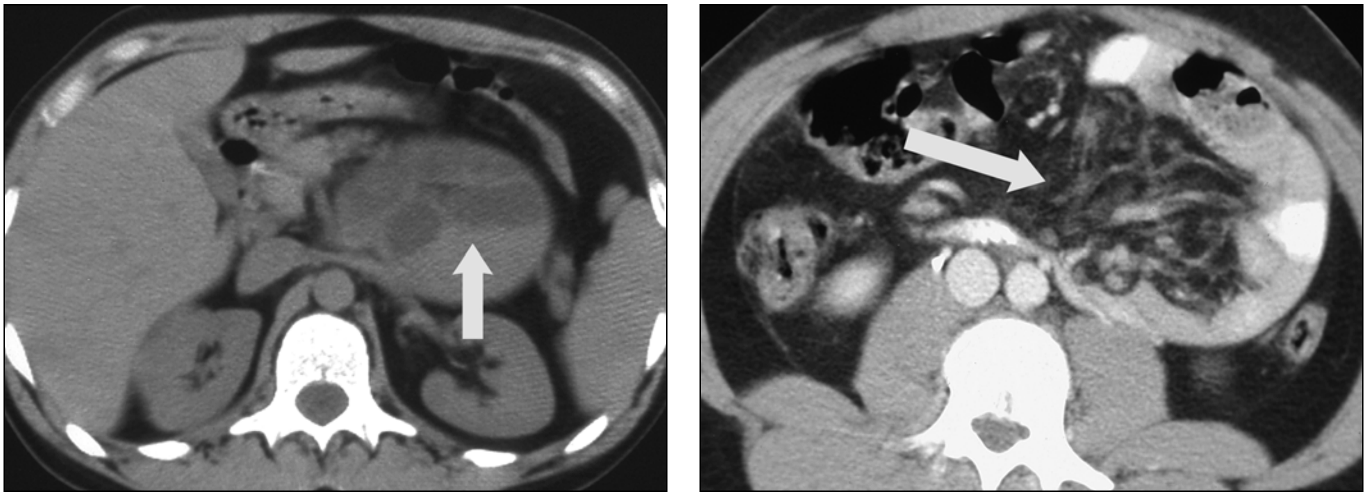


Fig. 4—CT scans from six patients with left paraduodenal hernia.
A, Axial contrast-enhanced CT scan in 11-year-old boy shows small-bowel loops (*arrows*) between stomach (S) and pancreas (P).
B, Axial contrast-enhanced CT scan in 28-year-old man shows small-bowel loops (*white arrow*) behind pancreas (P) itself. Black arrow indicates stomach.
C, Axial contrast-enhanced CT scan in 36-year-old man shows small-bowel loops (*arrows*) displaying inferior mesenteric vein (*arrowhead*) to left.
D, Coronal reconstruction of contrast-enhanced CT data set in 28-year-old man shows small-bowel loops between transverse colon (T) and left adrenal gland (*arrow*).
(Fig. 4 continues on next page)



E F

Fig. 4 (continued)—CT scans from six patients with left paraduodenal hernia.
E, Unenhanced axial CT scan in 35-year-old man shows evidence of small-bowel obstruction of herniated contents as multiple loops of dilated small bowel (*arrow*) with fluid–fluid levels noted.
F, Axial contrast-enhanced CT scan in 23-year-old man shows multiple engorged and prominent vessels (*arrow*) in herniated sac caused by vascular congestion and obstruction.

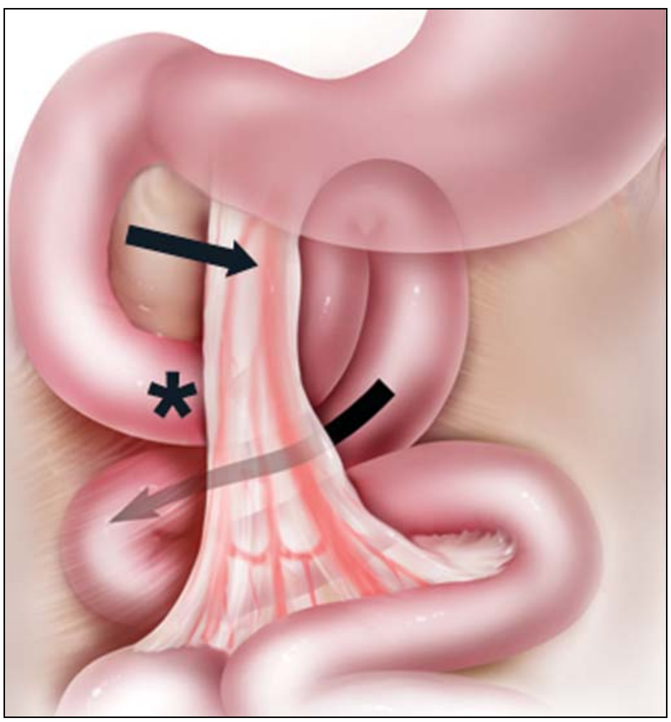
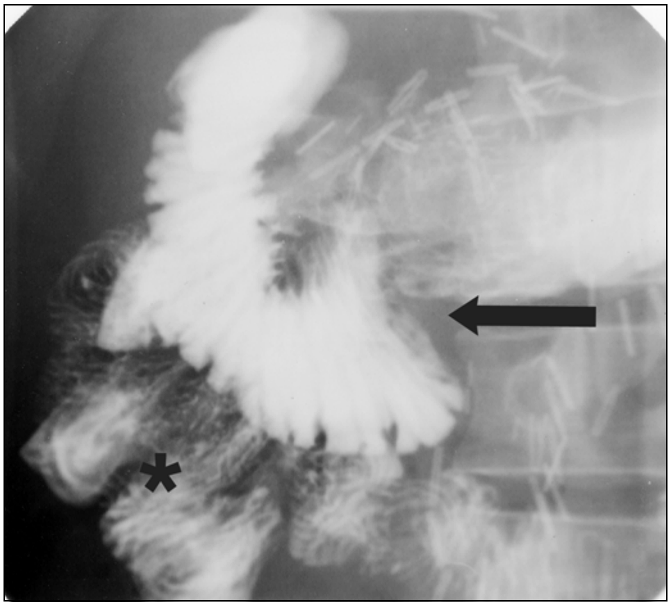


Fig. 5—Graphic illustration of right paraduodenal hernia shows loop of small bowel prolapsing (*curved arrow*) through Waldeyer's fossa, behind superior mesenteric artery (*straight arrow*) and inferior to third portion of duodenum (*asterisk*).

with approximately two thirds containing small bowel alone, and the remaining one third containing additional cecum and ascending colon and occasionally gallbladder, transverse colon, and omentum [1, 5, 6, 9, 14]. Risk factors for this type of hernia include an enlarged foramen of Winslow, an abnormally long small-bowel mesentery, persistence of the ascending mesocolon allowing marked mobility of bowel, and an elongated right hepatic lobe (such as a Riedel's lobe), which is thought to direct the mobile intestinal loops toward the foramen of Winslow [1, 5, 6, 9, 14, 15].

The typical patient is middle-aged, with acute onset of severe, progressive pain and signs of small-bowel obstruction [1]. Patients also often present with symptoms of a proximal bowel obstruction, which are caused by a pressure effect on the stomach by the herniated contents [14]. Symptom onset is often preceded by a change in intraabdominal pressure, such as parturition or straining [1, 5]. Occasionally, forward bending provides some relief [1]. Rarely, patients will present with jaundice or a distended gallbladder, again from pressure or stretching of the common bile duct by the herniated colon [5].

When the small bowel herniates, conventional radiographs may reveal a circumscribed collection of gas-filled loops in the upper abdomen, medial and posterior to the stomach, which may progress to a location anterior to the hepatic flexure [1, 5, 9]. Evidence of small-bowel obstruction will probably be seen [1, 5]. With barium studies, additional mass effect will likely be shown because the stomach and the first and second parts of the duodenum will shift anteriorly and laterally [1, 5, 14] (Figs. 10A and 10B). On occasion, this type of hernia can have the appearance of a cecal volvulus if the herni-



A

B

Fig. 6—23-year-old man with abdominal pain.
A, Anteroposterior projection from oral contrast small-bowel study reveals cluster of small-bowel loops (*asterisk*) posterior and lateral to second and third portions of duodenum (*arrow*).
B, Contrast-enhanced CT scan shows abnormal loop of small bowel (*arrow*) in right upper quadrant and reveals right paraduodenal hernia.

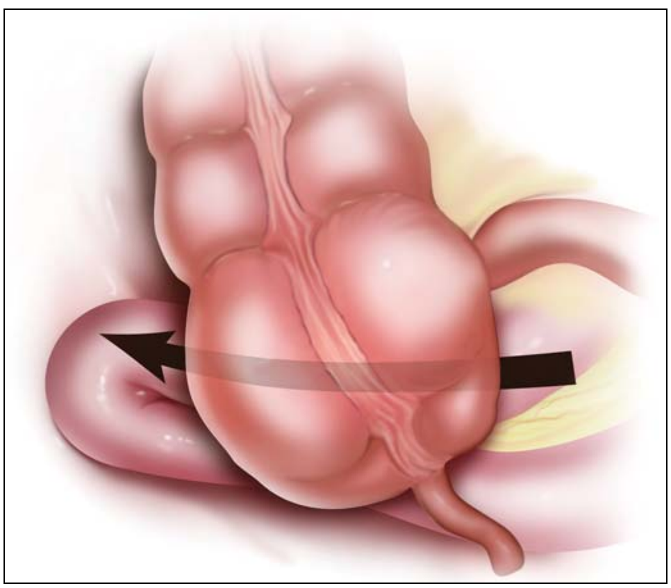
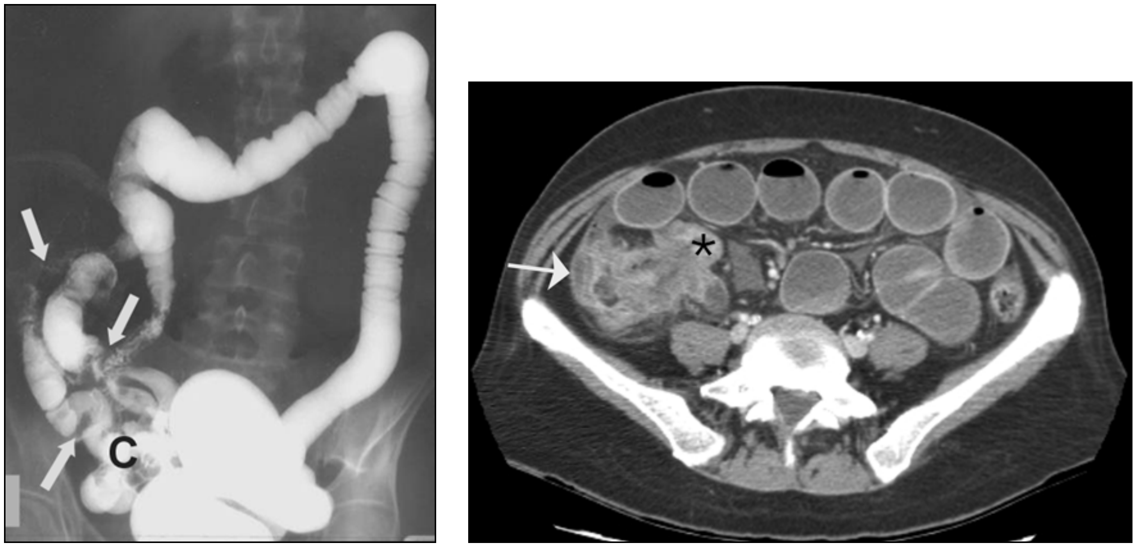


Fig. 7—Diagrammatic illustration of pericecal hernia shows loop of ileum prolapsing (*arrow*) through cecal mesenteric defect, behind and lateral to cecum, into right paracolic gutter.

ated sac contains cecum [1, 5, 14] (Fig. 11). The zone of transition of the obstruction is usually located near the hepatic flexure [1]. On CT, multiple gas-filled loops are located in the lesser sac, posterior to the liver hilum, anterior to the inferior vena cava, and between the stomach and pancreas, with tapering of the herniation through the foramen of Winslow [9] (Fig. 10C). There may be anterior and lateral displacement of the stomach and stretching of the mesenteric vessels through the foramen of Winslow [6]. Complications can arise if defects exist in the gastrocolic or gastrohepatic omentum, allowing reentry of herniated loops into the greater peritoneal cavity.

Foramen of Winslow hernias often present a similar radiographic appearance to that of left paraduodenal hernias. One key feature that can be useful in distinguishing between these entities is the presence of an encapsulating membrane seen with left paraduodenal hernias and not with those involving the foramen of Winslow. In addition, if the entry point can be identified, it will be slightly inferior and to the left of the spine, delineated anteriorly by the inferior mesenteric vein and the left colic artery with left paraduodenal hernias, whereas with foramen of Winslow hernias, the entry point will be relatively superior and to the right of the spine, delineated by the liver hilum anteriorly. Along the same lines, mass effect on the transverse colon more commonly indicates a left paraduodenal hernia, again because of its more inferior location. Occasionally, left paraduodenal hernias can be supracolic. Finally, prominent, congested blood vessels have more commonly been described with paraduodenal hernias, although not exclusively.



A B

Fig. 8—60-year-old man with right lower quadrant pain.
A, Single anteroposterior radiograph from barium enema study shows retrograde filling of herniated distal ileum (*arrows*) as loops of ileum pass posterior to cecum (C) through defect of ileocecal mesentery to reach right paracolic fossa. (Reprinted with permission from [1])
B, Contrast-enhanced axial CT scan shows loops of small bowel (*arrow*) posterior and lateral to cecum (*asterisk*) in right paracolic gutter, producing small-bowel obstruction. (Courtesy of Ghahremani GG, San Diego, CA)

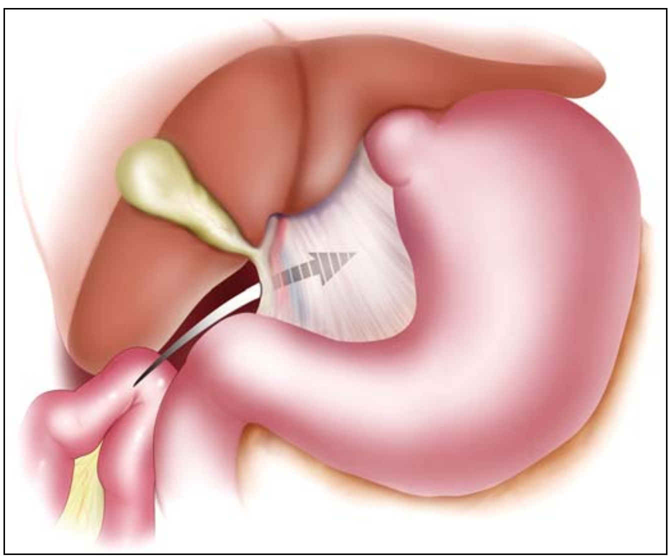


Fig. 9—Graphic illustration of foramen of Winslow hernia shows bowel about to prolapse (*arrow*) into lesser sac, behind hepatoduodenal ligament, the free edge of the lesser omentum.

Sigmoid-Related Hernias

Two or three main types of sigmoid-related hernias are seen, depending on the degree of adherence to the definition of internal hernia [5, 16]. The most common and most disputable, the intersigmoid type, develops when herniated bowel, usually ileum, protrudes into the intersigmoid fossa, formed between two adjacent sigmoid segments and their respective mesenteries [9]. Although this fossa is found at 65% of autopsies [1], it is debatable whether the opening of this fossa truly is an aperture. These hernias are often easily reducible [1]. A second type, the transmesosigmoid hernia, occurs when small bowel herniates through a complete defect involving both layers of the sigmoid mesocolon to lie in a position posterolateral to the sigmoid itself [1, 9, 16] (Fig. 12). In this type of hernia, the orifice is usually a long slit with its edge bounded by branches of the inferior mesenteric artery [5]. The third and least common type, the intramesosigmoid hernia, is herniation of viscera through an incomplete defect involving only one of the layers (usually the left leaf) of the mesosigmoid [1, 9, 16]. The third type therefore consists of a hernial sac that lies within the sigmoid mesocolon [16]. Both the second and third types are acquired subtypes of internal hernia, whereas the first is a normal congenital subtype. However, these three types are radiographically difficult to distinguish, and differentiation is not so important because they are treated surgically in a similar manner [9].

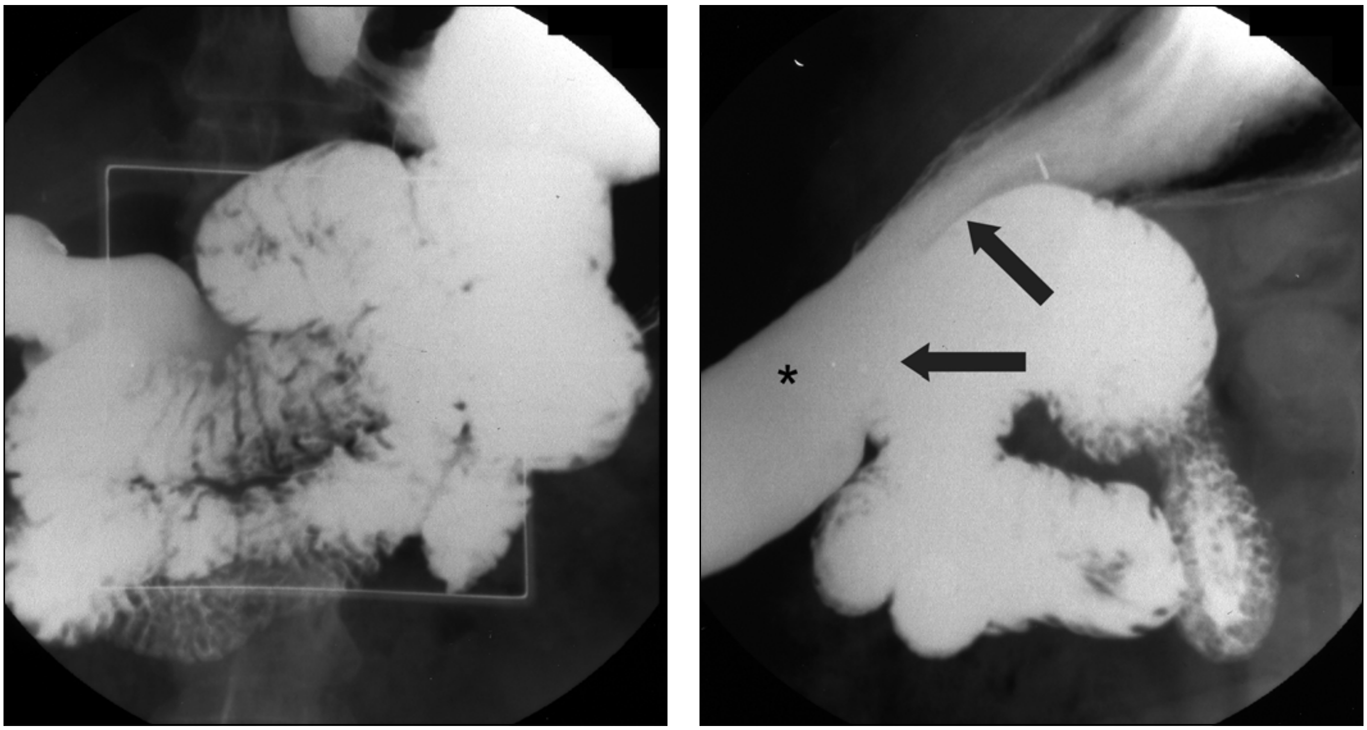
Clinically, these hernias present as described, with no distinctive or characteristic findings on history or physical examination.

If the patient has no evidence of obstruction, these hernias can be diagnosed with postevacuation barium enema radiographs, which will show sacculated ileal loops occupying the left lower quadrant and elevation and displacement of the sigmoid colon to the right [17]. If obstruction is present, however, CT findings include a cluster of Y- and X-shaped dilated small-bowel loops entrapped behind the left posterior and lateral aspect of the sigmoid colon, with the defect most commonly located between the sigmoid colon and the left psoas muscle, or between sigmoid loops if it is an intersigmoid type [4, 17] (Fig. 13). These bowel loops often cause mass effect, displacing the sigmoid colon anteromedially [17]. Additional findings of mesenteric vessel congestion and stranding of the fat, suggesting strangulation, may be seen [17].

Transmesenteric Hernias

Although previously an uncommon type of hernia, transmesenteric hernias are increasing in incidence and surpassed the frequency of paraduodenal hernias in one study [4, 7, 10]. These hernias have a bimodal distribution, occurring in both pediatric and adult patients. In children, transmesenteric hernias are the most common type of internal hernia, occurring in 35% of this patient population [1, 5, 9, 18]. In this age group, they are thought to arise from a congenital defect in the small-bowel mesentery, near the ileocecal region or ligament of Treitz [1, 5, 9]. One popular theory relates the cause to prenatal intestinal ischemia and subsequent thinning of the mesenteric leaves because the prenatal intestinal ischemia is associated with bowel atresia in 5.5% of the pediatric population [1, 2, 5, 18]. Other causes postulated include intraperitoneal inflammation, trauma, partial development regression, and fenestration of the mesentery by the colon during the embryologic displacement into the umbilical cord [6].

However, there is a second peak of occurrence in the adult population, and in this subset of patients, the cause is iatrogenic, usually related to prior abdominal surgery, especially with Roux-en-Y anastomosis, trauma, or inflammation [1, 5, 6, 9, 18]. Both liver transplantation and the most common type of gastric bypass surgery involve the formation of a Roux-en-Y loop at the choledochojejunostomy site, and these procedures are increasing



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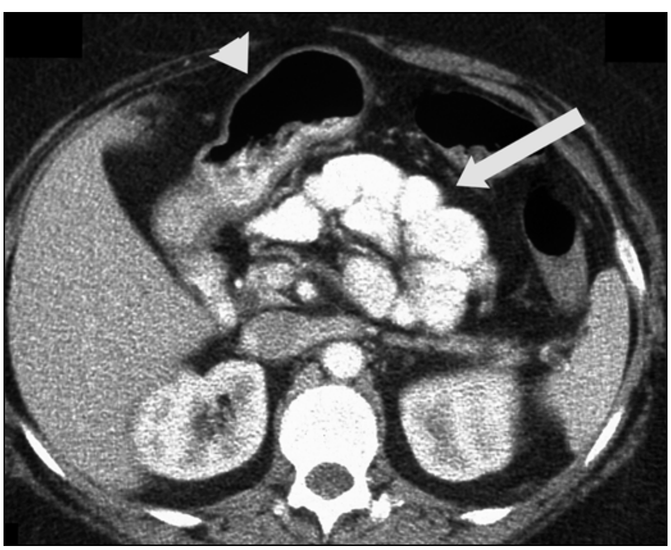
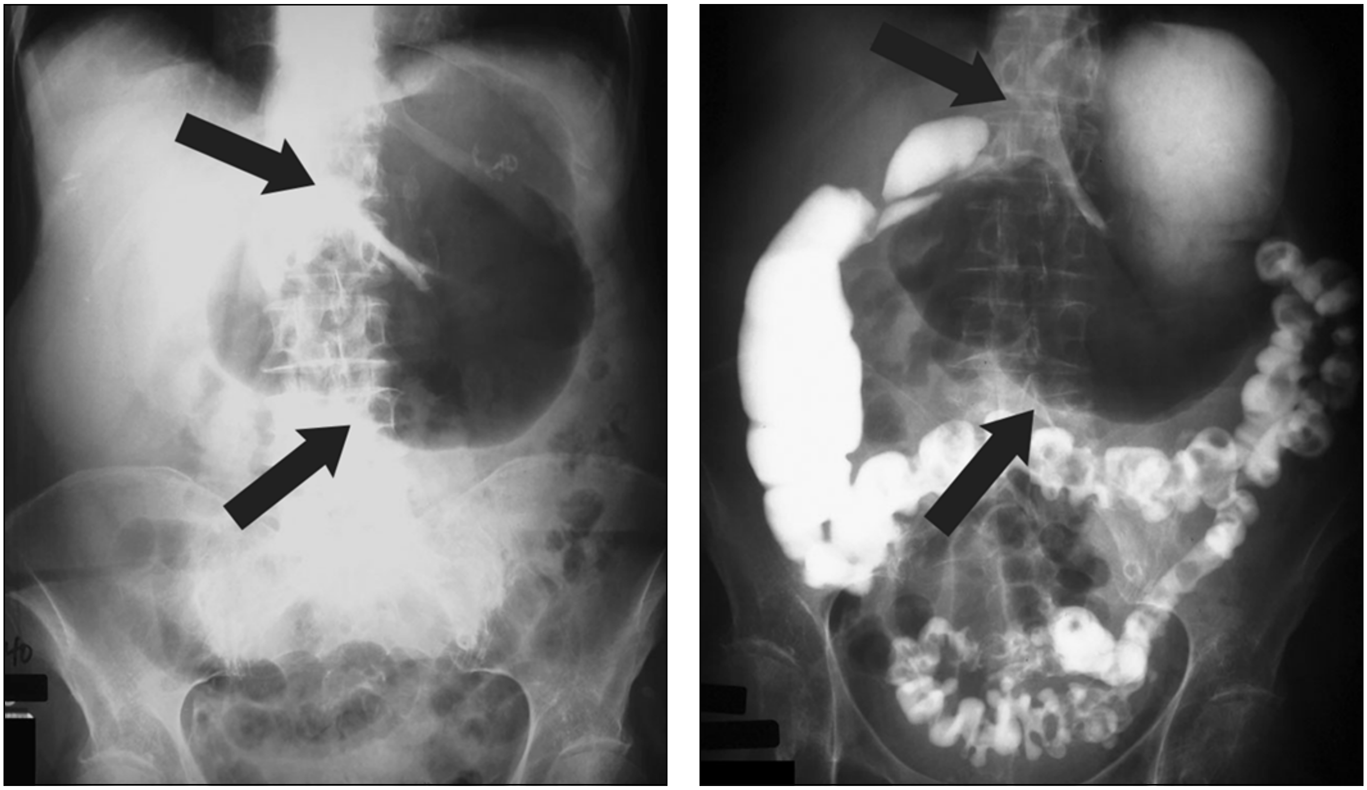


C

Fig. 10—54-year-old woman with abdominal pain.
A, Anteroposterior radiograph from upper gastrointestinal series shows abnormal cluster of small-bowel loops located in lesser sac, representing foramen of Winslow internal hernia.
B, Oblique lateral view from same gastrointestinal series shows abnormal cluster of small-bowel loops posterior to stomach (*asterisk*), indenting (*arrows*) and displacing stomach anteriorly.
C, Contrast-enhanced axial CT scan shows cluster of small-bowel loops (*arrow*) located in lesser sac, posterior to stomach (*arrowhead*).



A B

Fig. 11—70-year-old man with severe epigastric pain.
A, Anteroposterior projection of radiograph shows large collection of gas in left upper quadrant (*arrows*).
B, Barium enema (anteroposterior view) shows large, air-filled structure in upper abdomen (*arrows*), originally thought to represent a distended stomach but surgically confirmed to be cecum involved in foramen of Winslow hernia.

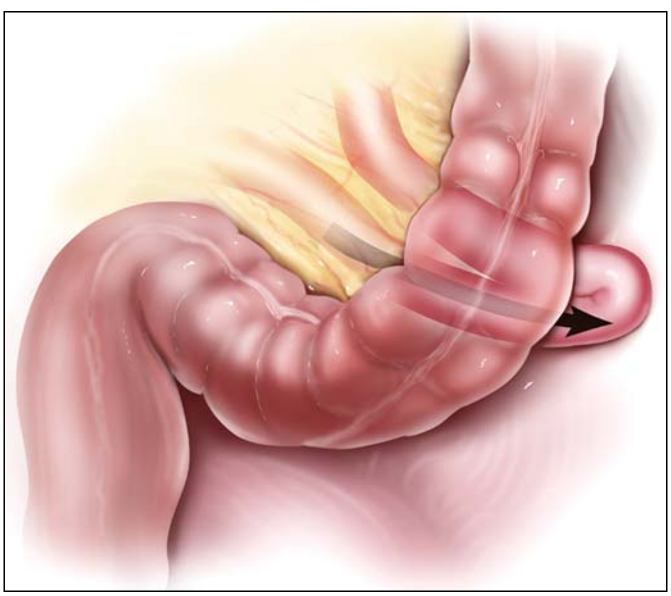


Fig. 12—Diagrammatic illustration of intersigmoid hernia shows bowel protruding (*arrow*) through defect in sigmoid mesocolon to lie posterolateral to sigmoid colon itself.

Fig. 13—85-year-old man with abdominal pain. Axial CT scan of sigmoid-related hernia (type 2, transmesosigmoid) reveals small-bowel loops (*arrow*) protruding through defect in sigmoid mesocolon, which usually occurs between left psoas muscle (*arrowhead*) and sigmoid colon (S), to lie posterior and lateral to sigmoid colon itself.

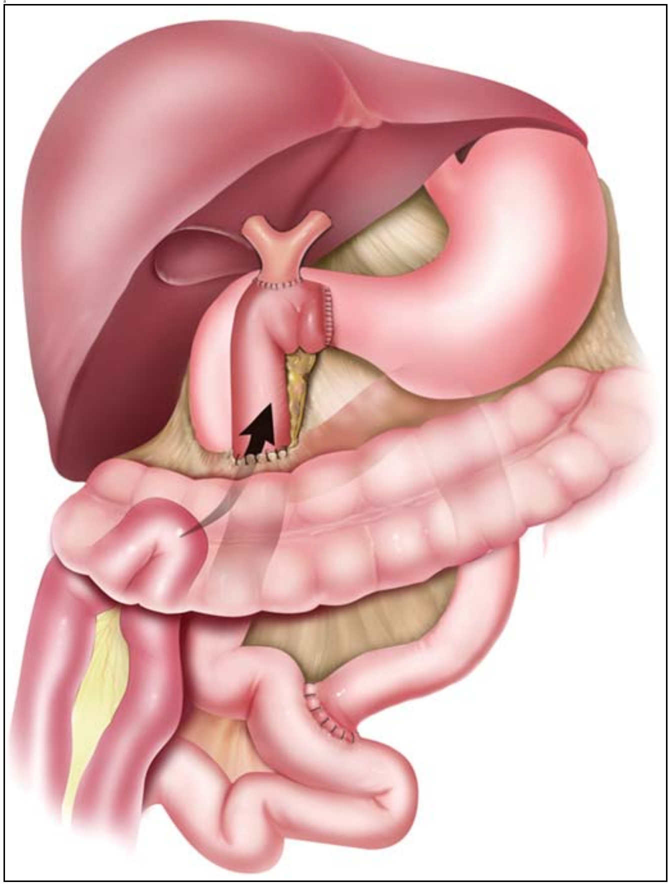


Fig. 14—Diagrammatic illustration shows retrocolic Roux-en-Y procedure, with loop of small bowel about to herniate through transverse mesocolon (*arrow*) at surgically created defect, in keeping with transmesocolic internal hernia.

in frequency (Fig. 14). If the Roux loop is placed anteriorly to the transverse colon, referred to as antecolic, there will be no defect created in the transverse mesocolon; however, this procedure is less commonly performed because of the required long segment of bowel needed to travel around the transverse colon to finally be anastomosed to the remaining gastric pouch. A more direct route involves creating a defect in the transverse mesocolon, allowing a shorter Roux limb length. However, this second surgical procedure, also known as a retrocolic type, is more associated with the potential complication of internal hernia (Fig. 14). Interestingly, internal hernias also appear to occur more commonly after laparoscopic Roux-en-Y gastric bypass than after open Roux-en-Y gastric bypass, for reasons unknown [15].

Three main types of transmesenteric internal hernias are seen. The first and most common is the transmesocolic, which has been documented to occur in 0.7–3.25% of patients after laparoscopic Roux-en-Y gastric bypass surgery [15]. The second type of transmesenteric internal hernia occurs when bowel prolapses through a defect in the small-bowel mesentery. Finally, the third type, known as the Peterson type, has also been described and involves the herniation of small bowel behind the Roux loop before the small bowel eventually passes through the defect in the transverse mesocolon [4].

Several predisposing factors have been postulated. Although surgeons attempt to close the defects created, they can be incompletely closed or can have a breakdown or a pulling of the suture material through the mesocolic fat [3, 15]. Enlargement of the mesenteric defect can occur with repeated herniation. An additional possible predisposing factor may be the rapid weight loss and decreased intraperitoneal fat that occurs in bariatric patients, causing enlargement of the defect [4]. Transmesenteric hernias are more likely than other subtypes to develop volvulus and strangulation or ischemia, the incidence of which is reported to be as high as 30% and 40%, respectively, with mortality rates of 50% for the treated groups and 100% for the nontreated subgroups [5–7, 18]. Volvulus and strangulation or ischemia may be partly caused by the usual small aperture of the defect (2–5 cm) in addition to the lack of encapsulation of the herniated loops, allowing a large length of small bowel to herniate through the mesenteric defect [5, 18].

Clinically, in both the pediatric and adult populations, patients present with signs and symptoms of small-bowel obstruction, with periumbilical, crampy pain, nausea, and distention [1, 7, 10]. Vomiting can be a less prominent feature than with other types of internal hernias because of fewer gastric and enteral secretions from the proximal gastric pouch or Roux limb that can accumulate above the level of obstruction [15]. Overall, however, symptom onset is often more acute than with other types of hernias [6]. Most (93%) transmesenteric internal hernias in the adult postoperative population occur more than 1 month after surgery (mean, 235 days), and the most common cause of obstruction during the first postoperative month is adhesions [4]. On physical examination, the "Gordian knot of herniated intestine" has been described, representing a tender abdominal mass [1].

Transmesenteric hernias are more difficult to diagnose on imaging studies because their appearance and location are more variable. This is partly because of the lack of a confining sac and therefore their potential location anywhere in the peritoneal cavity, although they tend to occur more commonly in the right mid abdomen [6, 9, 10]. Most commonly, it is the Roux loop itself that herniates with a cluster of a few loops of dilated small bowel in the expected location of the Roux loop [4] (Fig. 15). On radiography, there may be signs of small-bowel obstruction, occasionally with a closed loop appearance [18].

Although the transmesenteric hernia often causes obstruction of the limb proximal to the enteroenterostomy site, if the hernia is distal, an important clue may be the presence of significant air in the gastric remnant, which is only a normal finding in the early postoperative course (Fig. 16). Otherwise, this finding is of concern for a distal obstruction at or beyond the enteroenterostomy site.

Oral contrast material and cross-sectional studies will provide a variable appearance, depending on the type of transmesenteric hernia and the segment and length of herniated bowel. If the hernia is of the first type, through the mesocolon and consisting of only

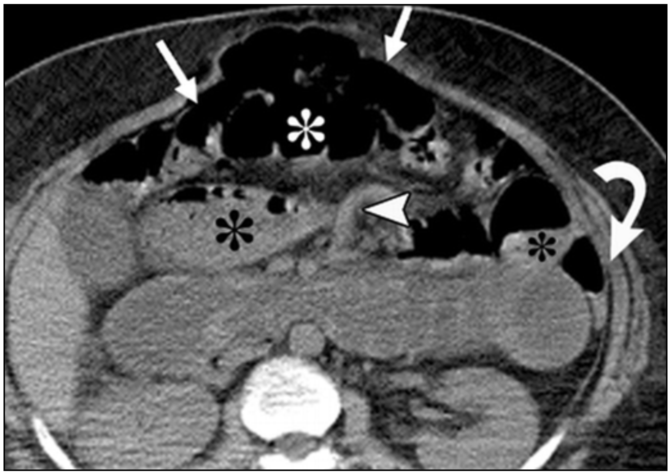


Fig. 15—40-year-old woman with nausea and vomiting. Contrast-enhanced axial CT scan of transmesenteric internal hernia 19 months after Roux-en-Y procedure shows dilated loops of duodenum (*large black asterisk*) and jejunum (*white asterisk*) in expected location of Roux loop. Note that Roux limb (*arrowhead*) is compressed. Straight arrows, curved arrow, and small black asterisk represent colon. (Reprinted with permission from [19])

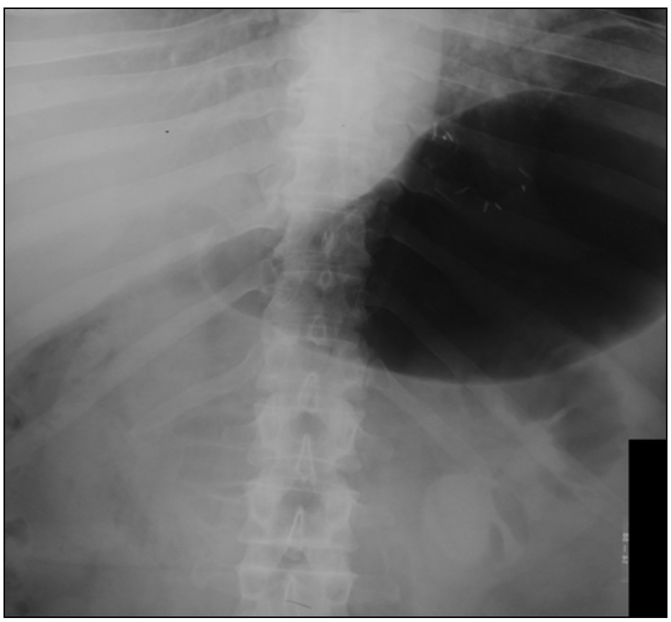


Fig. 16—36-year-old man with sudden onset of abdominal pain. Radiograph (anteroposterior projection) shows distended air-filled gastric remnant, which is normal finding in recently postoperative patient. However, in this patient several months after surgery, this finding is most worrisome for obstruction at distal anastomosis of Roux-en-Y loop.

a few loops of small bowel, oral contrast studies may show a beaked appearance of both the afferent and efferent loops and resultant mass effect on the stomach and transverse colon, simulating a left paraduodenal hernia [5]. With CT as with barium studies, these hernias can often be mistaken for or occur concomitantly with a small-bowel volvulus and closed loop obstruction, including a beaklike appearance of the closely opposed afferent and efferent loops [9, 18]. Again, there may be mass effect on the stomach and transverse colon.

On the other hand, a slightly different radiographic picture will emerge if the herniated segment is much longer or is of the second type, through the small-bowel mesentery. On CT, more typical findings have been described, in addition to the usual findings of small-bowel obstruction with transition point [6]. As described by Blachar and Federle [6] and Blachar et al. [7], the presence of clustered bowel loops in the periphery of the peritoneal cavity, lateral to the colon (a reversal of the normal pattern), with central, inferior, and posterior displacement of the transverse colon is one clue (Fig. 17A). Because, as previously mentioned, the herniated bowel is located more commonly on the right, it is often the hepatic flexure that is displaced inferiorly and medially [6].

The second described finding, again by the same authors [6, 7], involves displacement of the overlying omental fat, with the obstructed loops compressed and directly abutting the abdominal wall (Fig. 17B). It has been suggested that these two findings of peripherally located small bowel and lack of omental fat between the loops and the anterior abdominal wall might be the most helpful CT signs, with an overall sensitivity of 85% and 92% for each respective finding [7]. The mesenteric vasculature may also show an abrupt change in the course of the superior mesenteric artery, which is often displaced to the right, with crowding, stretching, engorgement, and displacement of its visceral branches [5, 6, 10, 18]. However, further studies concluded that the only statistically significant signs were relatively nonspecific findings of small-bowel dilatation with transition point, clustering of small-bowel loops, and mesenteric vessel abnormalities (including displacement of the main mesenteric trunk to the right), obtaining an overall average sensitivity of 63%, specificity of 73%, and accuracy of 77% [10]. Again, a "closed loop" sign, twisting of the mesenteric vessels and the whirl sign if volvulus is present, may also be seen [1, 6, 9]. Occasionally, there may even be evidence of ischemia with ascites and bowel wall thickening present [7].

With the third type of transmesenteric hernia associated with Roux-en-Y surgery, known to surgeons as the Peterson type, little has been described in the imaging literature other than nonspecific findings of partial small-bowel obstruction and crowding of the mesenteric vessels.

As previously mentioned, because of their variable imaging appearances, transmesenteric hernias are often confused with either right paraduodenal or pericecal hernias. One helpful distinguishing feature for the former includes the presence of an encapsulating membrane, which should be seen only with right paraduodenal hernias. Differentiating a pericecal hernia from a transmesenteric hernia can be more problematic. Location of herniated bowel loops (in the right upper quadrant for transmesenteric and right lower quadrant for pericecal) can sometimes provide a clue, although usually a history of surgery is the most helpful information.

Retroanastomotic Hernias

Retroanastomotic hernias occur when small-bowel loops herniate posteriorly through a de-

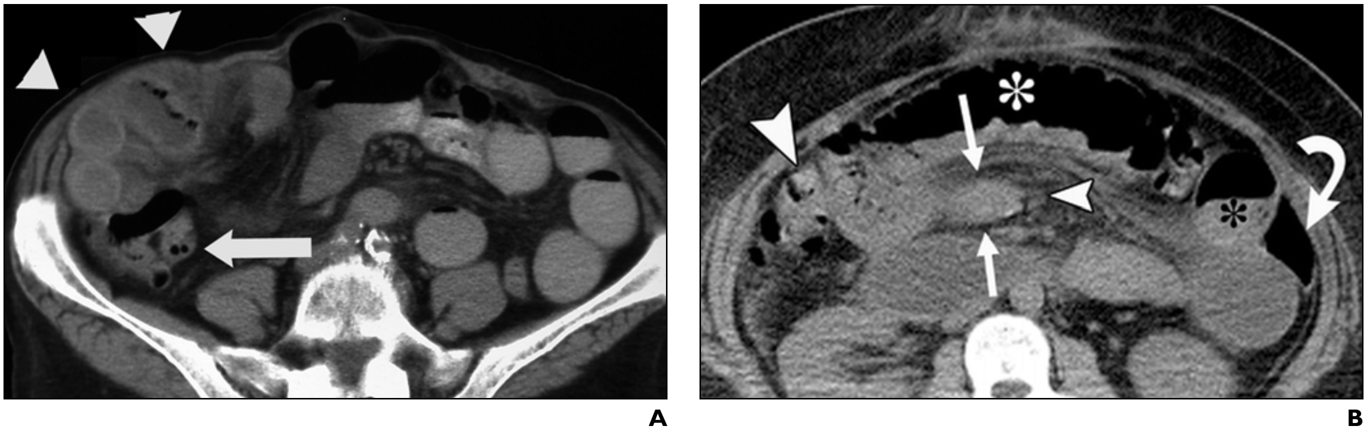


Fig. 17—CT scans in two different patients with transmesenteric internal hernias.
A, Contrast-enhanced axial CT scan of 84-year-old woman showing transmesenteric internal hernia after Roux-en-Y procedure shows dilated, fluid-filled loops of small bowel lateral to ascending colon (*arrow*) and displacing omental fat because loops of bowel lie directly beneath anterior abdominal wall (*arrowheads*).
B, Axial contrast-enhanced CT scan at level of transverse mesocolon in a 40-year-old woman shows dilated loop of jejunum directly abutting anterior abdominal wall (*white asterisk*). In addition, note compression of pancreaticobiliary limb (*straight arrows*), whereas Roux limb (*small arrowhead*) is barely visible. Large arrowhead, black asterisk, and curved arrow indicate colon. (Reprinted with permission from [19])

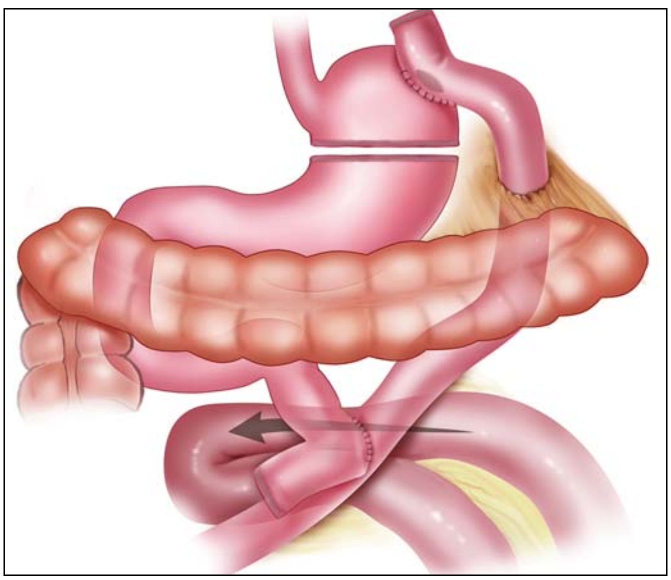


Fig. 18—Diagrammatic illustration shows retrocolic Roux-en-Y gastric bypass procedure. Arrow indicates loop of small bowel protruding posterior to enteroenterostomy, in keeping with a retroanastomotic internal hernia.

fect related to a surgical anastomosis; they are therefore by definition considered an acquired type, abnormal aperture subtype of internal hernia. Specifically, these hernias have been most commonly described with the Roux-en-Y formation and are ever increasing in incidence as liver transplantations and gastric bypasses for bariatric surgeries continue to become more frequent and widespread. If the surgery is of the antecolic type, the borders of the aperture consist of the transverse mesocolon superiorly, the ligament of Treitz inferiorly, and the gastrojejunostomy site and afferent limb of the jejunum anteriorly; hence the term “retroanastomotic” [5] (Fig. 18). The most common herniated loop consists of the efferent jejunal segment, which occurs in approximately 75% of cases [1]. However, controversy exists in the literature as to whether this occurs more commonly with the antecolic [5] or retrocolic [1] form of the surgery. Less commonly, a very long afferent limb, ileum, cecum, or omentum can herniate into the retroanastomotic space. However, if antecolic surgery is performed, the afferent loop will be the most commonly involved segment.

As opposed to the transmesenteric type of internal hernia related to the Roux-en-Y surgery, the retroanastomotic type tends to occur most commonly during the first postoperative month, with half of all cases presenting during this time [1, 5]. Of the remaining 50%, half will occur after the first year, and the other half (or 25% of the total) will occur between months 2 and 12 [5]. Also in contradistinction to the transmesocolic type, the retroanastomotic hernia is more common with the antecolic form of the surgery. Symptoms again depend on whether the retrocolic or antecolic form of the surgery was performed. If retrocolic, symptoms may be nonspecific findings related to a high small-bowel obstruction, such as crampy abdominal pain and nausea [1, 5]. Typically, there is less vomiting because of the relative lack of fluid and secretions in the gastric pouch or Roux limb [19]. On physical examination, there may be a tender mass in the left upper quadrant [1]. With the antecolic form of the surgery, patients more commonly present with persistent epigastric pain and tenderness, nonbilious vomiting, and increased amylase [1]. Compared with other types of internal hernias, these hernias are less likely to present with strangulation because of the large aperture size. However, uncommonly, complications can arise when the herniated loop reenters the greater peritoneal cavity through the foramen of Winslow or a gastrohepatic or gas-

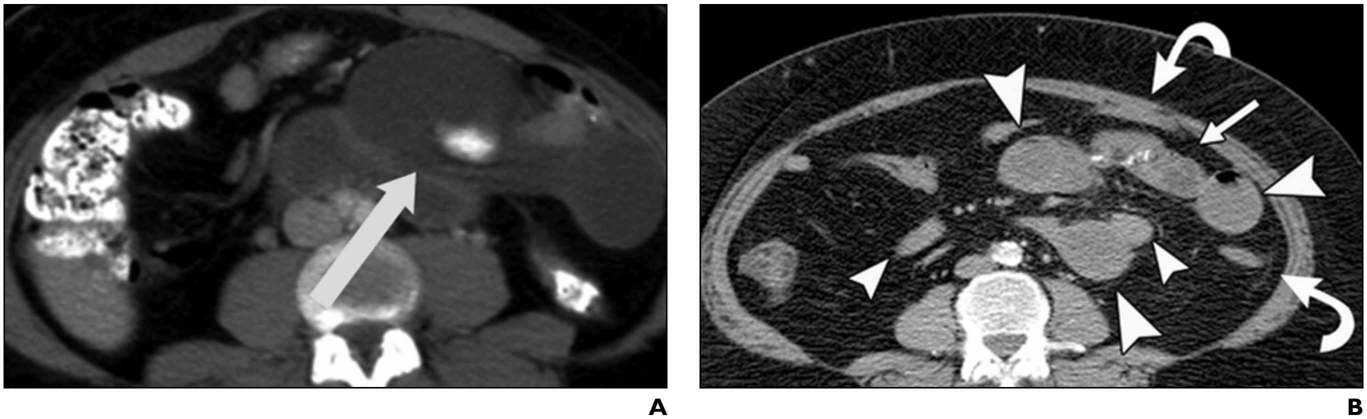


Fig. 19—CT scans from two different patients showing retroanastomatic hernias.
A, Contrast-enhanced axial CT scan of retroanastomotic hernia in 35-year-old woman shows loops of dilated fluid-filled small bowel (*arrow*) in left upper quadrant.
B, Axial CT scan in 58-year-old woman 2 months after Roux-en-Y gastric bypass shows herniated loop posterior to jejunojejunostomy site (*straight arrow*) and dilated proximal Roux limb (*large arrowheads*). Note decompressed distal ileal loops (*small arrowheads*) and colon (*curved arrows*). (Reprinted with permission from [19])

trocolic ligament [5]. Diagnostic considerations include more common postoperative complications such as gastric outlet obstruction, dumping syndrome, and postoperative pancreatitis, with a delay in the diagnosis potentially leading to strangulation (with mortality rates of 30% and 100% for the treated vs nontreated groups, respectively) [1, 5].

On radiographs, because the herniated bowel most often occurs from right to left, there may be a collection of dilated loops in the left upper quadrant. There also may be significant dilation of the bypassed stomach (Fig. 16). Upper oral contrast–enhanced gastrointestinal studies may reveal the abnormal loop posterior and lateral to the gastrojejunostomy, often with some degree of stasis and dilatation [1, 5]. On CT, the herniated jejunal loops are often noted to be fixed in the left upper quadrant, usually associated with some degree of dilatation (Fig. 19). However, with the antecolic form of surgery, findings on the oral contrast–enhanced studies may be more difficult to assess because of the difficulty in opacifying the afferent loop. On CT, a fluid-filled, markedly distended tubular structure is noted. Nuclear medicine studies can often be helpful in terms of visualizing the afferent loop by using an agent excreted by the biliary system into the duodenum, thereby delineating the location of the afferent loop.

Summary

Although internal hernias were previously an uncommon cause of small-bowel obstruction, the incidence appears to be increasing as more Roux-en-Y surgeries are performed for various reasons, thereby creating a shift from congenital to iatrogenic causes. It is important for the radiologist to be aware of the imaging findings of these hernias, particularly on CT, because CT is rapidly becoming a mainstay in the workup of acute abdominal pain.

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