Small Bowel Obstruction: What to Look For[1]

TEACHING POINTS
See last page

Ana Catarina Silva, MD • Madalena Pimenta, MD • Luís S. Guimarães, MD

Small bowel obstruction (SBO) is a common clinical syndrome for which effective treatment depends on a rapid and accurate diagnosis. Despite advances in imaging and a better understanding of small bowel pathophysiology, SBO is often diagnosed late or misdiagnosed, resulting in significant morbidity and mortality. A comprehensive approach that includes clinical findings, patient history, and triage examinations such as plain abdominal radiography will help the clinician develop an individualized treatment plan. When an SBO is accompanied by signs of strangulation, emergent surgical treatment is advised. If surgery cannot be performed immediately or if a partial obstruction is suspected, then a more detailed radiologic work-up is needed. The imaging techniques used subsequently vary according to the initial findings. If a low-grade partial obstruction is suspected, volume-challenge enteral examinations such as enteroclysis and computed tomographic (CT) enteroclysis are preferred. If a complete or high-grade obstruction is suspected, cross-sectional studies such as ultrasonography or multidetector CT are used to exclude strangulation. An algorithmic approach to imaging is proposed for the management of SBO to achieve accurate diagnosis of the obstruction; determine its severity, site, and cause; and assess the presence of strangulation. Radiologists have a pivotal role in clinical decision making in cases of SBO by providing answers to specific questions that significantly affect management.

Abbreviation: SBO = small bowel obstruction

RadioGraphics 2009; 29:423–439 • **Published online** 10.1148/rg.292085514 • **Content Code:** GI

[1]From the Department of Radiology, Unidade Local de Saúde de Matosinhos, EPE, Senhora da Hora, Rua Dr. Eduardo Torres, 4464-513 Matosinhos, Portugal (A.C.S.); the Department of Radiology, Hospital de São João, Porto, Portugal (M.P.); and the Department of Radiology, Hospital de São Teotónio, Viseu, Portugal (L.S.G.). Presented as an education exhibit at the 2007 RSNA Annual Meeting. Received February 19, 2008; revision requested April 1 and received June 2; accepted July 8. All authors have no financial relationships to disclose. **Address correspondence to** A.C.S. (e-mail: *catarina.silva.hph@gmail.com*).

Introduction

Small bowel obstruction (SBO) is a common clinical condition that occurs secondary to mechanical or functional obstruction of the small bowel, preventing normal transit of its contents. It is a frequent cause of hospitalization and surgical consultation, representing 20% of all surgical admissions for acute abdominal pain (1,2).

The radiologic investigation of patients with SBO and the indications for and timing of surgical intervention have changed over the past two decades (3). The old paradigm of the general surgeon when confronted with a possible SBO was to "never let the sun set or rise on an obstructed bowel." This approach reflected the clinical and radiologic limitations of the preoperative recognition of strangulation (4).

Nowadays, owing to the increased application of advanced modalities of abdominal imaging in the clinical context of SBO, combined with the widespread assumption that most of these conditions resolve spontaneously with nonsurgical treatment, namely nasointestinal decompression (5), imaging has become the primary focus in the treatment of patients with SBO. Therefore, radiology assumes considerable relevance in assisting the therapeutic decision of the surgeon in cases of SBO by addressing the following questions (6): Is the small bowel obstructed? How severe is the obstruction, where is it located, and what is its cause? Is strangulation present?

Teaching Point

Plain abdominal radiography continues to be the initial examination in these patients due to its wide availability and relatively low cost. However, radiographs are diagnostic in only 50%–60% of cases and have high sensitivity only for high-grade obstructions. Nevertheless, the results of this modality should serve as a basis for triage for further imaging work-up and assist in the therapeutic decision (7–9).

Sonography is not commonly used for the evaluation of SBO mainly because most of the time the bowel loops are filled with gas, producing nondiagnostic sonograms, and because adhesions, the most common cause of mechanical SBO, are not detected with this technique (10). However, when the obstructed bowel segments are dilated and filled with fluid, not only can the level of obstruction be recognized but the cause of the obstruction can also be demonstrated by using the fluid-filled bowel as a sonic window (3,10).

Contrast material–enhanced studies, particularly volume-challenge enteral examinations like enteroclysis, were once advocated as the definitive study in patients with clinical uncertainty about the diagnosis of SBO, since these studies correctly demonstrate the presence of obstruction in 100% of cases, the level (proximal vs distal) of obstruction in 89% of cases, and the cause of the obstruction in 86% of surgically treated patients (11). Nowadays, this technique and computed tomographic (CT) enteroclysis are used mainly in patients with clinically suspected low-grade SBO owing to the ability of these techniques to challenge the distensibility of the bowel wall and exaggerate the effects of mild or subclinical obstructions (12,13). However, CT enteroclysis can also be used in high-grade obstructions whenever relevant management questions are not answered with conventional CT.

Standard CT emerged two decades ago as the preeminent imaging modality for preoperative evaluation of SBO, with sensitivity of 90%–96%, specificity of 96%, and accuracy of 95%. However, these results appear to apply mostly to cases of high-grade obstruction, with low-grade obstruction being a relative "blind spot" for standard CT. Newer multidetector CT scanners with multiplanar reformation capability are significantly more effective in evaluation of SBO and correlation of the obstruction with pathologic tissue damage. Therefore, owing to the capability of CT for early demonstration of strangulation, CT is now considered the best modality for determining which patients would benefit from conservative management and close follow-up and which patients would benefit from immediate surgical intervention (14–19).

Teaching Point

In this article, we propose an algorithmic and schematic approach for imaging work-up and evaluation of patients with SBO, based on a review of the literature and the current approach to this entity. We also describe and illustrate the "what to look for" imaging findings of the different modalities used to diagnose SBO and characterize its severity, site, cause, and simple versus complicated nature.

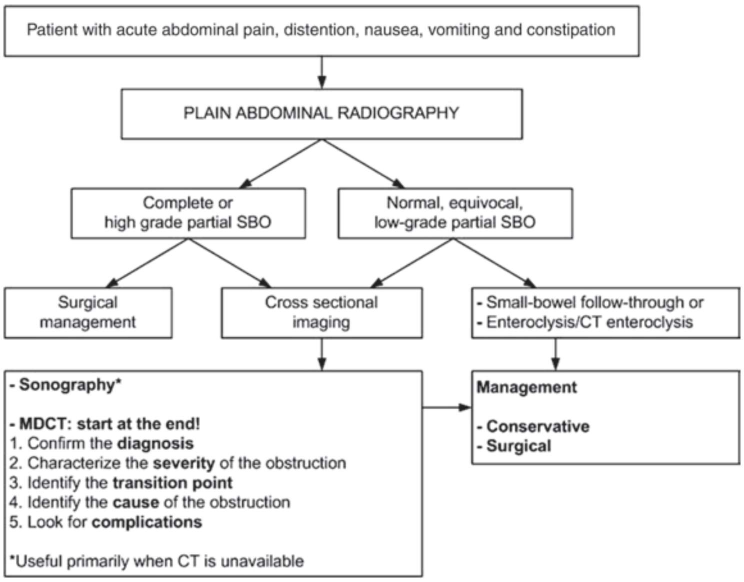


Figure 1. Algorithm for imaging work-up of patients suspected to have SBO. *MDCT* = multidetector CT.

Imaging Work-up: Algorithmic Approach

The dilemma that surgeons and radiologists face when confronted with a possible SBO on the basis of the patient's symptoms and signs is not the use of one imaging technique over another, but rather the decision which examination to use first to confirm the SBO and help determine the best therapeutic approach. A schematic approach is shown in Figure 1. When a patient presents to the emergency department with crampy abdominal pain, abdominal distention, nausea, and vomiting, one of the first diagnostic hypotheses is SBO.

Conventional abdominal radiography is the preferred initial radiologic examination (7). Results of this technique are diagnostic in 50%–60% of cases; equivocal in about 20%–30%; and normal, nonspecific, or misleading in 10%–20% (6). If the findings on plain radiographs are those of an unequivocal SBO pattern and a high-grade partial or complete SBO is suspected, immediate surgical evaluation should be performed (3,6,7).

However, if surgery is not imminently planned or other treatment options are being considered, assessment of the severity and cause of the obstruction with cross-sectional studies becomes a priority. CT and multidetector CT are the preferred additional imaging modalities, since they have a sensitivity of 82%–100% for high-grade and complete SBO and their results can potentially modify the treatment approach from surgical to conservative. In settings in which CT is unavailable, sonography can sometimes serve as a useful substitute (3,10).

Conversely, if the initial radiographic findings are interpreted as normal, equivocal, or suggestive of a low-grade partial SBO, an examination that challenges the distensibility of the small bowel such as small bowel follow-through study, enteroclysis, or CT enteroclysis is recommended, as these usually exaggerate the effects of mild obstructions (7,12–14,19). Nevertheless, we emphasize that a bowel obstruction is a dynamic and ever-changing process. It can rapidly evolve into a catastrophic condition with ischemia or resolve by itself. Therefore, in those cases where surgical treatment is not immediate or advocated, it is necessary to maintain close communication between the surgeon and radiologist in order to guarantee the appropriate imaging and clinical follow-up (20).

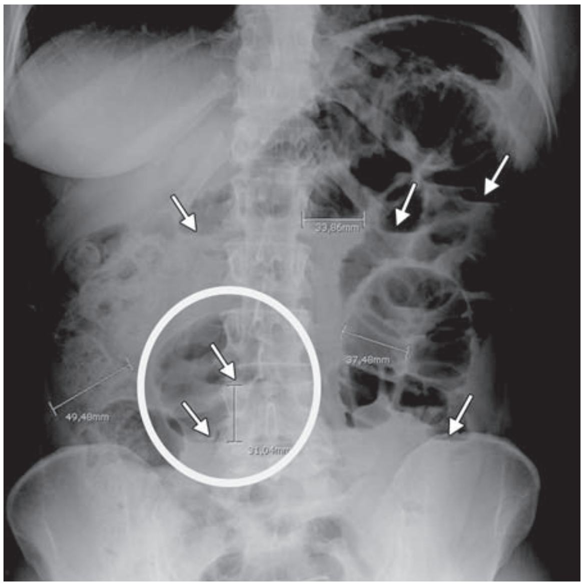


Figure 2. High-grade SBO. Plain abdominal radiograph shows multiple air-fluid levels (arrows), some with a width of more than 2.5 cm. In addition, there is a differential vertical height of more than 2 cm between corresponding air-fluid levels in the same bowel loop (circled area). There is also distention of the small bowel diameter to more than 2.5 cm and a small bowel–colon diameter ratio of greater than 0.5.

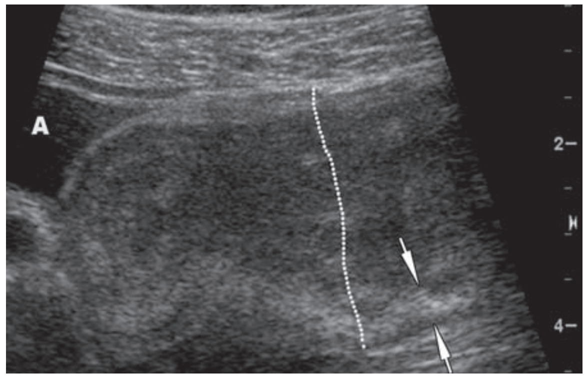


Figure 3. Ileal obstruction secondary to Crohn disease. Sonogram of the ileum shows a dilated fluid-filled bowel loop with a caliber of more than 3 cm (dotted line). The absence of valvulae conniventes allows the obstruction to be localized to the ileum. There is a thickened bowel wall with a stratified echo pattern (arrows) and ascites *(A)*.

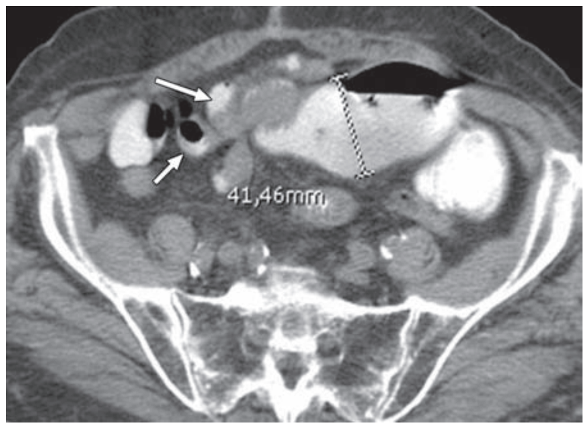


Figure 4. CT criteria for SBO. Axial CT scan shows a disparity in caliber between distended proximal small bowel loops (diameter >3 cm) (dotted line) and collapsed distal small bowel loops (arrows).

Findings at Plain Abdominal Radiography

Despite the low diagnostic accuracy and specificity of abdominal radiography, recognition of an unequivocal SBO pattern in the appropriate clinical context has significant value and greatly contributes to the initial diagnostic and therapeutic decision making.

The key radiographic signs that allow distinction between a high-grade SBO and a low-grade obstruction are the presence of small bowel distention, with maximal dilated loops averaging 36 mm in diameter and exceeding 50% of the caliber of the largest visible colon loop as well as a 2.5 times increase in the number of distended loops in the abdomen compared with the normal number. Other findings that are most significant and predictive of high-grade SBO, according to experienced gastrointestinal radiologists (7), are the presence of more than two air-fluid levels, air-fluid levels wider than 2.5 cm, and air-fluid levels differing more than 2 cm in height from one another within the same small bowel loop (Fig 2) (7,9).

Findings at Sonography

In the United States, sonography is not commonly the first choice for the initial work-up of patients with SBO. However, it is frequently used in many other countries where the availability

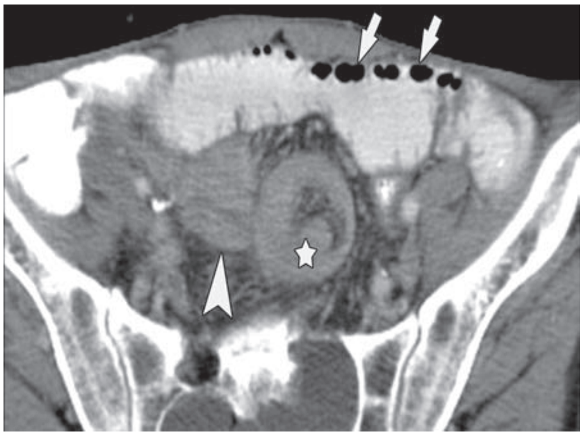


Figure 5. Simple complete SBO secondary to intussusception. Axial CT scan shows distended small bowel loops with intraluminal positive contrast material (arrows) proximal to an intussusception with a targetlike appearance (⋆). Completely collapsed bowel loops without intraluminal contrast material (arrowhead) are seen beyond the intussusception.

of CT is limited and expertise in sonography is high. Despite being an operator-dependent technique and having inherent limitations in the evaluation of gas-containing structures, abdominal sonography can be quite valuable in certain situations, with high sensitivity in demonstrating the presence of SBO, its level, and in some instances the cause and severity of the obstruction.

At sonography, bowel obstruction is considered to be present when the lumen of the fluid-filled small bowel loops is dilated to more than 3 cm, the length of the segment is more than 10 cm, and peristalsis of the dilated segment is increased, as shown by the to-and-fro or whirling motion of the bowel contents (10,21,22). The level of the obstruction is determined by means of the location of the bowel loops and the pattern of the valvulae conniventes.

As with other cross-sectional imaging techniques, the cause of the SBO may be determined by examining the area of transition from the dilated to normal bowel. Causes of SBO like bezoars, intussusception, Crohn disease, and tumors can be depicted with this method (Fig 3). Obstruction associated with external hernias is ideal for sonographic detection in that dilated loops of intestine may be traced to a portion of the gut with normal caliber but abnormal position (22).

The severity of the obstruction can also be assessed. The presence of free fluid between dilated small bowel loops, aperistalsis, and wall thickening (>3 mm) in a fluid-filled distended bowel segment suggests bowel infarction (10,22).

Findings at Multidetector CT

Multidetector CT plays a primary role in the evaluation of patients with acute SBO for several reasons. It is a fast examination, it usually does not require oral contrast material because the retained intraluminal fluid serves as a natural negative contrast agent, and it allows assessment of extramural areas that would not be visible at contrast-enhanced studies. Finally, results of multidetector CT can provide answers to specific questions that have a major effect on the clinical treatment of the patient. These questions include the following (13,14,18): Is the small bowel obstructed? What is the grade of severity of the obstruction? Where is the transition point? What is the cause of the obstruction? Are there any associated complications?

Is the Small Bowel Obstructed?

Teaching Point

CT criteria for SBO are the presence of dilated small bowel loops (diameter >2.5 cm from outer wall to outer wall) proximally to normal-caliber or collapsed loops distally (Fig 4) (16).

When CT findings are equivocal for the presence of obstruction after positive oral contrast material has been given, it is often helpful to perform delayed scanning to assess the passage of contrast material (23). Although there is no evidence in the literature that this technique can be used to distinguish complete from incomplete obstruction, one can deduce that the same criteria used in contrast-enhanced studies like enteroclysis and small bowel follow-through study could be applied to CT. Therefore, a complete obstruction is considered to be present when there is no passage of contrast medium beyond the point of obstruction on delayed scans obtained at 3–24 hours (Fig 5).

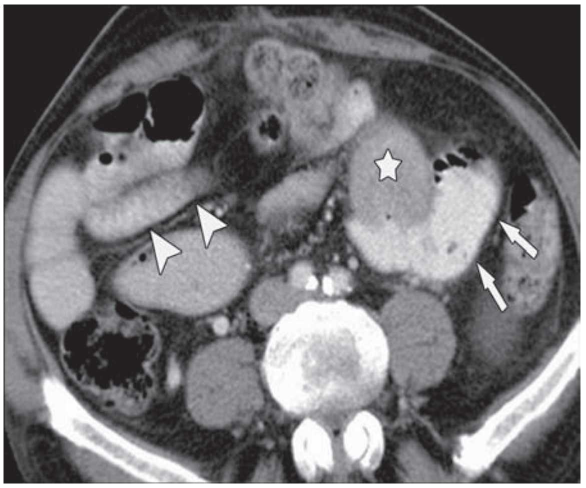


Figure 6. Low-grade partial SBO. Axial CT scan shows distended jejunal loops (arrows) proximal to an intussusception (⋆) filled with intraluminal positive oral contrast material. There is sufficient flow of contrast material through the intussusception to fill distal small bowel loops (arrowheads).

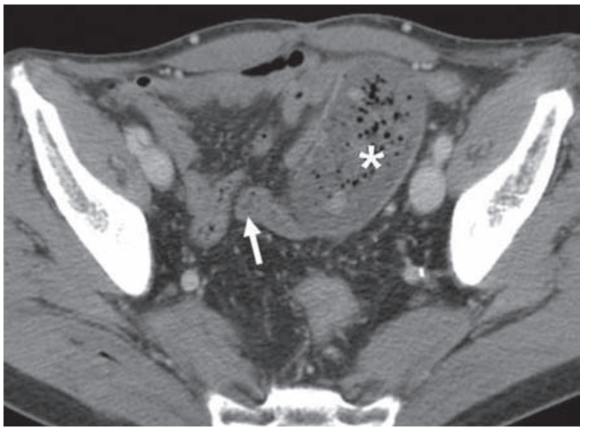


Figure 7. Small bowel feces sign in a patient with high-grade SBO secondary to postoperative adhesions. Axial CT scan shows gas bubbles mixed with particulate matter (*), a finding that represents the small bowel feces sign. Note the collapsed bowel loops (arrow) distal to the obstruction point.

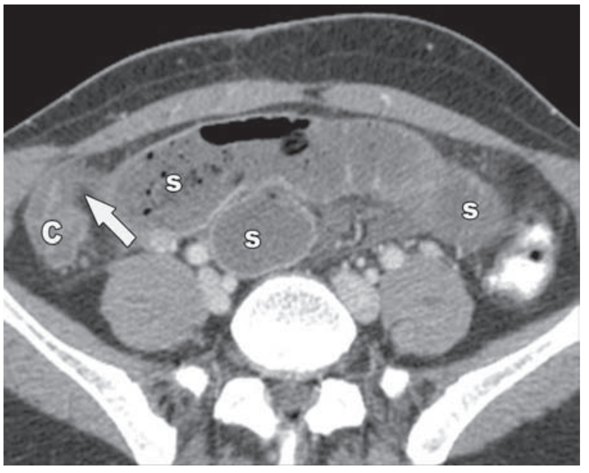


Figure 8. Identification of the transition point in an SBO secondary to postoperative adhesions. Axial CT scan shows dilated small bowel loops *(S)*. There is an abrupt change in caliber (arrow) between the proximal dilated bowel loops and collapsed distal bowel loops *(C)*. The change in caliber was due to adhesions.

A low-grade partial SBO is considered present when there is sufficient flow of contrast material through the point of obstruction (Fig 6). High-grade partial SBO is diagnosed when there is some stasis and delay in the passage of the contrast medium, so that diluted oral contrast material appears in the distended proximal bowel and minimal contrast material appears in the collapsed distal loops. As mentioned, these criteria are the same as the ones used in standard contrast-enhanced studies to diagnose and characterize SBO (24).

How Severe Is the Obstruction?

The presence of high-grade versus incomplete obstruction can be determined by the degree of distal collapse, proximal bowel dilatation, and the presence of the "small bowel feces" sign in cases where no positive oral contrast material has been given, although this last factor is controversial.

In a high-grade obstruction, there is a 50% difference in caliber between the proximal dilated bowel and the distal collapsed bowel (25). Also, a high-grade obstruction that has been present for several days leads to complete evacuation of the contents of the bowel segments distal to the obstruction point (26), highlighting the discrepancy in caliber between the proximal and distal small bowel loops.

The small bowel feces sign is present when intraluminal particulate material is identified in the dilated small bowel (Fig 7). Its prevalence is low (7%–8%), and it is described by some authors as being more likely to occur in moderate and high-grade obstruction (27). However, this is a controversial point, as other authors have found that

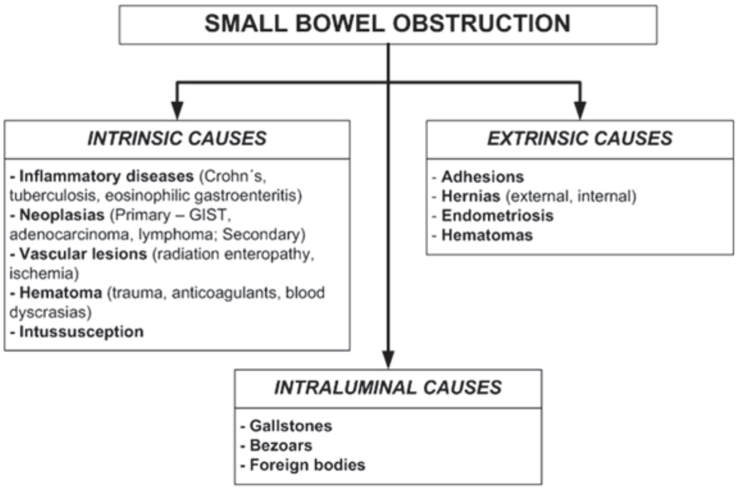


Figure 9. Causes of SBO. *GIST* = gastrointestinal stromal tumor.

this sign is associated predominantly with low-grade subacute obstruction. For this reason, it cannot be used as a reliable sign for assessing the severity of obstruction, but rather only to identify the transition point (28).

When positive oral contrast material is given, passage of the contrast material through the transition point into the collapsed distal bowel indicates an incomplete bowel obstruction.

Where Is the Transition Point?

The transition point is determined by identifying a caliber change between the dilated proximal and collapsed distal small bowel loops (Fig 8). Several methods can be used to improve detection of the transition point. One of these relates to the method of acquisition. By acquiring thin-section CT data with near-isotropic voxels, as currently available with multidetector CT scanners, multiplanar and three-dimensional capabilities can be exploited.

Another technique is based on the method of reading the examination results. Although scrolling through CT data in a cine mode at a workstation or picture archiving and communication system allows one to track the course of the small bowel more easily than by simply relying on static images, the adoption of a schematic approach is advised to rapidly and efficiently identify the transition point. This approach should begin in a retrograde fashion by starting at the rectum and proceeding proximally toward the cecum, ileum, and jejunum. If the transition point is located proximally (jejunum or duodenum), the position should be confirmed by using an antegrade approach, starting at the stomach (23). Finally,

Teaching Point

always look for the presence of the small bowel feces sign because, when present, it is usually present at the transition point.

What Is the Cause of the Obstruction?

Before searching for causes of SBO, it is mandatory to definitively exclude obstruction of the large bowel because causes, symptoms, and treatment differ. Afterward, the use of a systematic approach based on the surgical and clinical history of the patient and epidemiologic data will assist in determination of the cause of the obstruction (Fig 9).

A rule of thumb never to forget is that the answer is almost always in the transition point. Most intrinsic bowel lesions are seen at the transition point and manifest as localized mural thickening. Most extrinsic causes are seen adjacent to the transition point and usually have associated extraintestinal manifestations. Most intraluminal causes manifest as endoluminal "foreign objects" with imaging characteristics different from those of the remaining enteric content.

Teaching Point

The etiology of SBO has shifted over the past five decades from predominantly hernias to adhesions, Crohn disease, and malignancy as the top three causes of SBO in Western society. Hernias still represent the predominant cause in some developing countries. Crohn disease has been recognized as a leading cause in the surgery literature (29).

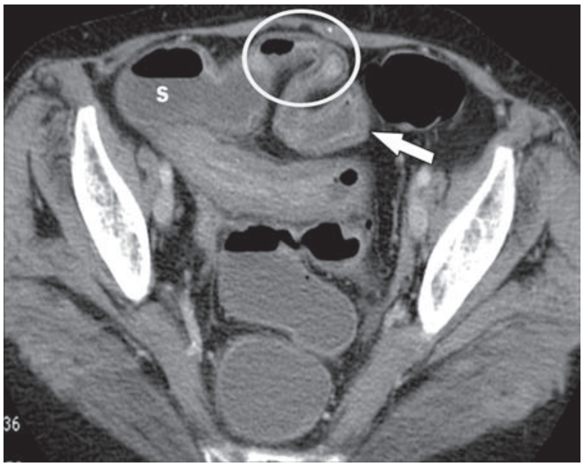


Figure 10. SBO secondary to the acute presentation of Crohn disease. Axial CT scan shows a dilated small bowel loop with a diameter of more than 2.5 cm *(S)* proximal to the thickened terminal ileum (arrow). Circle = transition point.

Intrinsic Causes of SBO

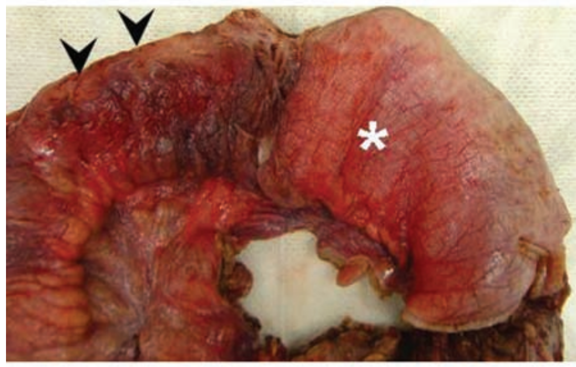
Crohn Disease.—SBO in Crohn disease can be a manifestation of three clinical situations that can occur in this disease. It can result from the acute presentation of the disease. This is characterized by bowel luminal narrowing secondary to the transmural acute inflammatory process (Fig 10). It can be a manifestation of long-standing disease, which usually results in cicatricial stenosis of affected segments (Fig 11). Finally, it can be secondary to adhesions, incisional hernias, exacerbation of the inflammatory condition, or postoperative strictures in patients who have undergone previous intestinal surgery (18,30–33).

Distinguishing between these conditions is essential for proper patient treatment.

Neoplasia.—Primary neoplastic causes of SBO are rare. Intrinsic small bowel neoplasms constitute less than 2% of gastrointestinal malignancies. When a small bowel adenocarcinoma manifests as SBO, it is usually at an advanced state and shows pronounced, asymmetric, and irregular mural thickening at the transition point (Fig 12) (18,30).

Small bowel involvement by metastatic cancer is more common than involvement by primary neoplasms. It is more frequent in the form of peritoneal carcinomatosis, which is suggested when extrinsic serosal disease involving the small bowel wall is seen in association with a transition point. However, SBO caused by isolated metastases to the bowel seems to be an extremely rare event and poses a significant diagnostic challenge (34).

a.



b.

Figure 11. SBO due to the stenotic phase of Crohn disease. **(a)** Axial CT scan shows fluid-filled dilated small bowel loops with intraluminal positive contrast material of different dilutions (⋆). At the terminal ileum, a transition point with a thickened bowel wall and mural stratification (arrowheads) and perienteric hypervascularity are identified. **(b)** Photograph of the gross specimen shows the narrowed lumen of the involved segment (arrowheads) and a dilated bowel loop proximally (*); this bowel loop corresponds to one of the bowel loops seen on the CT image (⋆ in **a**).

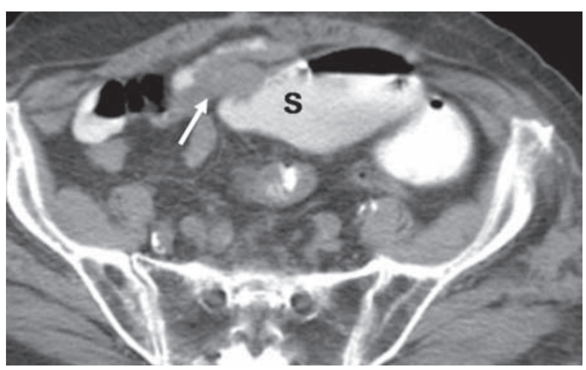
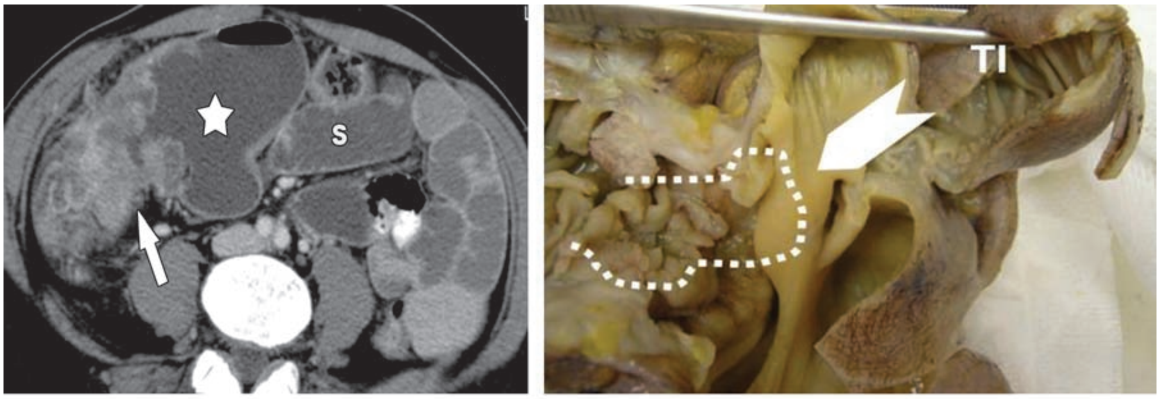
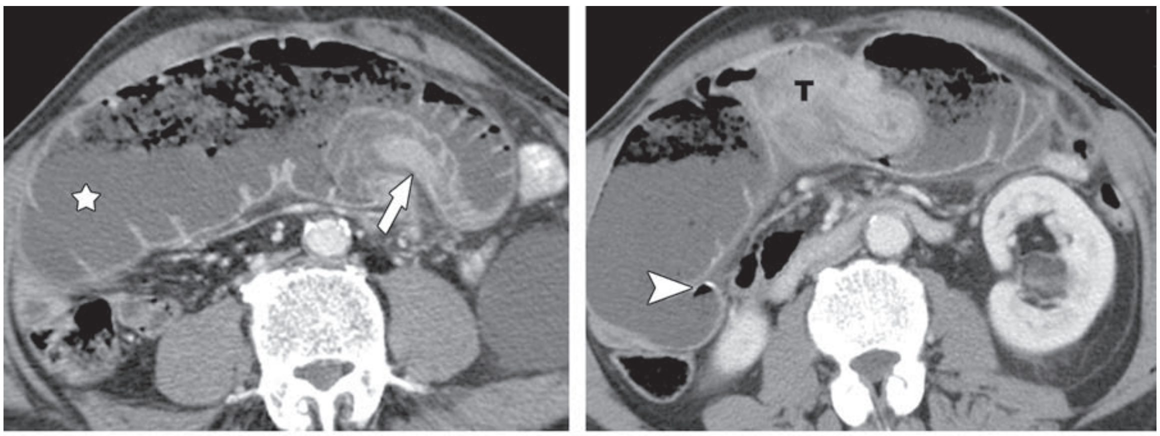


Figure 12. SBO secondary to adenocarcinoma. Axial CT scan shows asymmetric and irregular mural thickening of an ileal loop (arrow), which causes dilatation of the proximal small bowel *(S)*.



a. b.

Figure 13. SBO secondary to adenocarcinoma of the cecum with ileocecal valve involvement. **(a)** Axial CT scan shows dilatation of small bowel loops *(S)* and the cecum (⋆) proximal to a stenotic cancer of the cecum (arrow) that involves the terminal ileum. **(b)** Photograph of the gross specimen shows involvement of the ileocecal valve (arrow) by the neoplasm (dotted line). *TI* = terminal ileum.



a. b.

c.

Figure 14. SBO caused by intussusception and an adhesive band. **(a, b)** Axial CT scans show the intussusceptum (arrow in **a**) invaginating into the intussuscipiens (⋆ in **a**) secondary to a submucosal tumor (*T* in **b**). The intussuscipiens is dilated because of an adhesion (arrowhead in **b**). **(c)** Photograph of the gross specimen shows the submucosal tumor as a large polypoid mass (arrow).

Malignancies that involve the cecum and colon can also result in SBO when there is involvement of the ileocecal valve (Fig 13).

Intussusception.—Intussusception is a relatively rare condition in adults, accounting for less than 5% of SBOs (35). Only lead-point intussusceptions secondary to neoplasms, adhesions, or foreign bodies are associated with SBO. Transient intussusceptions are not associated with this condition.

At CT, the presence of a bowel-within-bowel configuration with or without mesenteric fat and mesenteric vessels is pathognomonic for intussusception. A leading mass as the cause of the intussusception can be identified, but this finding should be carefully interpreted and differentiated from the soft-tissue pseudotumor that represents the intussusception itself (Fig 14) (35–39).

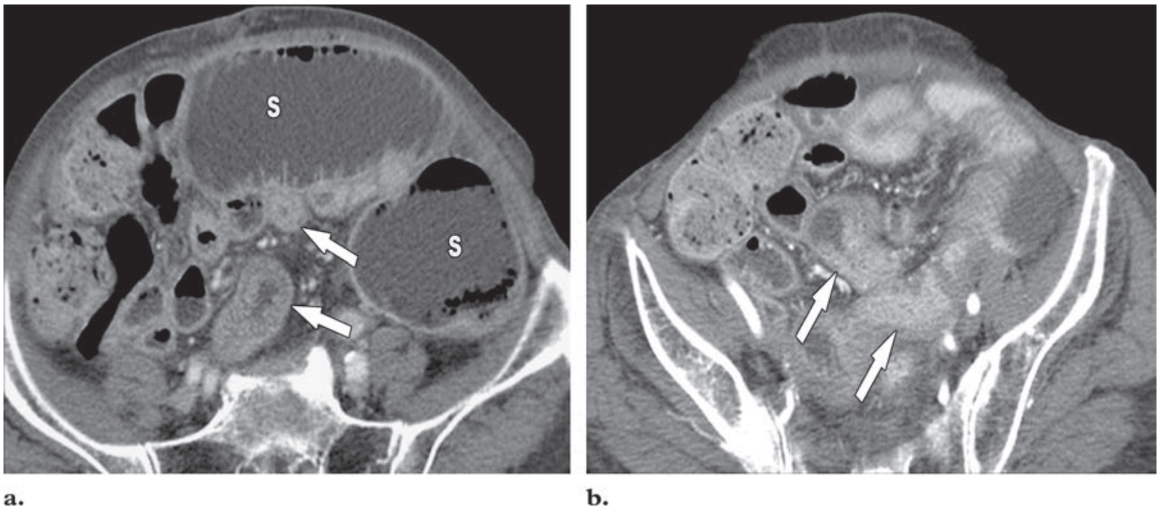


Figure 15. SBO secondary to radiation enteropathy. Axial CT scans show markedly distended small bowel loops (*S* in **a**) secondary to narrowing of the lumen from mural thickening and fibrous strictures (arrows).

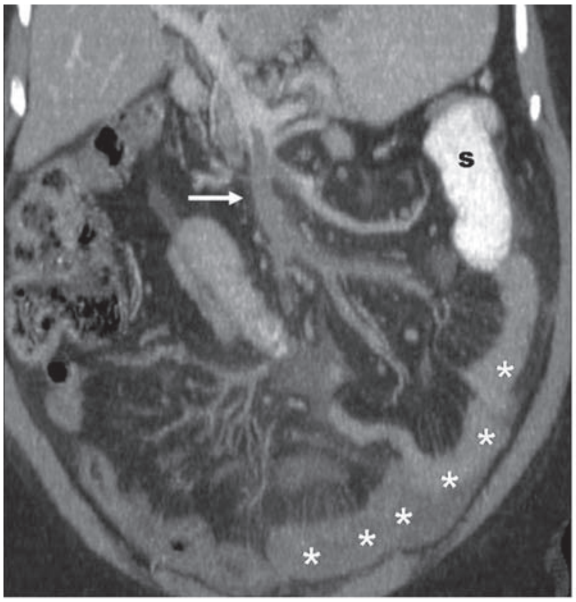
Figure 16. SBO secondary to a spontaneous bowel hematoma in an overcoagulated patient. Axial nonenhanced CT scan shows circumferential hyperattenuating mural thickening of the ileum with luminal narrowing (arrows), which causes proximal small bowel distention *(S)*.

Radiation Enteritis.—Radiation enteritis causes obstruction in the late phase 1 year after radiation therapy, usually to the pelvis. Therefore, the ileal loops are the most affected. Radiation enteritis causes SBO primarily by producing adhesive and fibrotic changes in the mesentery. There are also changes produced within the bowel, such as luminal narrowing and dysmotility induced by radiation serositis (40). CT shows narrowing of the lumen secondary to mural thickening, an angular bowel wall due to adhesions, and retraction of the mesentery (Fig 15). There may also be abnormal enhancement of the thickened bowel wall caught in the line of the radiation field (37–40).

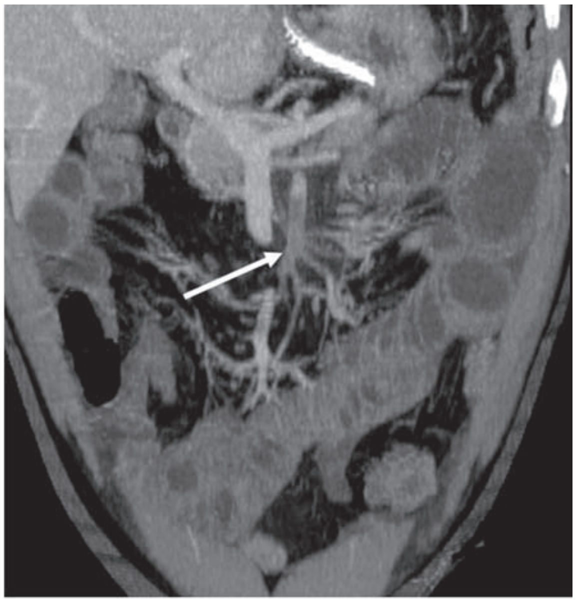
Hematomas.—Intramural small bowel hematoma may occur secondary to anticoagulant therapy, iatrogenic intervention, or trauma. The development of SBO is usually due to luminal narrowing.

If this condition is suspected, nonenhanced CT should be performed, as it will show a spontaneously hyperattenuating clot. CT also demonstrates circumferential, homogeneous, regular, and spontaneously hyperattenuating wall thickening with moderate mesenteric infiltration (Fig 16) (41).

Vascular Causes.—Occlusion or stenosis of the mesenteric arterial or venous vascular supply to the bowel usually produces bowel ischemia, which subsequently causes wall thickening, resulting in SBO. CT shows thrombosis or occlusion of the mesenteric vessels and also thickening of the bowel wall in the affected loops with noncircumferential or asymmetric wall enhancement. In advanced cases, a bowel infarct may be present, which manifests at CT as pneumatosis and air in the portal venous system (Figs 17–19) (42).

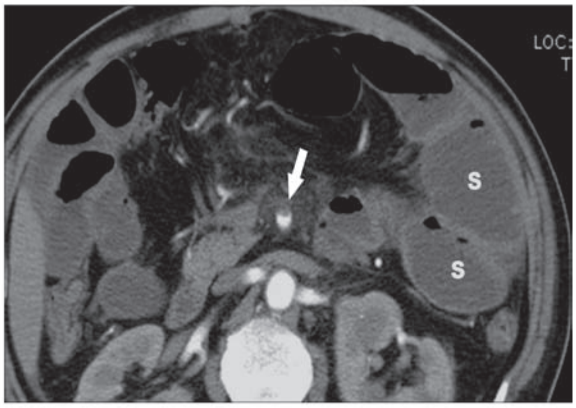


17a.



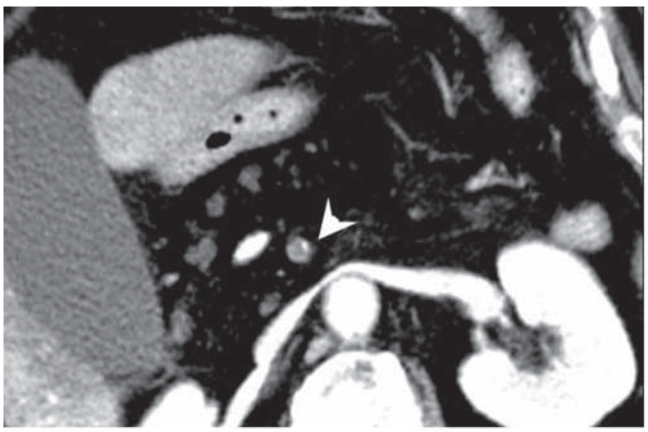
18a.

17b.

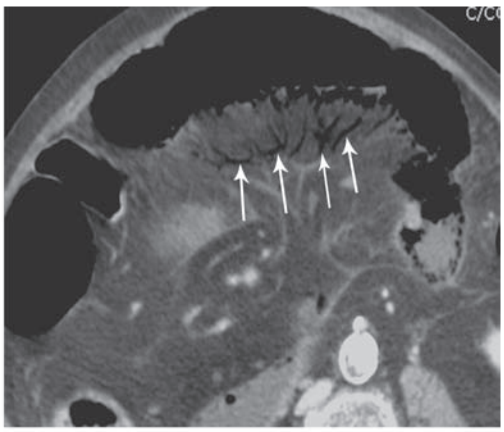


18b.

Figures 17, 18. **(17)** SBO secondary to thrombosis of the superior mesenteric vein. **(a)** Coronal CT scan shows thrombosis of the superior mesenteric vein (arrow) in association with circumferential wall thickening of ileal loops (*) due to submucosal edema. *S* = dilated small bowel loop. **(b)** Photograph of the gross specimen shows an infarcted small bowel loop that has hemorrhagic mucosa with thickened valvulae. **(18)** SBO due to intestinal ischemia secondary to arterial occlusion. Coronal maximum intensity projection **(a)** and axial **(b)** CT scans show an endoluminal defect of the superior mesenteric artery (arrow) due to thrombosis. *S* in **b** = proximal dilated small bowel loops.



a.



b.

Figure 19. Ischemic small bowel secondary to superior mesenteric artery thrombosis. Axial CT scans show thrombosis of the superior mesenteric artery (arrowhead in **a**) and pneumatosis intestinalis with air in the vasa recta of the mesentery (arrows in **b**).

Extrinsic Causes of SBO

Adhesions.—Adhesions are the main cause of SBO, ranging from 50%–80% of all cases. Almost all of them are postoperative, with a minority being secondary to peritonitis (36–39,43).

The diagnosis of SBO due to adhesions is primarily one of exclusion because adhesive bands are not seen at conventional CT; only an abrupt change in the caliber of the bowel is seen without any associated mass lesion, significant inflammation, or bowel wall thickening at the transition point. This finding combined with a history of abdominal surgery and associated kinking and tethering of the adjacent nonobstructed bowel usually suggests the diagnosis (Fig 20) (36–39,43).

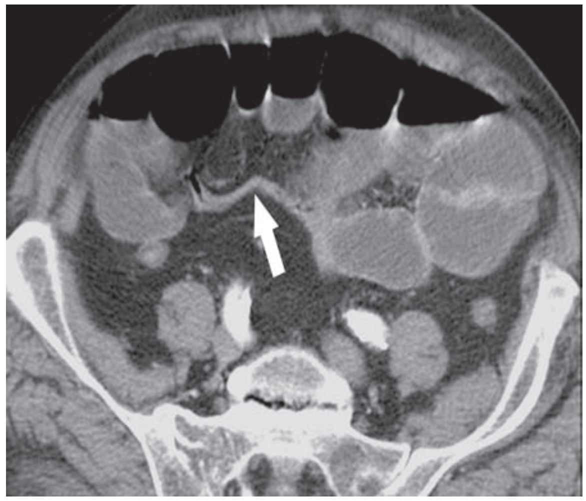


Figure 20. SBO secondary to adhesions after abdominal surgery. Axial CT scan shows an abrupt change in bowel caliber at the transition zone (arrow). Otherwise, the involved bowel wall and lumen and the adjacent organs have a normal appearance, which allows exclusion of other possible causes.

Hernias.—Hernias are considered by some authors to be the second most common cause of SBO, responsible for 10% of cases. In developing countries, they are still considered the foremost cause; however, this scenario is changing (29).

Hernias are classified according to the anatomic location of the orifice through which the bowel protrudes. They are broadly classified as external or internal. An external hernia results from a defect in the abdominal and pelvic wall at sites of congenital weakness or previous surgery (Fig 21). The less common internal hernia occurs when there is protrusion of the viscera through the peritoneum or mesentery and into a compartment within the abdominal cavity.

Diagnosis of an internal hernia is almost always radiologic, whereas external hernias in most cases are obvious at clinical examination. Reformatted images are sometimes helpful in assessing the size of the hernial defect, depicting adverse features, and demonstrating hernial anatomy (38,44).

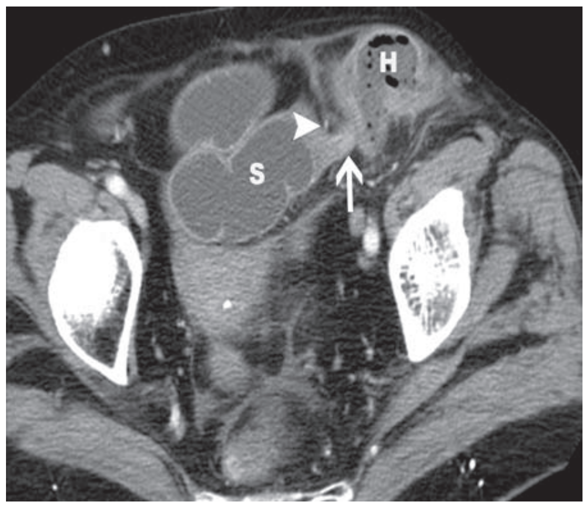
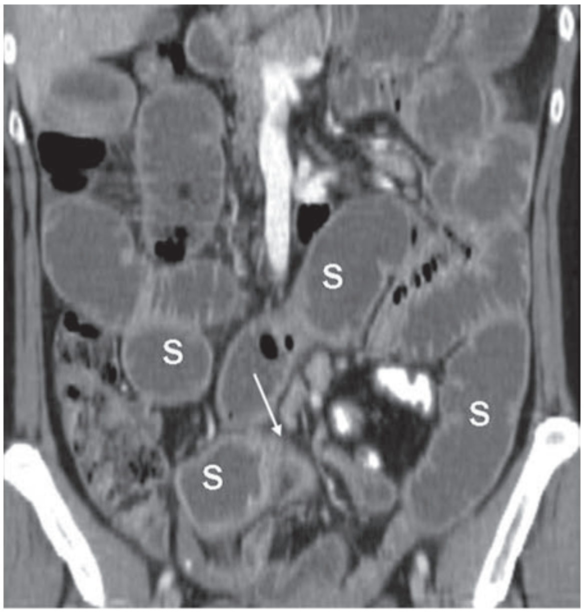


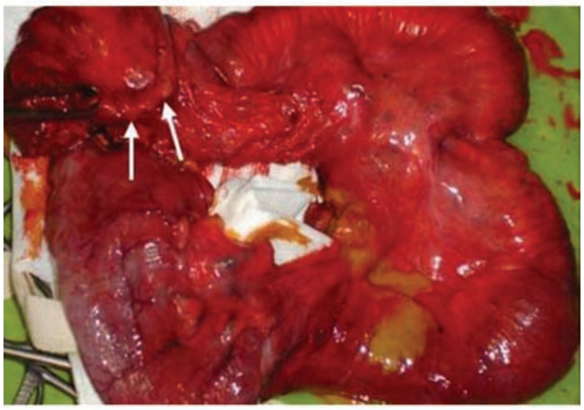
Figure 21. SBO secondary to an inguinal hernia. Axial CT scan shows small bowel dilatation *(S)* due to an incarcerated inguinal hernia *(H)*. The transition point (arrow) is lateral to the inferior epigastric artery (arrowhead).

Endometriosis.—Endometriosis affects about 5% of women of reproductive age. However, the exact prevalence of bowel endometriosis is unknown.

Endometrial implants are typically located on the antimesenteric edge of the bowel, and their appearance is variable. The typical appearance of intestinal endometriosis is a solid nodule with positive enhancement contiguous with or penetrating the thickened bowel wall. When the endometriotic lesion infiltrates the submucosa, it typically appears as a hypoattenuating layer between the muscularis and the mucosa (Fig 22) (36–39,45).



a.

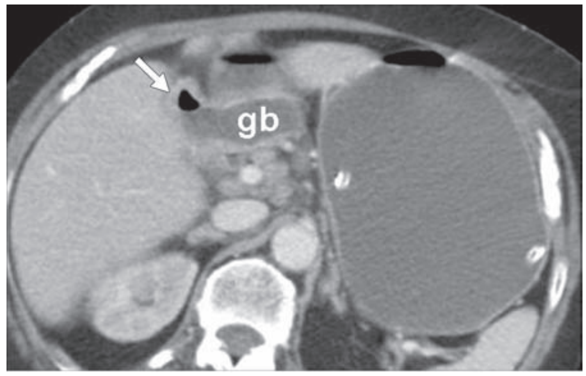


b.

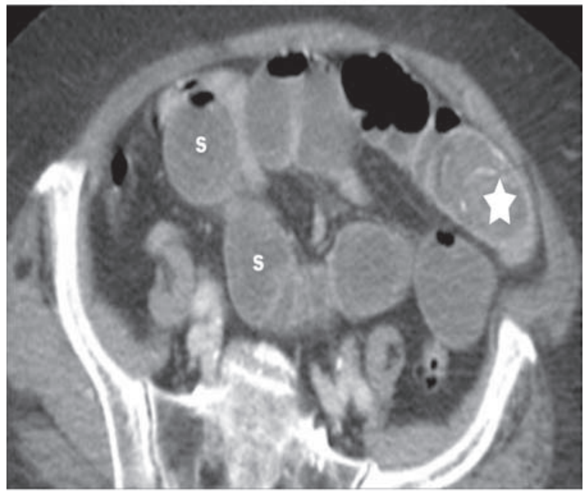
Figure 22. SBO secondary to intestinal endometriosis. **(a)** Coronal CT scan shows distended fluid-filled small bowel loops *(S)*. The transition point appears as circumferential mural thickening with a hypoattenuating outer layer (arrow). **(b)** Photograph of the gross specimen shows the stricture due to fibrosis secondary to endometriotic implants (arrows).

Intraluminal Causes of SBO

Gallstone Ileus.—Gallstone ileus is a rare complication of recurrent cholecystitis, caused by migration of a large gallstone through a biliary-intestinal fistula with subsequent impaction in the small bowel. CT findings are pathognomonic, corresponding to the radiographic triad of pneumobilia, ectopic gallstone, and SBO (Fig 23) (46).



a.



b.

Figure 23. Gallstone ileus. **(a)** Axial CT scan shows pneumobilia (arrow) and the gallbladder *(gb)* adjacent to the gastric antrum. **(b)** CT scan shows an impacted gallstone (⋆) in the distal jejunum with proximal bowel dilatation *(S)*.

Bezoar.—SBO secondary to a bezoar is rare, but the number of cases has increased owing to the high frequency of gastric outlet surgery. Such surgery prevents adequate digestion of vegetable fibers, which become impacted, causing obstruction. At CT, a bezoar appears as an intraluminal mass with an ovoid shape and a mottled gas pattern (47).

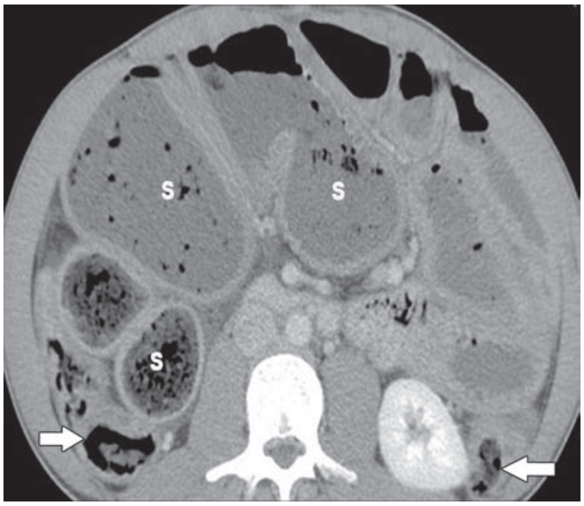


Figure 24. SBO in a patient with distal intestinal obstruction syndrome. Axial CT scan shows markedly dilated small bowel loops with feculent contents *(S)*. Arrows = colon.

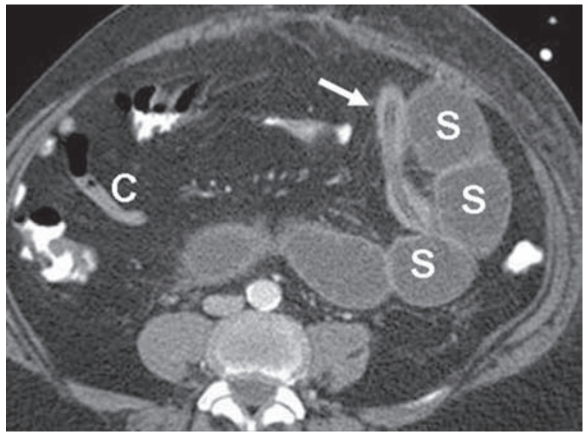
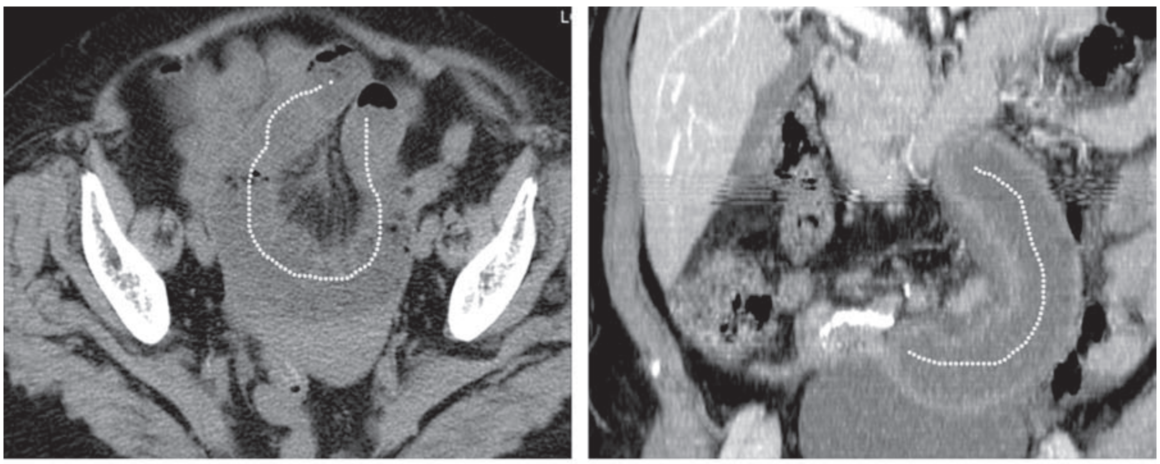


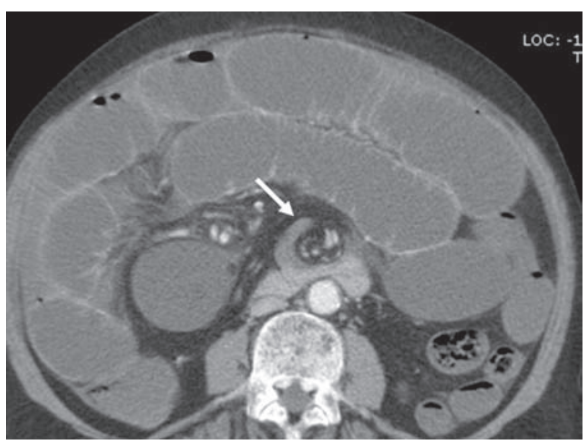
Figure 25. SBO secondary to a foreign body. Axial CT scan shows distended small bowel loops *(S)* secondary to excessive tunneling at the insertion site of a jejunostomy tube (arrow). Collapsed bowel loops *(C)* are evident distal to the foreign body.

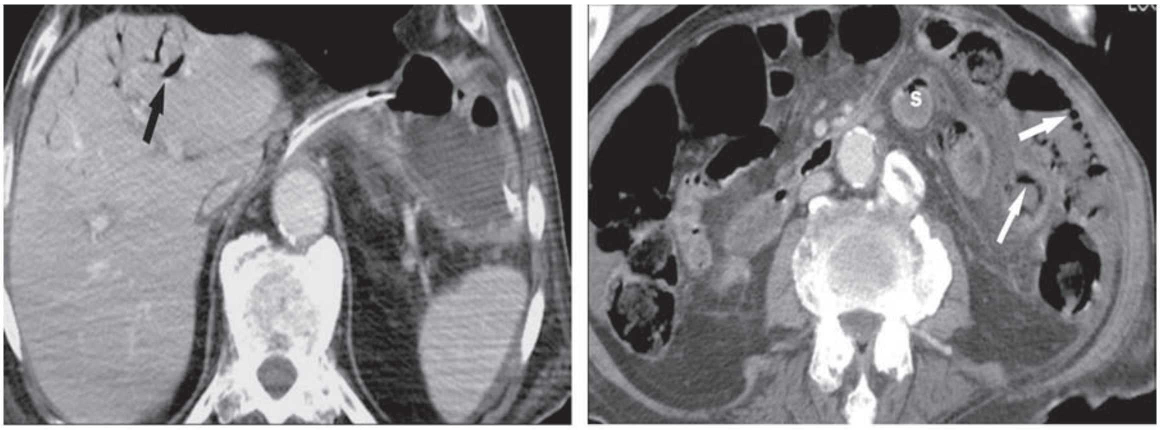


a. b.

Figure 26. Closed-loop SBOs secondary to postoperative adhesions. **(a)** Axial CT scan shows a radial distribution of small bowel loops with a U-shaped configuration (dotted line) and stretched mesenteric vessels converging toward the site of torsion. **(b)** Oblique coronal CT scan shows incarcerated small bowel with a C-shaped configuration (dotted line).

Figure 27. Closed-loop SBO in a patient with intestinal torsion. Axial CT scan shows a whirl sign (arrow) produced by mesenteric vessels and collapsed bowel loops. The transition point is at the site of the torsion.





a. b.

Figure 28. Strangulated SBO due to adhesions. **(a)** Axial CT scan shows gas in the intrahepatic portal veins (arrow). **(b)** Axial CT scan shows dilated small bowel loops *(S)* proximal to infarcted bowel segments, which demonstrate pneumatosis (arrows).

Distal Intestinal Obstruction Syndrome.—Distal intestinal obstruction syndrome is a cause of SBO that usually occurs in older children and adults with cystic fibrosis. The obstruction is secondary to impaction of thick stool, which is probably related to inadequately controlled intestinal absorption secondary to pancreatic insufficiency. Because this condition responds to medical treatment, it is important to recognize it. At CT, the findings consist of SBO with feculent filling defects in the small bowel (Fig 24) (30,48).

Other Intraluminal Causes.—Intestinal obstruction caused by a foreign body usually occurs in children or in emotionally disturbed or mentally disabled patients. With increasing use of endoscopic capsules to evaluate inaccessible portions of the bowel, capsule retention in patients with small bowel luminal narrowing is a problem. At CT, the findings consist of SBO with evidence of a foreign body at the transition point (Fig 25) (49).

Is the SBO Simple or Complicated?

On the basis of the pathophysiology of the obstructive process in the small bowel, SBO can be divided into two types: simple obstructions and closed-loop obstructions. Simple obstruction of the bowel is considered when the bowel is occluded at one or several points along its course. The proximal part of the bowel is variably distended, depending on the severity and duration of the process. Closed-loop obstructions are diagnosed when a bowel loop of variable length is occluded at two adjacent points along its course. The occlusion can be partial or complete.

At CT, the findings of a closed-loop obstruction depend on the length, degree of distention, and orientation of the closed loop in the abdomen. Axial scans reveal a characteristic fixed radial distribution of several dilated, usually fluid-filled bowel loops with stretched and prominent mesenteric vessels converging toward the point of torsion. The configuration can be U-shaped or C-shaped, depending on the orientation of the closed loop (Fig 26). Because of the presence of constrictions of two adjacent bowel segments and the intervening mesentery, a narrow pedicle can be formed, leading to torsion of the loops and producing a small bowel volvulus. At CT, a "beak sign" is seen at the site of the torsion as a fusiform tapering, and occasionally a "whirl sign" can be seen, reflecting rotation of the bowel loops around the fixed point of obstruction (Fig 27) (50).

Strangulation is defined as a closed-loop obstruction associated with intestinal ischemia. This condition is seen in approximately 10% of patients with SBO, mainly when there is a delay in establishing the correct diagnosis and subsequent surgical treatment. It is associated with a high mortality rate. CT has a detection rate in this condition of 63%–100%. Findings indicative of strangulation include thickening and increased attenuation of the affected bowel wall, a halo or "target sign," pneumatosis intestinalis, and gas in the portal vein (Fig 28), but these findings are not specific for strangulation. A specific finding is lack of wall enhancement; asymmetric enhancement or even delayed enhancement may also be found. Localized fluid and hemorrhage in the mesentery can also be seen (13,31,50).

Conclusions

Management issues are nowadays at the core of imaging in SBO. Historically, acute SBO was surgically treated relatively early owing to the difficulty of confidently excluding—on clinical and imaging grounds—complicated SBO, which is associated with high mortality rates.

Today, with increased evidence that some obstructions resolve with conservative management and that the latest modalities of abdominal imaging allow confident diagnosis or exclusion of small bowel ischemia, early surgery is now performed more and more selectively. In this context, the role of the radiologist as a consultant to the surgeon is a critical one. Therefore, a full understanding of which imaging modalities to use, when to use them, and what imaging findings to look for to allow an individualized treatment approach to each patient is of paramount importance.

References

1. Foster NM, McGory ML, Zingmond DS, Ko CY. Small bowel obstruction: a population-based appraisal. J Am Coll Surg 2006;203(2):170–176.
2. Welch JP. General considerations and mortality in bowel obstruction. In: Welch JP, ed. Bowel obstruction: differential diagnosis and clinical management. Philadelphia, Pa: Saunders, 1990; 59–95.
3. Maglinte DD, Howard TJ, Lillemoe KD, Sandrasegaran K, Rex DK. Small-bowel obstruction: state-of-the-art imaging and its role in clinical management. Clin Gastroenterol Hepatol 2008;6(2):130–139.
4. Silen W, Hein MF, Goldman L. Strangulation obstruction of the small intestine. Arch Surg 1962;85:121–129.
5. Peetz DJ Jr, Gamelli RL, Pilcher DB. Intestinal intubation in acute, mechanical small-bowel obstruction. Arch Surg 1982;117(3):334–336.
6. Maglinte DD, Balthazar EJ, Kelvin FM, Megibow AJ. The role of radiology in the diagnosis of small bowel obstruction. AJR Am J Roentgenol 1997;168(5):1171–1180.
7. Lappas JC, Reyes BL, Maglinte DD. Abdominal radiography findings in small-bowel obstruction: relevance to triage for additional diagnostic imaging. AJR Am J Roentgenol 2001;176(1):167–174.
8. Nicolaou S, Kai B, Ho S, Su J, Ahamed K. Imaging of acute small-bowel obstruction. AJR Am J Roentgenol 2005;185(4):1036–1044.
9. Thompson WM, Kilani RK, Smith BB, et al. Accuracy of abdominal radiography in acute small-bowel obstruction: does reviewer experience matter? AJR Am J Roentgenol 2007;188(3):W233–W238.
10. Lim JH. Intestinal obstruction. In: Maconi G, Porro GB, eds. Ultrasound of the gastrointestinal tract. Berlin, Germany: Springer-Verlag, 2007; 27–34.
11. Shrake PD, Rex DK, Lappas JC, Maglinte DD. Radiographic evaluation of suspected small bowel obstruction. Am J Gastroenterol 1991;86(2):175–178.
12. Maglinte DD, Sandrasegaran K, Lappas JC, Chiorean M. CT enteroclysis. Radiology 2007;245(3):661–671.
13. Herlinger H, Maglinte DDT. Small bowel obstruction. In: Herlinger H, Maglinte DDT, eds. Clinical radiology of the small intestine. Philadelphia, Pa: Saunders, 1989; 479–507.
14. Ros PR, Huprich JE. ACR Appropriateness Criteria on suspected small-bowel obstruction. J Am Coll Radiol 2006;3(11):838–841.
15. Frager D, Medwid SW, Baer JW, Mollinelli B, Friedman M. CT of small-bowel obstruction: value in establishing the diagnosis and determining the degree and cause. AJR Am J Roentgenol 1994;162(1):37–41.
16. Fukuya T, Hawes DR, Lu CC, Chang PJ, Barloon TJ. CT diagnosis of small-bowel obstruction: efficacy in 60 patients. AJR Am J Roentgenol 1992;158(4):765–769.
17. Maglinte DD, Heitkamp DE, Howard TJ, Kelvin FM, Lappas JC. Current concepts in imaging of small bowel obstruction. Radiol Clin North Am 2003;41(2):263–283.
18. Qalbani A, Paushter D, Dachman AH. Multidetector row CT of small bowel obstruction. Radiol Clin North Am 2007;45(3):499–512.
19. Maglinte DD, Herlinger H, Turner WW, Kelvin FM. Radiologic management of small bowel obstruction: a practical approach. Emerg Radiol 1994;1(13):138–149.
20. Baker SR. ACR Appropriateness Criteria on small-bowel obstruction: a critique of the term and its terms. J Am Coll Radiol 2007;4(7):443–445.

21. Wilson SR. The gastrointestinal tract. In: Rumack CM, Wilson SR, Charboneau JW, eds. Diagnostic ultrasound. 3rd ed. St Louis, Mo: Mosby, 2005; 269–320.
22. Meiser G, Meissner K. Sonographic differential diagnosis of intestinal obstruction: results of a prospective study of 48 patients [in German]. Ultraschall Med 1985;6(1):39–45.
23. Khurana B, Ledbetter S, McTavish J, Wiesner W, Ros PR. Bowel obstruction revealed by multidetector CT. AJR Am J Roentgenol 2002;178(5): 1139–1144.
24. Maglinte DD, Gage SN, Harmon BH, et al. Obstruction of the small intestine: accuracy and role of CT in diagnosis. Radiology 1993;188(1):61–64.
25. Singh J, Kumar R, Kalyanpur A. “Small bowel feces sign”: a CT sign in small bowel obstruction. Indian J Radiol Imaging 2006;16(1):71–74.
26. Canon CL. Gastrointestinal tract. In: Lee JKT, Sagel SS, Stanley RJ, Heiken JP, eds. Computed body tomography with MRI correlation. 4th ed. Philadelphia, Pa: Lippincott Williams & Wilkins, 2006; 771–828.
27. Lazarus DE, Slywotsky C, Bennett GL, Megibow AJ, Macari M. Frequency and relevance of the “small bowel feces” sign on CT in patients with small-bowel obstruction. AJR Am J Roentgenol 2004;183(5):1361–1366.
28. Jacobs SL, Rozenblit A, Ricci Z, et al. Small bowel faeces sign in patients without small bowel obstruction. Clin Radiol 2007;62(4):353–357.
29. Miller G, Boman J, Shrier I, Gordon PH. Etiology of small bowel obstruction. Am J Surg 2000;180(1): 33–36.
30. Mak SY, Roach SC, Sukumar SA. Small bowel obstruction: computed tomography features and pitfalls. Curr Probl Diagn Radiol 2006;35(2):65–74.
31. Furukawa A, Yamasaki M, Furuichi K, et al. Helical CT in the diagnosis of small bowel obstruction. RadioGraphics 2001;21(2):341–355.
32. Zissin R, Hertz M, Paran H, Bernheim J, Shapiro-Feinberg M, Gayer G. Small bowel obstruction secondary to Crohn disease: CT findings. Abdom Imaging 2004;29(3):320–325.
33. Chiorean MV, Sandrasegaran K, Saxena R, Maglinte DD, Nakeeb A, Johnson CS. Correlation of CT enteroclysis with surgical pathology in Crohn’s disease. Am J Gastroenterol 2007;102(11): 2541–2550.
34. Idelevich E, Kashtan H, Mavor E, Brenner B. Small bowel obstruction caused by secondary tumors. Surg Oncol 2006;15(1):29–32.
35. Agha FP. Intussusception in adults. AJR Am J Roentgenol 1986;146(3):527–531.
36. Delabrousse E, Destrumelle N, Brunelle S, Clair C, Mantion G, Kastler B. CT of small bowel obstruction in adults. Abdom Imaging 2003;28(2): 257–266.
37. Furukawa A, Yamasaki M, Takahashi M, et al. CT diagnosis of small bowel obstruction: scanning technique, interpretation and role in the diagnosis. Semin Ultrasound CT MR 2003;24(5):336–352.
38. Sinha R, Verma R. Multidetector row computed tomography in bowel obstruction. I. Small bowel obstruction. Clin Radiol 2005;60(10):1058–1067.
39. Boudiaf M, Soyer P, Terem C, Pelage JP, Maissiat E, Rymer R. CT evaluation of small bowel obstruction. RadioGraphics 2001;21(3):613–624.
40. Deitel M, Vasic V. Major intestinal complications of radiotherapy. Am J Gastroenterol 1979;72(1):65–70.
41. Pretorius ES, Fishman EK, Zinreich SJ. CT of hemorrhagic complications of anticoagulant therapy. J Comput Assist Tomogr 1997;21(1):44–51.
42. Wiesner W, Khurana B, Ji H, Ros PR. CT of acute bowel ischemia. Radiology 2003;226(3):635–650.
43. Attard JA, MacLean AR. Adhesive small bowel obstruction: epidemiology, biology and prevention. Can J Surg 2007;50(4):291–300.
44. Aguirre DA, Casola G, Sirlin C. Abdominal wall hernias: MDCT findings. AJR Am J Roentgenol 2004;183(3):681–690.
45. Biscaldi E, Ferrero S, Remorgida V, Rollandi GA. Bowel endometriosis: CT-enteroclysis. Abdom Imaging 2007;32(4):441–450.
46. Lorén I, Lasson A, Nilsson A, Nilsson P, Nirhov N. Gallstone ileus demonstrated by CT. J Comput Assist Tomogr 1994;18(2):262–265.
47. Delabrousse E, Brunelle S, Saguet O, Destrumelle N, Landecy G, Kastler B. Small bowel obstruction secondary to phytobezoar: CT findings. Clin Imaging 2001;25(1):44–46.
48. Chaun H. Colonic disorders in adult cystic fibrosis. Can J Gastroenterol 2001;15(9):586–590.
49. Agrawal GA, Johnson PT, Fishman EK. Intermittent small bowel obstruction with retained endoscopic capsule: MDCT and plain radiographic appearance. Emerg Radiol 2007;13(6):319–321.
50. Balthazar EJ. George W. Holmes Lecture: CT of small-bowel obstruction. AJR Am J Roentgenol 1994;162(2):255–261.

Small Bowel Obstruction: What to Look For

Ana Catarina Silva, MD, et al

RadioGraphics 2009; 29:423–439 • **Published online** 10.1148/rg.292085514 • **Content Code:** GI

Page 424
Therefore, radiology assumes considerable relevance in assisting the therapeutic decision of the surgeon in cases of SBO by addressing the following questions (6): Is the small bowel obstructed? How severe is the obstruction, where is it located, and what is its cause? Is strangulation present?

Page 424
Therefore, owing to the capability of CT for early demonstration of strangulation, CT is now considered the best modality for determining which patients would benefit from conservative management and close follow-up and which patients would benefit from immediate surgical intervention (14–19).

Page 427
CT criteria for SBO are the presence of dilated small bowel loops (diameter >2.5 cm from outer wall to outer wall) proximally to normal-caliber or collapsed loops distally (Fig 4) (16).

Page 429
This approach should begin in a retrograde fashion by starting at the rectum and proceeding proximally toward the cecum, ileum, and jejunum. If the transition point is located proximally (jejunum or duodenum), the position should be confirmed by using an antegrade approach, starting at the stomach (23).

Page 429
A rule of thumb never to forget is that the answer is almost always in the transition point. Most intrinsic bowel lesions are seen at the transition point and manifest as localized mural thickening. Most extrinsic causes are seen adjacent to the transition point and usually have associated extraintestinal manifestations. Most intraluminal causes manifest as endoluminal “foreign objects” with imaging characteristics different from those of the remaining enteric content.