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A BIWEEKLY REVIEW OF CLINICAL RADIOLOGIC PRACTICE

Imaging in Acute Intestinal Obstruction

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After participating in this educational activity, the diagnostic radiologist should be better able to evaluate the presence or absence of bowel obstruction, location of transition point, grade, and occasionally the cause of acute small or large bowel obstruction on imaging.

Category: General Radiology
Subcategory: Gastrointestinal
Modality: Radiography

Key Words: Acute Abdomen, Small Bowel Obstruction, Large Bowel Obstruction, Imaging of Bowel Obstruction

Acute intestinal obstruction is a common cause of morbidity in patients who present with an acute abdomen and accounts for 20% of admissions for "surgical abdomen." Imaging is important in confirming the diagnosis and identifying the underlying cause. Safe and effective management depend on prompt and accurate diagnosis. Bowel obstruction is subdivided into small and large bowel obstruction, based on the site of luminal narrowing. The causative factors for the two subgroups are usually quite different.

Small bowel obstruction is caused by postoperative adhesions in 70% of all cases (Figure 1).[1] Other common causes include incarcerated hernias (Figures 2 and 3), neoplasms (Figure 4), and Crohn disease (Figure 5).[1,2] The important question in small bowel obstruction management lies in determining whether early laparotomy is required or whether a trial of nonoperative management can be instituted.[2] Imaging plays a key role in this decision, because it can indicate the location, degree, cause of an obstruction, and assess for the presence of ischemia.

Large bowel obstruction is four to five times less frequent than small bowel obstruction. Colonic malignancy remains the most common cause of large bowel obstruction (>60%).[3] Additional causes of large bowel obstruction include entities such as diverticulitis, colonic volvulus, and adhesions. Colonic obstruction is seen most often in elderly individuals, as the aforementioned causes of obstruction are more common in advanced age groups.

Clinical Presentation

The classic clinical features of acute bowel obstruction are colicky abdominal pain, vomiting, abdominal distension, and severe constipation. The order and timescale in which these clinical features appear vary depending on the level of bowel obstruction. Severe constipation and abdominal pain are more prominent early in large bowel obstruction, whereas vomiting is the predominant early feature in small bowel obstruction. Grades of bowel obstruction range from low to high grade and complete. Low-grade bowel obstruction permits passage of some fluid or gas through the narrowed bowel segment with less than 50% difference in caliber between the obstructed and nonobstructed bowel loops. Bowel obstruction is high grade if it permits minimal passage of fluid or gas beyond the site of obstruction and there is more than 50% difference in caliber between the proximal obstructed loops and the distal bowel loops. Intestinal obstruction is complete when there is no transit of intestinal contents beyond the transition point.

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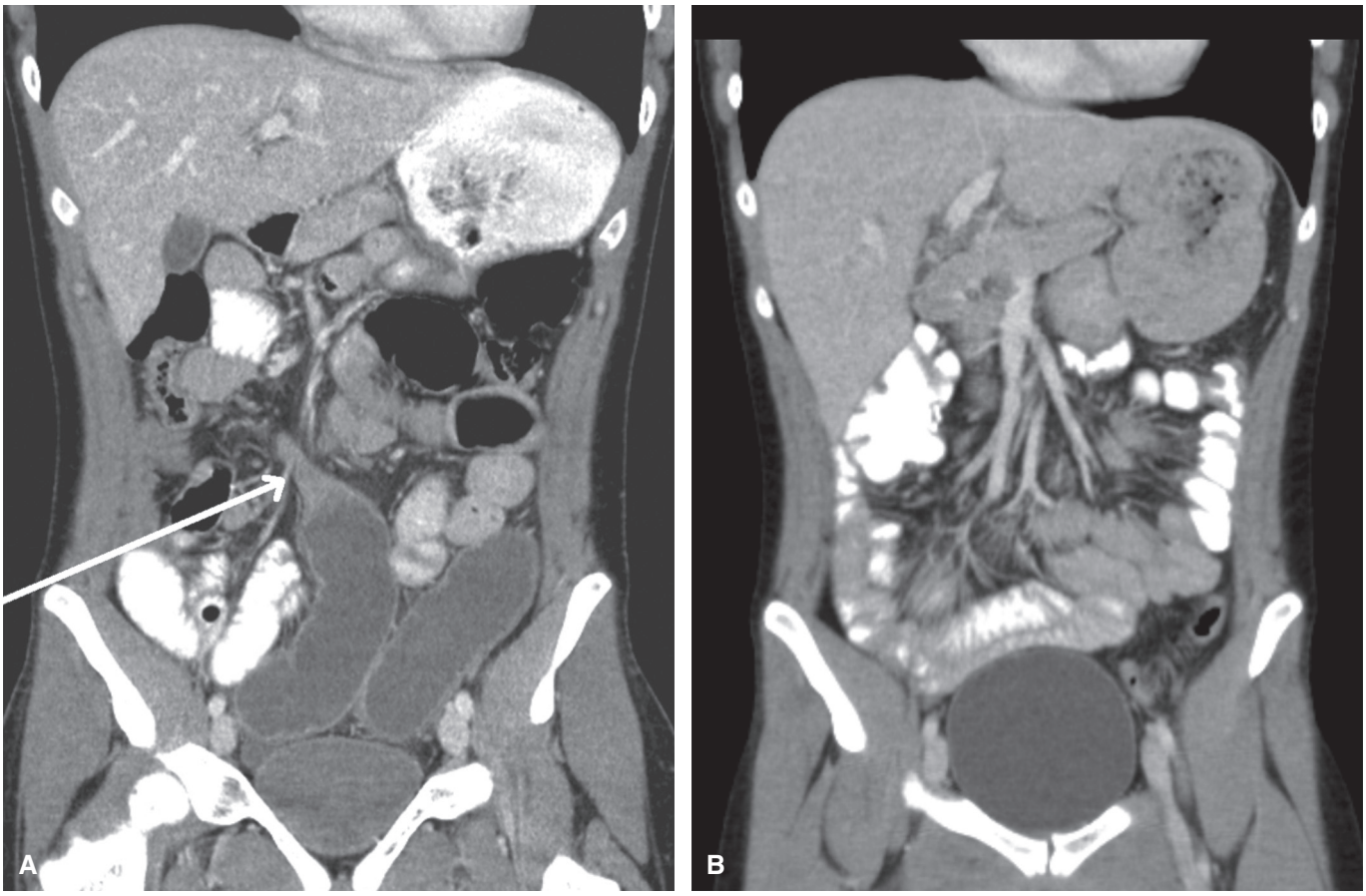

Figure 1. Adhesions causing small bowel obstruction in a 20-year-old man with Crohn disease. *A*: Coronal, CT scan after ileocecectomy with ileocolic anastomosis shows postoperative high-grade small bowel obstruction secondary to adhesions causing severe narrowing (*arrow*) of the ileum. *B*: Coronal, CT scan of the same patient after surgical resection of adhesions demonstrates resolution of small bowel obstruction.

In high-grade bowel obstruction, there is greater than 50% difference in caliber between the proximal obstructed bowel loops and the distal bowel loops.

Imaging Techniques in Acute Bowel Obstruction

Plain Radiography

Plain radiography is an integral component of imaging acute bowel obstruction. It is the most appropriate initial imaging modality in patients with suspected acute intestinal obstruction, and it should not be bypassed for other sophisticated cross-sectional imaging techniques. Air within the bowel provides an excellent contrast to the surrounding soft tissues within the abdomen and pelvis. Plain radiography not only allows for the evaluation of presence or absence of intestinal obstruction, but also detects the level and grade of obstruction. Sensitivity of plain radiographs ranges from 50% to 66%. Plain radiography is indeterminate in 20% to 30% of cases, and in the remaining 10% to 20% of cases, it can appear normal, misleading, and nonspecific.[4,5] The sensitivity of plain radiographs is higher for high-grade obstruction. Patients with low-grade intestinal obstruction are more likely to have normal or nonspecific abdominal radiographs.

The continuing education activity in *Contemporary Diagnostic Radiology* is intended for radiologists.

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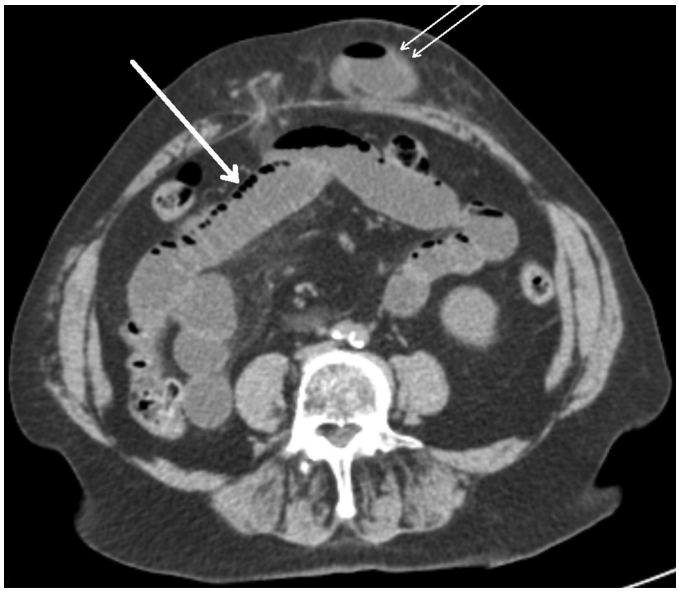

Figure 2. String-of-beads sign in a 77-year-old woman with a surgical history of right nephrectomy for renal cell carcinoma. The patient presented with abdominal pain. This axial, CT scan demonstrates dilated small bowel loops secondary to ventral wall hernia containing incarcerated small bowel loop (*double arrows*). The dilated intraperitoneal small bowel loops are fluid filled with small-quantity of nondependent intraluminal air giving a string-of-beads appearance (*arrow*).

Plain abdominal radiography is the most appropriate initial imaging modality in patients with suspected acute intestinal obstruction; its sensitivity ranges from 50% to 66%.

The standard acute abdomen series includes three radiographs: AP abdomen supine view, PA abdomen erect view, and PA chest upright view. In some practices, only the supine abdominal radiograph is obtained to reduce patient radiation dose. Erect views help identify the presence of extraintestinal or free air. The chest radiograph also rules out pulmonary causes of abdominal pain. In patients who are too ill to stand upright, modified abdominal radiographs comprising cross-table lateral decubitus or cross-table supine views may be obtained.

Normal bowel gas pattern in erect abdomen radiographs shows presence of the gastric bubble, two to three air-fluid levels in nondistended small bowel loops, and presence of air in rectum. The upper limit of normal caliber of small bowel loops is 3.0 cm and that of large bowel loops is 6.0 cm except in cecum, where its caliber can reach up to 9.0 cm.[6] Radiographic signs of intestinal obstruction depend on the level of obstruction, grade of obstruction, and the presence of complications. The more proximal the obstruction, the earlier it will present. However, in the large bowel, the obstructed left colon manifests earlier due to the smaller caliber of the descending and sigmoid colon in comparison to the cecum. Signs of intestinal obstruction include dilated

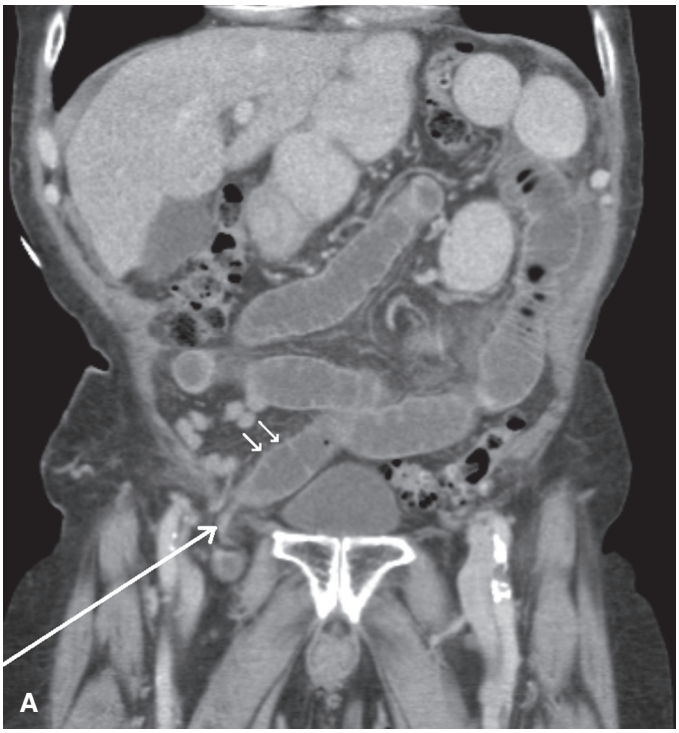

Figure 3. Obstructed right inguinal hernia. Coronal (*A*) and sagittal (*B*) CT scans of an 87-year-old man with sudden-onset nausea and vomiting. The patient had an obstructed right inguinal hernia containing a short small bowel segment with narrowed lumen at the hernia orifice (*long arrows* in *A* and *B*). The proximal bowel loop was distended (*double arrows*). Inguinal hernia is the second most common cause of small bowel obstruction after postoperative adhesions.

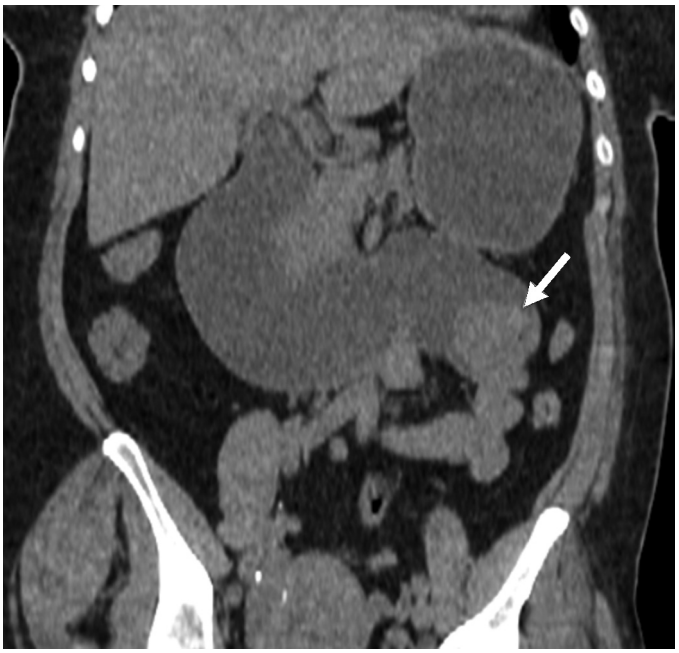

Figure 4. Small bowel tumor causing intestinal obstruction in a 42-year-old woman with proximal small bowel obstruction secondary to adenocarcinoma. This oblique, coronal, reformatted CT scan shows the intraluminal obstructing mass (*arrow*) at the duodenojejunal junction.

bowel loops, multiple air-fluid levels, bowel wall thickening, pneumatosis intestinalis, air in portal venous system, and free intraperitoneal air. High-grade and complete bowel obstruction have unequivocal radiographic signs; denoted by more than 50% difference in caliber between the proximal dilated and distal collapsed bowel loops, larger number of dilated proximal bowel loops, 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. In evolving intestinal obstruction, serial radiography is very useful. Complications of bowel obstruction include intestinal ischemia, gangrene, and perforation.

The upper limit of normal caliber of small bowel loops is 3 cm and of large bowel loops is 6 cm (except the cecum may reach up to 9 cm).

The strength of plain radiographs is the excellent depiction of air-soft tissue interface; therefore, they are of limited value in fluid-filled dilated bowel loops. If there is residual intestinal air, these patients can have "string-of-beads" sign (ie, presence of small amounts of air in valvulae conniventes of fluid-filled dilated small bowel loops). Another instance in which radiographs can be misleading is in patients with large bowel obstruction who have an incompetent ileocecal valve; air escapes into the small bowel, producing the false impression of distal small bowel obstruction.[6] CT is superior to radiographs in differentiating large bowel obstruction from pseudo-obstruction or ileus, as it will demonstrate cause of obstruction in cases of large bowel obstruction and absence of a transition point in ileus.[6]

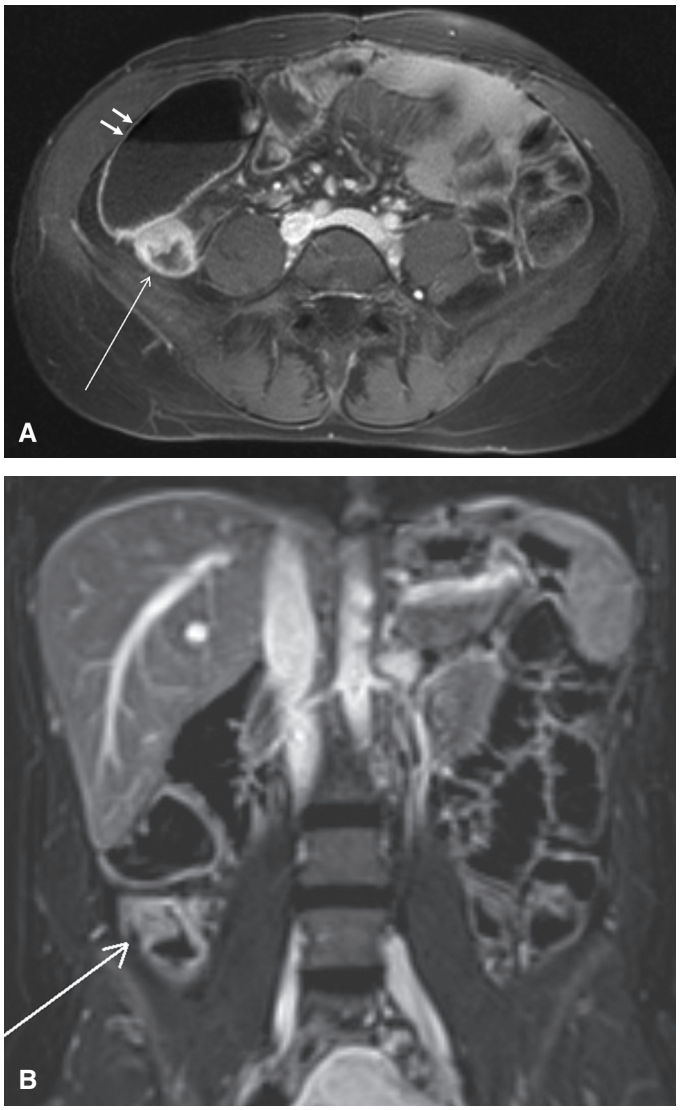

Figure 5. Crohn disease causing small bowel obstruction. Postcontrast, axial (*A*) and coronal (*B*) MR images in a 39-year-old woman with active Crohn disease demonstrate terminal ileal wall thickening and stricture (*long arrows* in *A* and *B*), causing proximal small bowel obstruction (*short arrows* in *A*).

In patients with large bowel obstruction and an incompetent ileocecal valve, air escapes into the small bowel producing the false radiographic impression of distal small bowel obstruction.

In most instances, it is not possible to identify the exact cause of intestinal obstruction on plain radiographs. Exceptions include incarcerated inguinal hernia, gallstone ileus, colonic volvulus, and sometimes perforated appendicitis where an appendicolith and small bowel obstruction (from peritonitis) are both present.

The merits of plain radiography are its widespread availability; low cost; and ability to pick up high-grade obstruction, presence of free air, and identify those subsets of patients with pulmonary causes of abdominal pain. The drawbacks are its inability to identify cause of bowel obstruction and the exact site of obstruction, and it can grossly underestimate the severity of obstruction.

Contrast Radiography

Administering barium in patients with intestinal obstruction degrades the quality of a subsequent CT study (if required), limiting its role.

In patients with suspected intestinal obstruction and normal radiographs or in patients with known intestinal adhesions, small bowel follow-through with water-soluble contrast medium is a superior problem-solving examination. It can be employed in patients with adhesions to identify which fixed, nondilated intestinal loops are tethered by intraperitoneal adhesions. It also assesses the amount of contrast medium that passes through the small bowel obstruction, thereby identifying the subset of patients who will benefit from immediate surgery. In the clinical setting of suspected low-grade intestinal obstruction, contrast radiography is the definitive examination in differentiating such cases from patients without any intestinal obstruction. The therapeutic role of Gastrografin in patients with partial small bowel obstruction is uncertain and not an established management regimen.[7]

Contrast enema is useful in differentiating large bowel obstruction from pseudo-obstruction. Absence of a transition point excludes large bowel obstruction. When sigmoid volvulus cannot be excluded by radiography and gangrene or perforation is not suspected, single-contrast barium enema can show the characteristic "bird's beak" or "bird-of-prey" sign at the rectosigmoid junction (Figure 6). Water-soluble contrast enema is an acceptable alternative. Contrast enema can show a colonic mass; however, CT is often the preferred modality in such cases, as it provides additional staging information regarding adenopathy and distant metastasis.[6]

The role of fluoroscopy in diagnosis of acute bowel obstruction is limited because in low-grade obstructions, the prestenotic intestinal dilatation can be transitory and missed. In higher grade obstructions, the positive contrast tends to remain in the stomach for longer periods and also becomes diluted due to the large amounts of retained fluid in the small bowel loops.

Ultrasound

Presence of radiolucent air in bowel loops makes radiography the first line of imaging in patients with suspected intestinal obstruction, but it is the primary cause of limited usage of ultrasound, as air scatters ultrasound waves and prevents further penetration in tissues. However, ultrasound has a dominant role in pediatric imaging where pediatric abdomen is relatively gasless in comparison to adults. It is used to diagnose intussusception and in therapeutic management (ultrasound-guided reduction with pneumatic or water contrast enema). Ultrasound has a high diagnostic sensitivity of 98% to 100% and a specificity of 88% to 100% for intussusception.[8]

Ultrasound has a high diagnostic sensitivity (98%–100%) and specificity (88%–100%) for intussusception.

Ultrasound can be used to detect peristalsis and distinguish between mechanical and functional intestinal obstruction. The caveat is strangulated obstruction, where peristalsis ceases. In fluid-filled loops, their diameter can be measured (normal small bowel loops, up to 3 cm; normal large bowel loops, 5–6 cm). Bowel wall thickness also can be measured (>3 mm is abnormal) and vascularity assessed on color Doppler imaging. Therefore, ultrasound has a limited but crucial role in pediatrics in its applicability for intestinal obstruction.

CT

CT is the mainstay for imaging intestinal obstruction. For several reasons, CT is the technique of choice in acute obstruction after obtaining plain radiographs. It is rapid, noninvasive, and readily available. It can be performed without oral contrast material because retained intraluminal fluid serves as a natural negative contrast agent. It also allows visualization and evaluation of extraluminal pathology (if present) that cannot be assessed by radiography. CT has a sensitivity of 81% to 94% and a specificity of 96% for diagnosing high-grade obstructions. However, when all grades of small bowel obstruction are taken into account, the reliability of CT decreases dramatically (sensitivity of 64% and specificity of 79%).[9] Therefore, CT is not the sole technique for diagnosis of low-grade or subacute intestinal obstructions and may need to be complemented by a contrast study, ideally enteroclysis.[10]

Diagnosis of small bowel obstruction on CT involves identifying dilated loops of bowel proximally with normal-caliber/collapsed loops distally. A small bowel caliber greater than

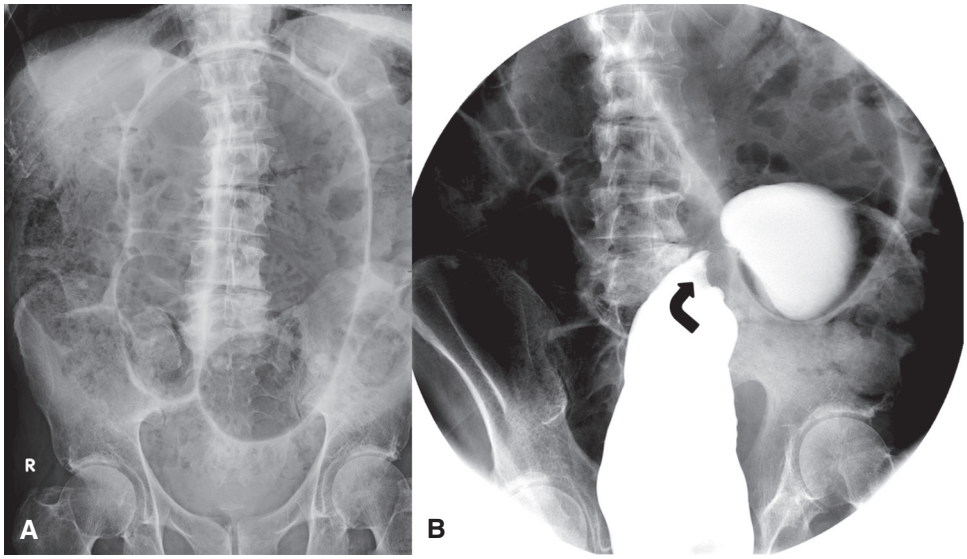

Figure 6. Sigmoid volvulus. Plain supine radiograph (*A*) in a 74-year-old man shows a grossly dilated, twisted sigmoid colon loop in a classic inverted U shape, with the limbs pointing toward the pelvis. This appearance is known as the "coffee bean" sign. Barium enema (*B*) in the same patient demonstrates narrowing of the barium column at the site of the twisted sigmoid colon, which is known as the "bird's beak sign."

2.5 cm and large bowel caliber greater than 5 to 6 cm are considered dilated bowel.[10] If a transition point is detected, the diagnosis is more certain.[10] The transition point often resembles a beak (Figure 1). This finding has been shown to be present in 60% cases of simple small bowel obstruction.[11] Other reliable features include the string-of-beads sign (Figure 2) and the "small bowel feces" sign. The small bowel feces sign is a result of stasis and mixing of small bowel contents that mimics feces, and it is present in 82% of cases of small bowel obstruction (Figure 7).[9] Occasionally, visualization of an adhesion band is possible, although it is uncommon. The most important information that CT can provide the surgeon about intestinal obstruction is whether associated strangulation is present. The sensitivity of contrast enhanced CT for intestinal ischemia has been reported to be as high as 90%.[2] Various signs have been associated with intestinal ischemia, including bowel wall thickening, ascites, pneumatosis intestinalis, and portal/mesenteric venous gas. The target sign is a trilaminar appearance of the ischemic thickened bowel wall resulting from hyperenhancement of the mucosal layer, hypodense submucosal edema, and reduced outer wall enhancement relative to bowel walls with preserved vascularity (Figure 8). Increased attenuation of bowel wall on noncontrast scans also is a sign of bowel ischemia, secondary to submucosal hemorrhage.

The most important information that CT can provide the surgeon about intestinal obstruction is whether associated strangulation is present.

Figure 7. Small bowel feces sign. Coronal, CT scan in a 65-year-old man shows fecal material in terminal ileum (*arrow*) secondary to distal large bowel obstruction (not shown) and an incompetent ileocecal valve. Concomitant right lower abdominal wall abscess is visualized.

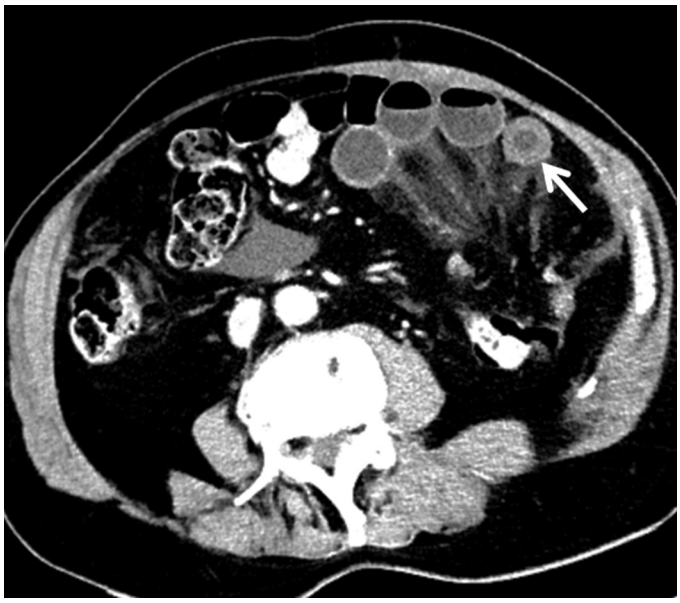

Figure 8. Target sign. Axial, contrast enhanced, CT scan in a 47-year-old man with complete small bowel obstruction demonstrate focal small bowel wall thickening with stratified mural appearance secondary to ischemia, also known as the target sign (*arrow*).

CT is the imaging modality of choice for large bowel obstruction, as it is a well-tolerated, rapid technique that allows image acquisition in one breath in the frail patient without the need for the rectal contrast medium or air insufflation.[6] Multiplanar reformatting provides accurate delineation of large bowel morphology. Diagnosis of intraluminal, mural, and extramural causes of large bowel obstruction is possible. In patients with large bowel obstruction secondary to malignancy, CT offers the additional benefit of detecting local and distant metastases.[6] The detection of large bowel obstruction with CT has been reported to have sensitivity and specificity of 96% and 93%, respectively.[12] Absence of a transition point on CT helps diagnose ileus in the appropriate clinical setting.

MRI

Clinical experience with MRI in the diagnosis of acute small bowel disease is limited, and its use in this capacity depends on the availability of suitable equipment. MRI can provide rapid and accurate identification of intestinal obstruction without the use of ionizing radiation; however, it usually is not considered the preferred choice, mostly because CT is more easily and readily available, and scan times are much faster than MRI. MRI is useful in pregnant patients, children, and young adults who have had multiple prior CT examinations.

MRI uses intraluminal air and fluid as a natural contrast agent and is not limited by previous administration of barium. Diagnosis of small bowel obstruction on MRI is similar to CT and involves identifying dilated loops of bowel proximal to the obstruction, a distinct transition point, and collapsed or reduced caliber bowel distally. Multiplanar capabilities of MRI allow visualization of the cause of small bowel obstruction accurately, with superior soft tissue resolution (Figure 9). However, MRI is unlikely to replace CT for evaluating bowel obstruction because of increased cost, longer scanning time, and comparative inferior resolution.

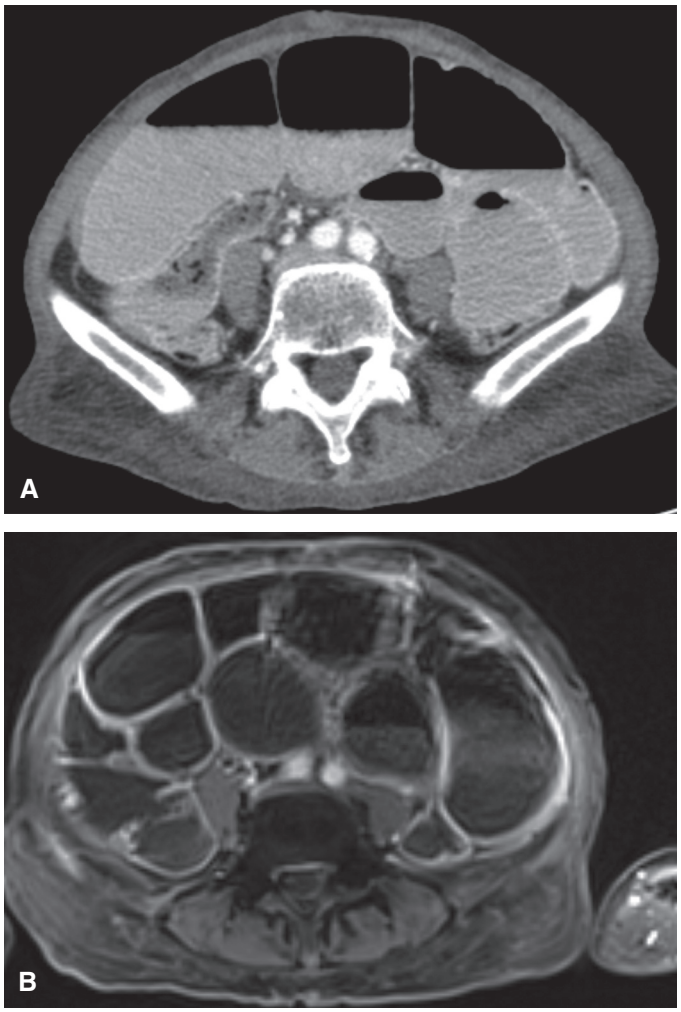

Figure 9. Axial postcontrast CT scan (*A*) and MR image (*B*) in a 49-year-old woman. The patient developed recurrent small bowel obstructions after surgery for cervical carcinoma that had invaded the sigmoid colon. Postcontrast MR images show the superior depiction of bowel wall enhancement and thickness in comparison to CT. However, the MR image quality is somewhat degraded by bowel peristalsis and respiratory motion artifacts, an area where CT prevails due to shorter scan times.

MRI is used more frequently in the evaluation of inflammatory bowel diseases.

Angiography

Conventional angiography has a very limited role in acute bowel obstruction. Although angiography is a sensitive method for demonstrating vascular occlusion, its role is limited because alternative and less invasive techniques are available. CT angiography and color Doppler imaging provide the same information.

Nuclear Medicine Studies

Radionuclide scanning has no specific role in the diagnosis of bowel obstruction.

Pearls/Essentials

- Plain radiographs are the first-line imaging modality in intestinal obstruction. Radiography is cheap, readily available, and can be performed serially to follow clinical progression. It should not be omitted as an initial study in favor of CT.
- Small bowel follow-through with water-soluble contrast medium is invaluable in cases with low-grade or subacute small bowel obstructions. They are superior to CT in their ability to demonstrate the actual temporal transit of contrast medium across partially obstructed bowel.
- CT provides necessary information such as confirmation of obstruction, site and degree of obstruction, cause of obstruction, and presence of ischemia or gangrene.
- MRI has no role in acute intestinal obstruction due to greater cost, increased scan time, and lesser resolution.
- Utility of angiography in intestinal obstruction is limited.
- Nuclear medicine studies have no role in acute intestinal obstruction.

Conclusion

Acute intestinal obstruction is a common clinical presentation for which effective management depends on proper utilization of appropriate imaging techniques for rapid and accurate diagnosis.

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1. Which one of the following is the best *initial* imaging modality in suspected acute intestinal obstruction?
- **A.** CT
- **B.** MRI
- **C.** Ultrasound
- **D.** Nuclear radiology
- **E.** Plain radiography

2. Identification of which one of the following intestinal abnormalities may be limited on the abdominal CT examination?
- **A.** Ischemic bowel
- **B.** Internal hernia
- **C.** Adhesions
- **D.** Volvulus
- **E.** Acute low-grade intestinal obstruction

3. The normal caliber of small bowel loops on radiographs is
- **A.** 3 cm
- **B.** 4 cm
- **C.** 5 cm
- **D.** 6 cm
- **E.** 7 cm

4. All of the following are radiographic signs of high-grade intestinal obstruction, *except*
- **A.** greater than 50% difference in caliber between the proximal dilated and distal collapsed bowel loops
- **B.** large number of dilated proximal bowel loops
- **C.** gasless abdomen
- **D.** air-fluid levels wider than 2.5 cm
- **E.** air-fluid levels differing more than 2 cm in height from one another within the same small bowel loop

5. Which one of the following statements regarding the imaging evaluation of acute intestinal obstruction is *false*?
- **A.** Radionuclide scanning has no specific role.
- **B.** A normal radiographic appearance is frequent with low-grade obstructions.
- **C.** Ultrasound is useful to evaluate peristalsis and vascularity of bowel loops.
- **D.** CT identifies associated gangrenous bowel loops.
- **E.** Radiographs invariably identify the cause of obstruction.

6. Which one of the following statements concerning acute intestinal obstruction is *false*?
- **A.** Severe constipation is more prominent early in large bowel obstruction.
- **B.** Vomiting is the predominant early feature of small bowel obstruction.
- **C.** Small bowel obstruction is more common than large bowel obstruction.
- **D.** High-grade obstruction is complete obstruction.
- **E.** In low-grade obstruction, some fluid and gas passes through the narrowed bowel segment.

7. On abdominal imaging, the "string-of-beads" sign should suggest
- **A.** Meckel's diverticulum
- **B.** small bowel lymphoma
- **C.** ileoileal intussusception
- **D.** necrotic small bowel adenocarcinoma
- **E.** small bowel obstruction

8. On abdominal radiographs, the cause of the "coffee bean" sign is
- **A.** rectal foreign body
- **B.** sigmoid colon volvulus
- **C.** ulcerative colitis
- **D.** cecal adenocarcinoma
- **E.** ileocolonic intussusception

9. The *most* common cause of small bowel obstruction is
- **A.** small bowel adenocarcinoma
- **B.** postoperative adhesion
- **C.** incarcerated hernia
- **D.** ileoileal intussusception
- **E.** Crohn disease

10. The *most* common cause of large bowel obstruction is
- **A.** cecal volvulus
- **B.** sigmoid diverticulitis
- **C.** large bowel malignancy
- **D.** postoperative adhesion
- **E.** ulcerative colitis