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Quarterly Review

Multi detector computed tomography (MDCT) evaluation of small bowel obstruction: pictorial review

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ABSTRACT

Small bowel obstruction (SBO) is one of the most perplexing clinical situations encountered by a surgeon in the emergency room. The decision to operate or not depends upon many factors including the probable cause and chances of bowel strangulation / ischemia. The clinical, biochemical and radiological features help the surgeon in making this decision. Plain X-rays have been the mainstay in the radiological diagnosis of SBO and its complications. In the last 20 years, CT scan has ushered in a revolution in establishing the diagnosis of SBO, its causes and complications earlier than the traditional methods and has helped in reducing morbidity and mortality. Here, we have summarised the role of multidetector CT scan in diagnosing various aspects of SBO.

KEYWORDS: intestinal obstruction, diagnosis, computed tomography (CT).

Introduction

Intestinal obstruction is a common clinical occurrence and can be either dynamic or adynamic. Small bowel obstruction (SBO) is usually mechanical (dynamic) in nature, occasionally it may result from mesenteric vascular occlusion. The clinical manifestations vary according to the nature of presentation – acute or subacute, complete or partial and simple or complicated. Surgical intervention is indicated in acute intestinal obstruction due to organic pathology, closed loop obstruction, complications like strangulation or perforation. The diagnosis of strangulation is rarely possible before the gangrene has already set in. The old saying "never let the sun set or rise on an obstructed bowel" was a teaching to minimize missing strangulation. However, recent developments in radiologic modalities has promised to pick up the patients at risk of complications early and helped in decreasing delayed exploration and negative laparotomies. The primary imaging modality is plain abdominal radiography, however it has a sensitivity of 48% to 80%.[1] CT has emerged as an important diagnostic tool in the evaluation of small bowel obstruction and has a reported sensitivity of 93%, specificity of up to 100% and accuracy of 94% in diagnosing SBO.[2] Helical CT with its multiplanar reformatted imaging can accurately characterize the level, degree, cause and associated complications of obstruction. In this article we describe the multidetector CT (MDCT) findings in different causes of small bowel obstruction.

CT technique

Volume data of the abdomen is acquired with MDCT. Sagittal, coronal, and curved multiplanar reformatted images aid in the diagnosis when the axial images are indeterminate.[3] Oral administration of contrast is not required in high grade obstruction where retained fluid acts as a natural negative contrast agent.[4,5] However, in cases of partial obstruction

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administration of oral contrast medium (1.2% barium or 2% iodinated water-soluble contrast material) 30–120 minutes before scanning[6] is preferred for identification of enteric abnormalities in mildly distended loops.[7] CT enteroclysis (CTE) is preferred in cases of low grade partial obstruction.[8]

At our institution, we perform MDCT (Philips Brilliance 40P), with a detector collimation of 2.5 mm, a section thickness of 3 mm, and a section reconstruction interval of 2 mm. Approximately 100 to 120 ml of non ionic contrast material is administered at a rate of 2–3 ml/sec and images are acquired in the portal venous phase. For CT enteroclysis, the catheter (12 Fr) is placed under fluoroscopic guidance, with the catheter tip positioned in the proximal jejunum and 1.5 L saline infused at 100 ml/min. On the CT table, again 1.5 L saline is infused at 100 ml/min. 100-120 ml intravenous contrast is administered and scan performed at 50 seconds delay.

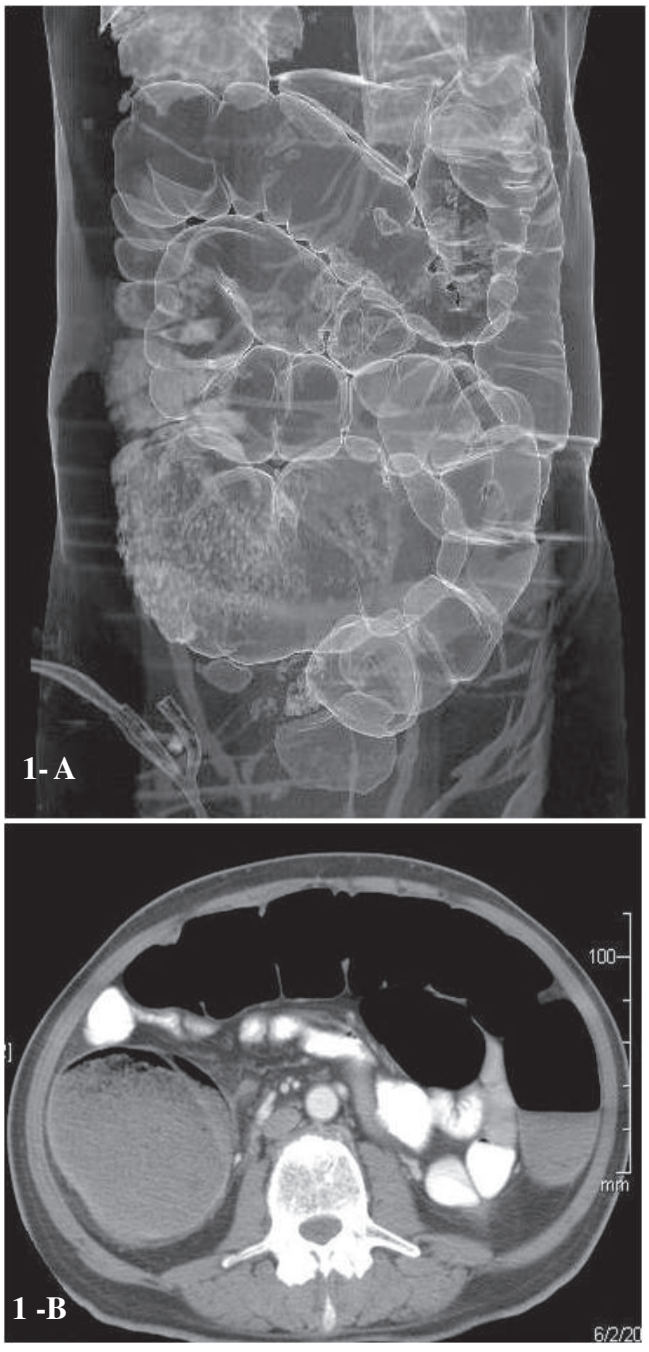


Figure 1: Pseudo obstruction. (A) Coronal volumetric rendering technique(VRT) and (B) axial CECT images show dilated small and large bowel loops in a case of post operative paralytic ileus.

Differentiating small bowel obstruction from pseudo-obstruction

Small bowel obstruction is diagnosed on CT when there is dilatation of proximal bowel (caliber >2.5 cms) with transition to normal caliber or collapsed bowel loops distally.[9] In contrast, there is distension of both small and large bowel in ileus with colonic distension usually predominating (**Figure 1A,B**).[10]

The presence of intraluminal gas and particulate material in the dilated loops 'the small bowel feces sign' is abnormal.[12,13,15] It is associated with SBO in 82% of the patients[11] and is used to identify the transition point.[12] However, it is not exclusive to obstruction and may also be seen in patients with ischemia, Crohn's disease, infectious enteritis and vigorous jejunostomy tube feeding.[13]

The 'string of beads sign' is said to be pathognomonic of small bowel obstruction (**Figure 2A,B**).[11]

Defining the degree of obstruction

The degree of obstruction, whether it is complete, high grade partial or low grade partial[14] is more easily diagnosed on conventional contrast radiography.[11] On CT in a high-grade obstruction, there is a 50% difference in caliber between the proximal dilated bowel and the distal collapsed bowel (**Figure 3**).

If there is passage of the oral contrast material through the transition zone to the collapsed distal bowel it indicates incomplete obstruction – high grade if minimal contrast in the distal loops and low grade if sufficient contrast flows across the transition point.[16] On CT enteroclysis if the fold pattern in distal bowel is clearly identified it indicates low grade obstruction.[11] CTE has a reported sensitivity and specificity of 89 and 100%, respectively in the diagnosis of SBO.[8]

Defining the level of obstruction

This is determined by identifying the transition point and the relative lengths of dilated and collapsed bowel.[4] However, it is important to remember that dilated bowel loops may have an abnormal disposition. Bowel tracking in an antegrade or retrograde manner on the workstation of MDCT helps to accurately identify the transition point.[5]

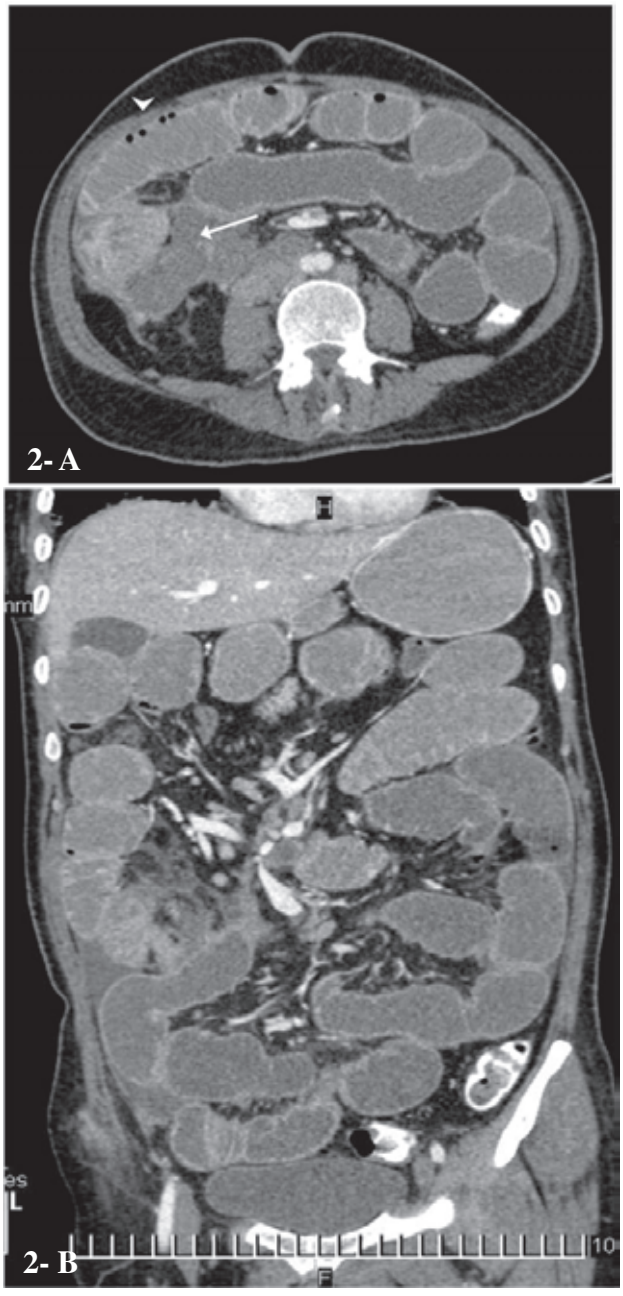


Figure 2: Small bowel obstruction secondary to appendicitis. (A) CT scan shows inflammatory changes in the right lower quadrant. Small bowel dilatation with 'string of beads sign' (arrow) is also seen. (B) Coronal reformatted image depicts the inflammatory changes with minimal fluid collection in right paracolic gutter.

Figure 3: Small bowel obstruction secondary to adhesions. Axial image shows transition zone (arrow) in the mid small bowel with more than 50% calibre change of the distal bowel loops suggestive of high grade obstruction.

Identifying complications

Closed-loop obstruction

Closed-loop obstruction (CLO) is a form of mechanical obstruction where a segment of bowel is occluded at two points along its course. It is seen in approximately 10% of SBO.[10] CT signs of CLO as described by Balthazar[17,18] include :

1. A distended C shaped, U shaped or 'coffee bean' shaped loop with engorged mesenteric vessels is seen when the loop is horizontal (**Figure 4A**).
2. If the bowel is more vertically oriented, fluid filled loops may be seen radiating away from the sites of obstruction.
3. Oval or triangular collapsed loops may be seen at the site of obstruction.
4. A 'beak sign' is seen at the site of torsion as a fusiform tapering (**Figure 4B**).
5. The closed loop is distended with fluid more markedly than the proximal bowel. The distal bowel is non-distended.
6. A tightly twisted mesentery 'whirl sign' may be seen in cases associated with volvulus.

Strangulation

Strangulation is seen in CLO or in simple obstruction associated with impaired venous drainage. It is seen in 5% to 42%[19] of small bowel obstruction and is associated with a high mortality rate - from 20% to 37%.[20] CT signs of ischemia include –

1. Poor or no enhancement of the bowel wall (sensitivity 34%; specificity 100%)
2. Serrated beak sign (sensitivity 32%; specificity 100%)
3. A large volume of ascites (sensitivity 29%; specificity 98%)
4. An unusual course of the mesenteric vasculature (sensitivity 56%; specificity 95%)
5. Diffuse engorgement of the mesenteric vasculature (sensitivity 66%; specificity 95%).

Non specific findings 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.[5]

A combination of the above mentioned findings should be used to diagnose strangulation.

Identifying the cause of small bowel obstruction

SBO can be due to extrinsic, intrinsic or intraluminal causes (**Table 1**). It is important to evaluate the transition point to differentiate between these. Extrinsic causes are seen adjacent to the transition point with associated extra-intestinal manifestations. Intrinsic bowel lesions are seen at the transition point as localized mural thickening. Intraluminal causes manifest as endoluminal lesions with differential density from the small bowel contents.

Table 1: Causes of small bowel obstruction

Extrinsic lesions:	Adhesions
	External hernias
	Internal hernias
	Hematoma
	Endometriosis Extrinsic Masses
Intrinsic lesions:	Tumors
	• Adenocarcinoma
	• Metastasis
	• Lymphoma
	• Gastrointestinal stromal tumor
	Inflammatory lesions
	• Crohn's disease
	• Tuberculosis
	• Eosinophilic gastroenteritis
	Vascular lesions
	• Radiation enteropathy
	• Ischemia
	Hematoma
	• Trauma
	• Anticoagulants
	• Blood dyscrasias
	Intussusception
	Adhesions
	Tumors
Intraluminal lesions:	Gallstones
	Bezoars
	Foreign bodies

Source —Adapted from references 4 and 5.

Figure 4: Closed loop obstruction secondary to adhesions. (A) Coronal reformatted image demonstrates a markedly dilated and horizontally oriented ileal loop. (B) Characteristic 'beak sign' is seen as fusiform tapering of the loop in the corresponding axial image (arrow).

Extrinsic lesions

Adhesions

Adhesions are responsible for approximately 50% to 75% of cases of SBO.[20] These are commonly seen in post-operative patients (80% cases), may be associated with peritonitis (15%)

or be congenital or unexplained in origin.[21] SBO due to adhesions is diagnosed on CT when there is an abrupt change in the caliber of the bowel without any associated mass lesion, significant inflammation, or bowel wall thickening at the transition point (**Figure 3**).

External Hernias

External hernias occur through a defect in abdominal or pelvic wall at sites of previous surgery or congenital defects.[22] Indirect inguinal hernia is the most common type and is usually identified clinically.[23] CT is useful for diagnosing occult hernias especially in obese patients and depicting the precise site and type of hernia, its contents and associated complications (**Figure 5**).

Internal Hernias

Internal hernia is a herniation of the bowel loops through developmental recesses of the peritoneum or surgically created defects in the mesentery.[21] These include right paraduodenal, left paraduodenal (**Figure 6**), foramen of Winslow, pericaecal, intersigmoid, transmesenteric, transmesocolic and retroanastomotic.[22] CT diagnosis is based on the identification of a cluster of small bowel loops in an abnormal position with altered course of mesenteric vessels.

Other causes of extrinsic compression include endometriosis, hematoma, neoplastic, congenital (duplications cyst) (**Figure 7**) and inflammatory lesions. These may cause bowel obstruction, either by direct luminal compression or by producing a desmoplastic reaction of the bowel wall.[4]

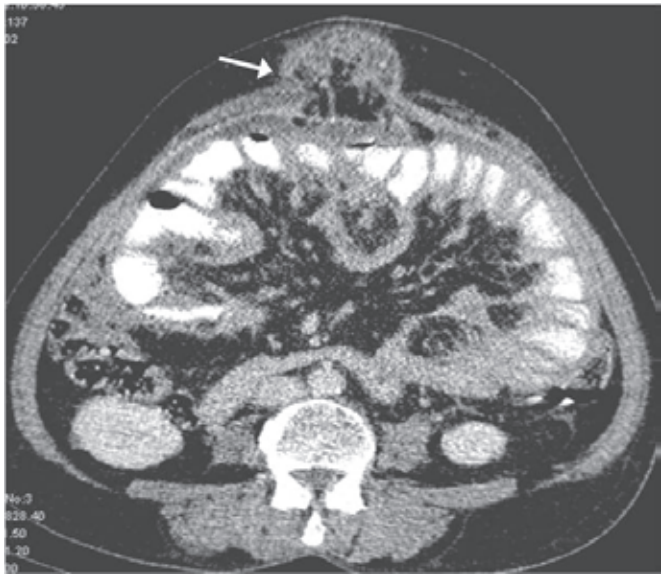


Figure 5: Umbilical hernia. Air containing bowel loop and omental fat is seen protruding through the umbilical defect (arrow).

Intrinsic Lesions

Neoplasia

Primary neoplasms of the small bowel are rare. Adenocarcinoma of small bowel is seen on CT as asymmetric, irregular mural thickening with luminal narrowing at the transition point (**Figure 8**). CT also helps in defining the extent of the tumor.[23]

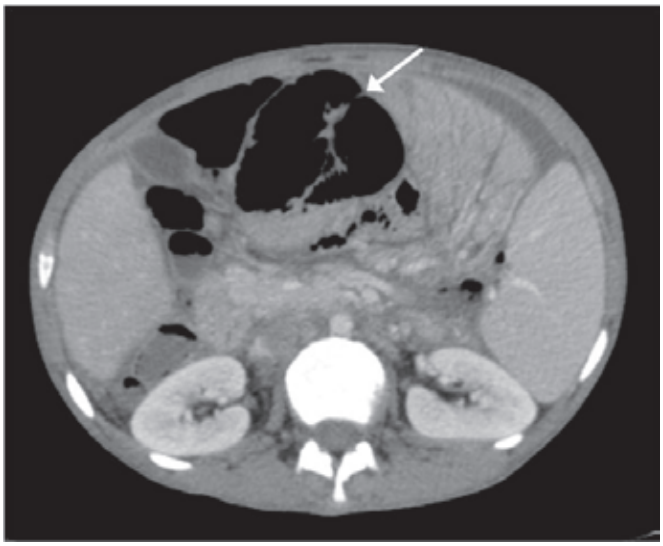


Figure 6: Left paraduodenal hernia. Axial CECT image shows a cluster of dilated small bowel loops (arrow) lying between the stomach and pancreas.

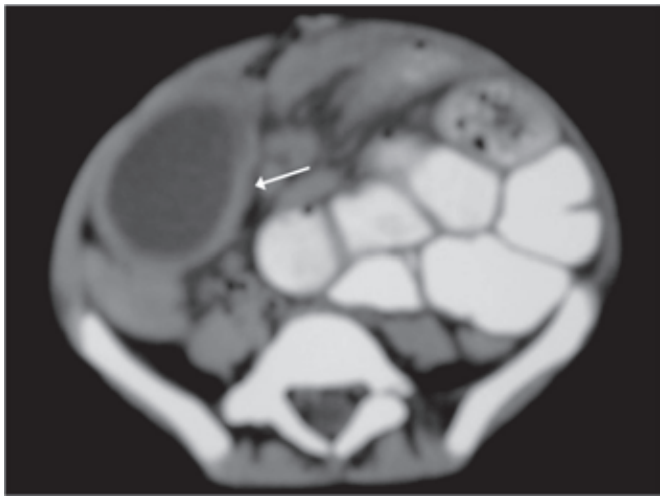


Figure 7: Duplication cyst. A homogeneous fluid density oval lesion with uniform rim enhancement (arrow) is seen in the right iliac fossa with proximal small bowel dilatation. Surgery and histopathological examination revealed duplication cyst of the ileum.

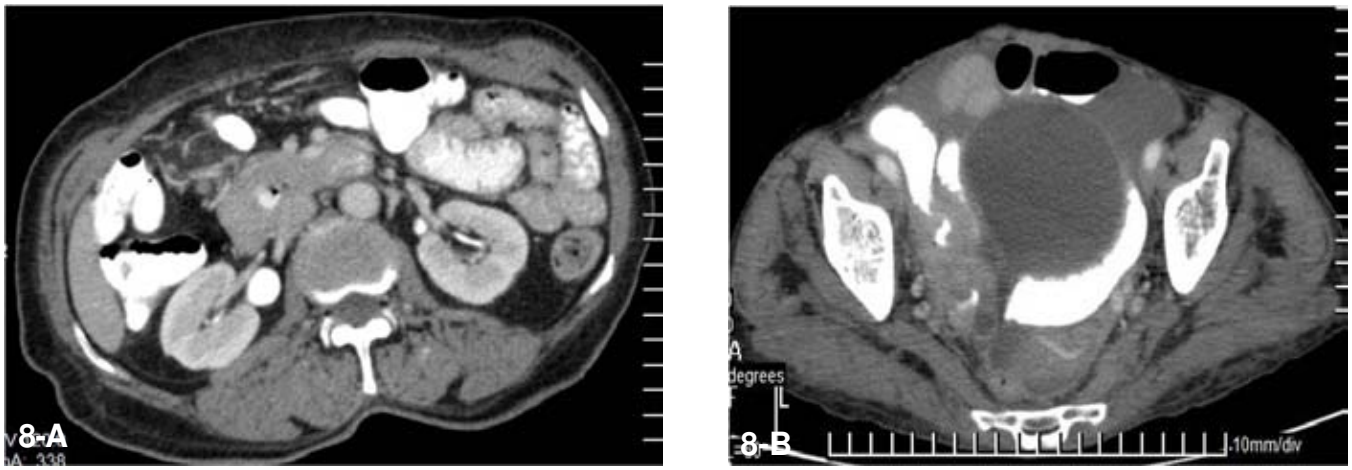


Figure 8: Adenocarcinoma of small bowel. (A) Asymmetric and irregular mural thickening of duodenum is seen in a surgically proven case of adenocarcinoma. (B) SBO secondary to adenocarcinoma of distal ileum. Asymmetric mural thickening is noted with dilatation of the proximal small bowel loops and ascites.

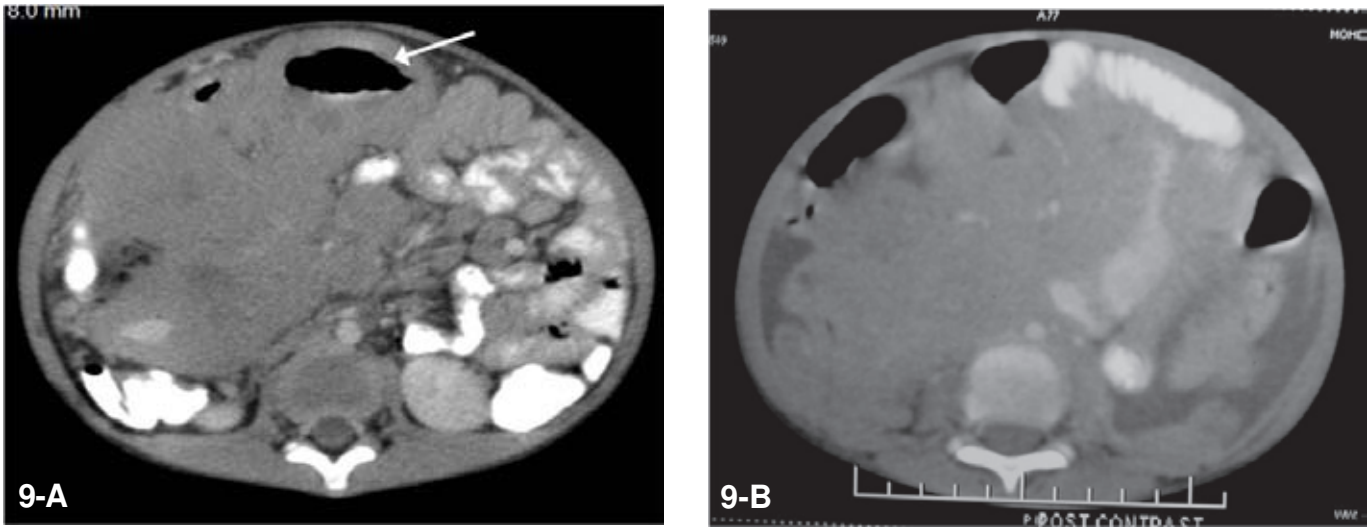


Figure 9: Lymphoma. (A) Large homogenous mesenteric mass with infiltration of adjacent bowel loops is seen. Also note the segmental aneurysmal dilatation of bowel loop (arrow). (B) Confluent nodal mass in another case of Non Hodgkin's lymphoma causing extrinsic compression of adjacent small bowel loop.

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

Nodal non-Hodgkin lymphomas may arise in the mesentery and grow to invade small bowel segments and may cause obstruction by compression, kinking, and infiltration.[24] On CT homogenous mesenteric nodal mass with infiltration of adjacent bowel loops is seen (**Figure 9**). Primary non-Hodgkin lymphomas of the small bowel are non-obstructing soft lesions that infiltrate the bowel wall and tend to produce early cavitation.

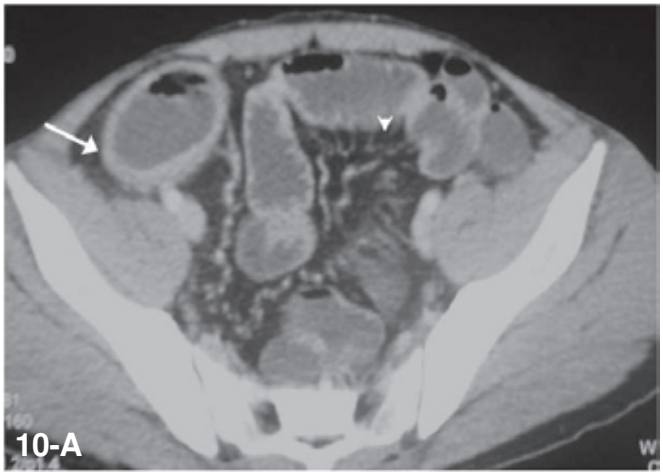
Peritoneal carcinomatosis can lead to SBO by either extrinsic compression or desmoplastic reaction with resultant bowel loop angulation and distortion.[25] The common causes include carcinoma of the ovary, colon, stomach, pancreas, breast, and endometrium.

Crohn's Disease

SBO can occur in the active phase due to acute inflammation causing luminal narrowing. Small bowel loops show mural stratification with target appearance and peri-enteric hyperaemia resulting in the 'comb sign' (**Figure 10A**). In the chronic phase, cicatricial stenosis of the bowel segments with fibrofatty proliferation is seen (**Figure 10B**).[10] CT also helps to diagnose complications like abscesses, fistulas, post-operative adhesions, incisional hernias and malignancy.[11]

Tuberculosis

Small bowel tuberculosis can be ulcerative or hypertrophic and commonly involves the ileocaecal region. CT demonstrates



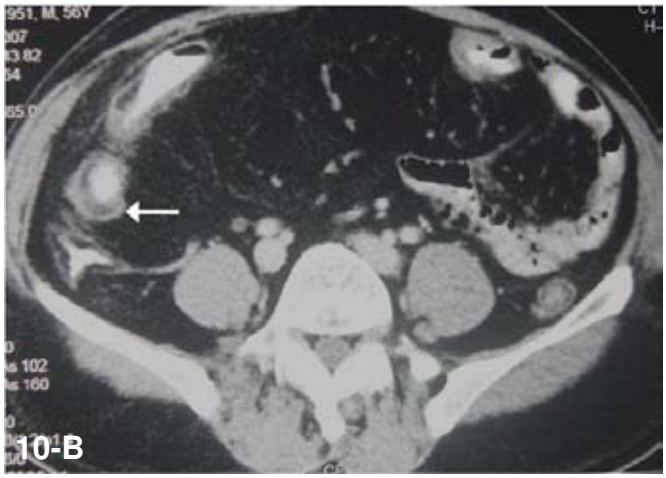
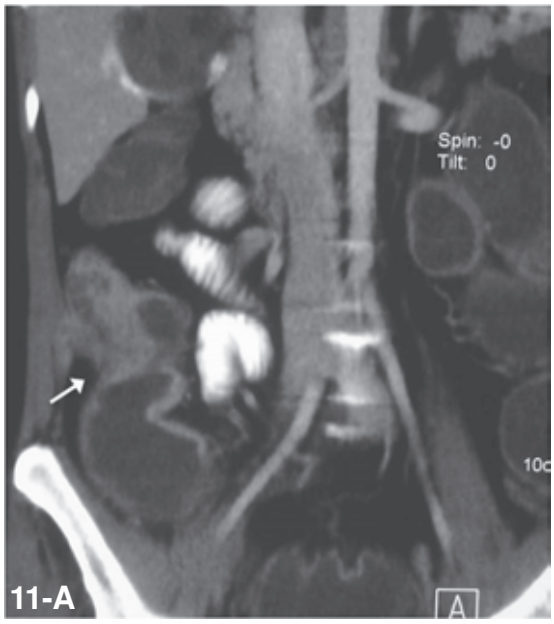


Figure 10: Crohn's disease. (A) CT enteroclysis shows mural thickening and a target like appearance (arrow) in the distal ileal loop. 'Comb sign' in the form of perienteric hyperemia is clearly seen (arrowhead). (B) Axial CECT image in another patient of Crohn's disease shows multiple segments of bowel wall thickening with 'double halo sign' (arrow). Note the marked fatty proliferation.



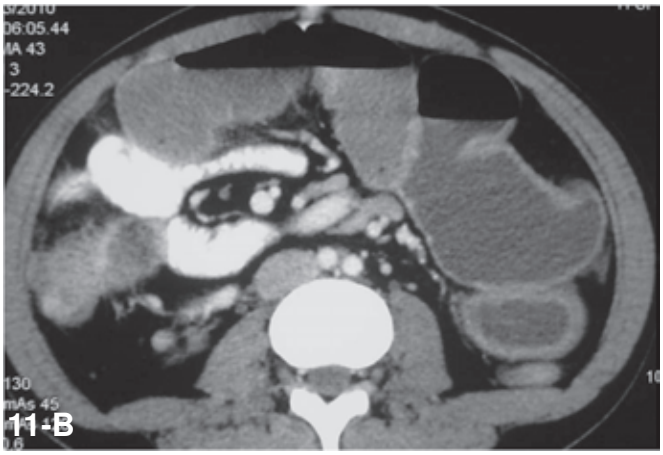


Figure 11: Ileocaecal tuberculosis. (A) Coronal MPR image shows thickening of terminal ileum and caecum with deformed ileocaecal valve (arrow) causing SBO. (B) Dilated small bowel loops with multiple air fluid levels are seen. Note the thickened and contracted caecum.

asymmetric, irregular wall thickening of terminal ileum and caecum (**Figure 11**) with enlargement of ileocaecal valve and mesenteric adenopathy (**Figure 12**) with central low attenuation areas suggestive of necrosis.[26]

Abdominal Cocoon

Also known as sclerosing encapsulating peritonitis, it is a rare condition where the small bowel is encased by a thick fibrotic peritoneum.[27] The common etiological factors include tuberculosis, prior abdominal surgery or peritonitis and chronic peritoneal dialysis. CT shows concentration of a part of or the entire small bowel in the center of the abdomen encased by a soft tissue-density mantle (**Figure 13**).[28]

Radiation Enteritis

Commonly occurs after 1 year of therapy in the irradiated area usually the pelvis. SBO occurs primarily due to adhesive and fibrotic changes in the mesentery and occasionally due to radiation serositis which causes luminal narrowing and dysmotility.[29] CT shows mural thickening, angulation and kinking of the bowel wall and retraction of the mesentery.[23]

Hematoma

Can occur due to trauma, anticoagulant medication or blood dyscrasias and cause SBO due to luminal narrowing. Non-contrast CT shows hyperattenuating circumferential mural thickening.[23,30]

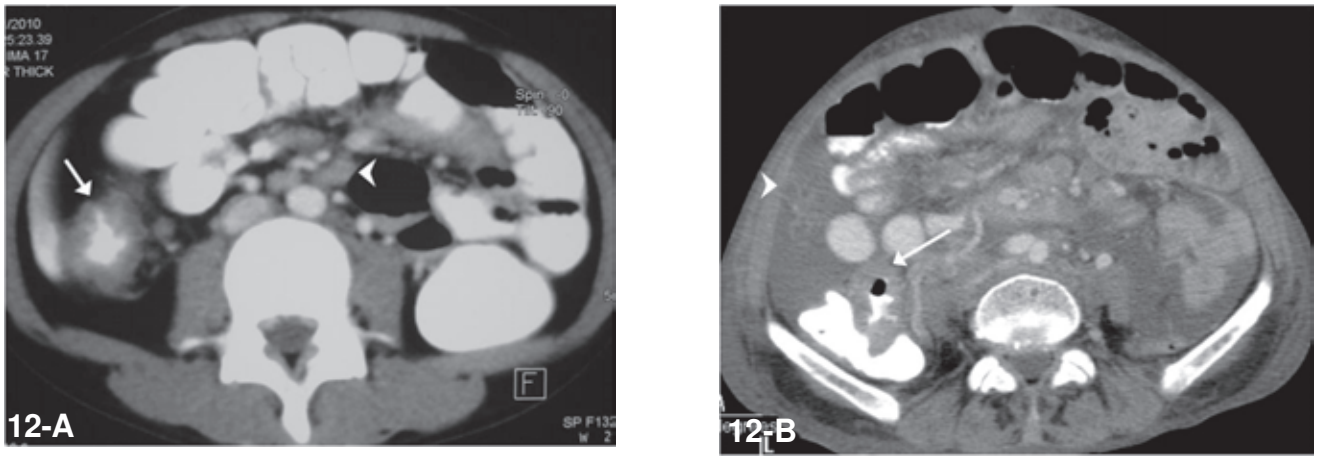


Figure 12: Abdominal tuberculosis. (A) Concentric thickening in the ileocaecal region (arrow) causing proximal dilatation of small bowel loops and associated mesenteric lymphadenopathy (arrowhead) in a case of abdominal Koch's. (B) Axial CECT image in another patient of abdominal Koch's shows thickening of ileocaecal valve (arrow). Also note ascites, omental thickening (arrowhead) and enlarged mesenteric lymph nodes.

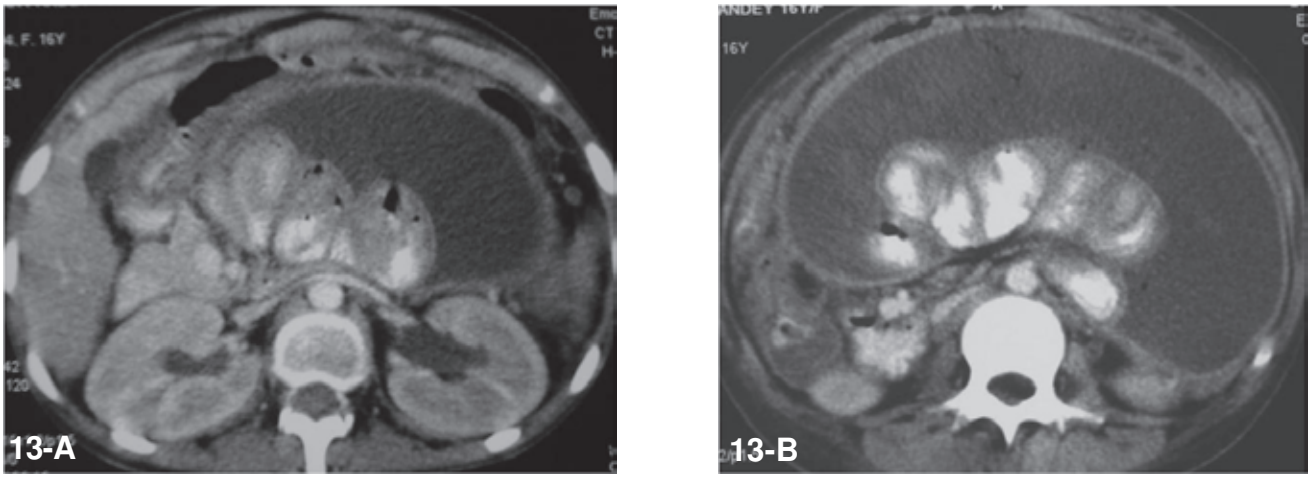


Figure 13: Abdominal cocoon or sclerosing encapsulating peritonitis. Adherent small bowel loops are seen lying in the centre of the abdomen encased by fluid and enhancing peritoneal membrane.

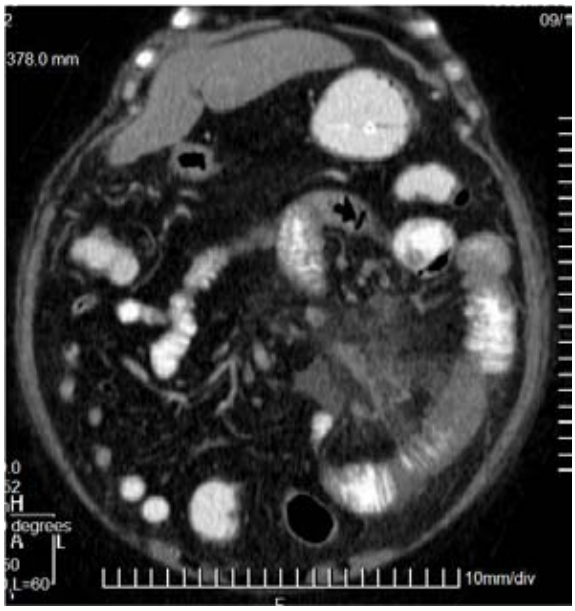


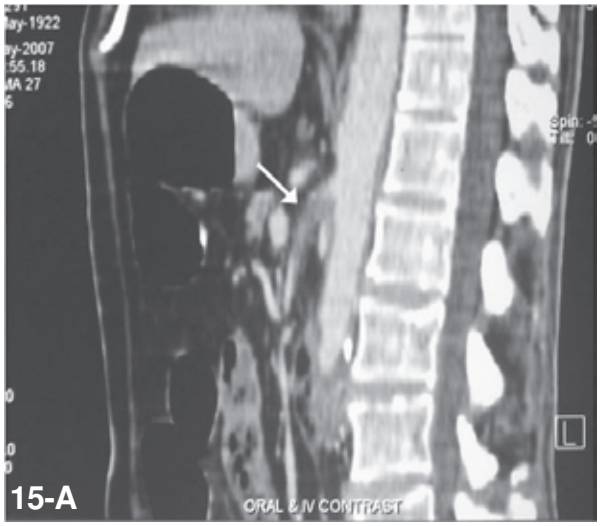
Figure 14: Small bowel ischemia. Coronal reformatted image reveals circumferential bowel wall thickening, mesenteric haziness and fluid.

Vascular

Bowel ischemia occurs due to occlusion of the mesenteric arterial or venous vascular supply. CT shows thrombosis or occlusion of the mesenteric vessels, thickening of the bowel wall with asymmetric wall enhancement, pneumatosis and air in the portal venous system (**Figures 14 and 15**).[20] Bowel ischemia may result secondary to volvulus, commonly seen in association with malrotation. This is characterized by "cork screw appearance" on upper GI study (**Figure 16A**) and the "whirl sign" on CECT (**Figure 16B**).

Intussusception

Small bowel intussusception may result from various extrinsic, intrinsic, or intraluminal processes.[31] 80% of cases in adults are associated with underlying causes such as neoplasm (**Figure 17**), adhesion, inverted Meckel's diverticulum, foreign



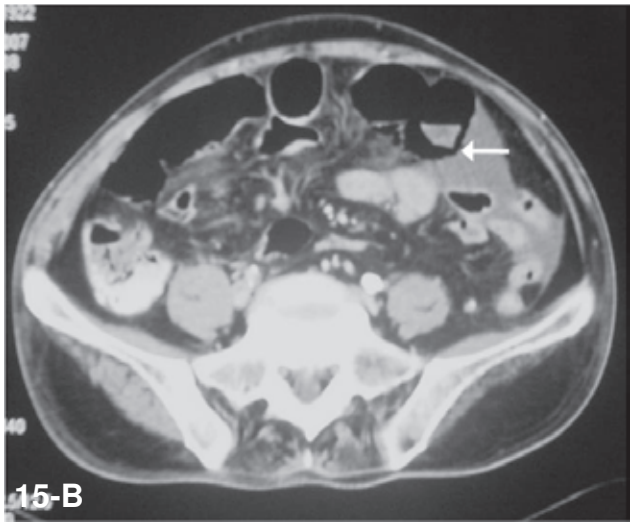
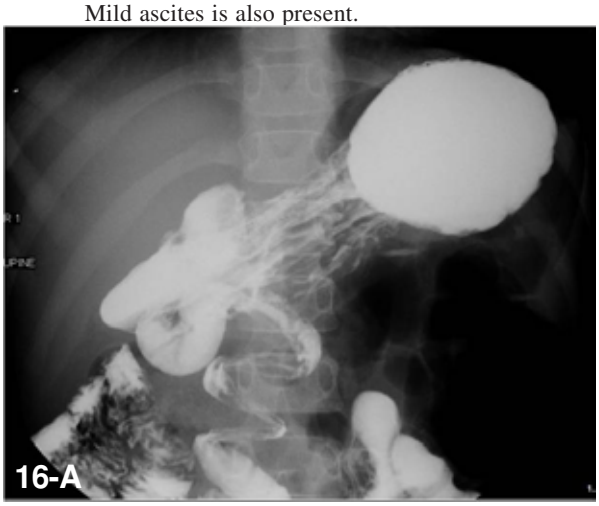


Figure 15: SBO due to intestinal ischemia secondary to arterial occlusion. (A) Sagittal MPR image reveals thrombus in the superior mesenteric artery (arrow). (B) Axial CT image shows air (arrow) in dependent wall of small bowel loops (pneumatosis intestinalis). Mild ascites is also present.



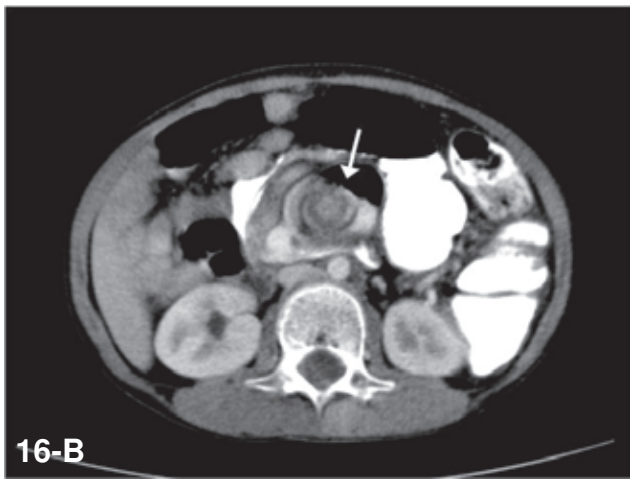


Figure 16: Malrotation with midgut volvulus. (A) Barium meal upper GI study reveals the characteristic 'cork screw' appearance. (B) Axial CECT image reveals 'whirl sign' (arrow), a finding that is highly characteristic of intestinal volvulus.

Figure 17: Intussusception secondary to ileal lipoma. Telescoping of a segment of bowel (the intussusceptum) into another more distal segment of bowel (the intussuscepiens) with lipoma (arrow) identified at the lead point.

Figure 18: Ileocolic intussusception. Axial CT image demonstrates intussuscepted bowel and mesenteric fat with a target-like appearance in the right iliac fossa with proximal small bowel obstruction.

Figure 19: Intestinal worms. Axial CT image demonstrating curvilinear low density intraluminal structures consistent with ascariasis (arrow).

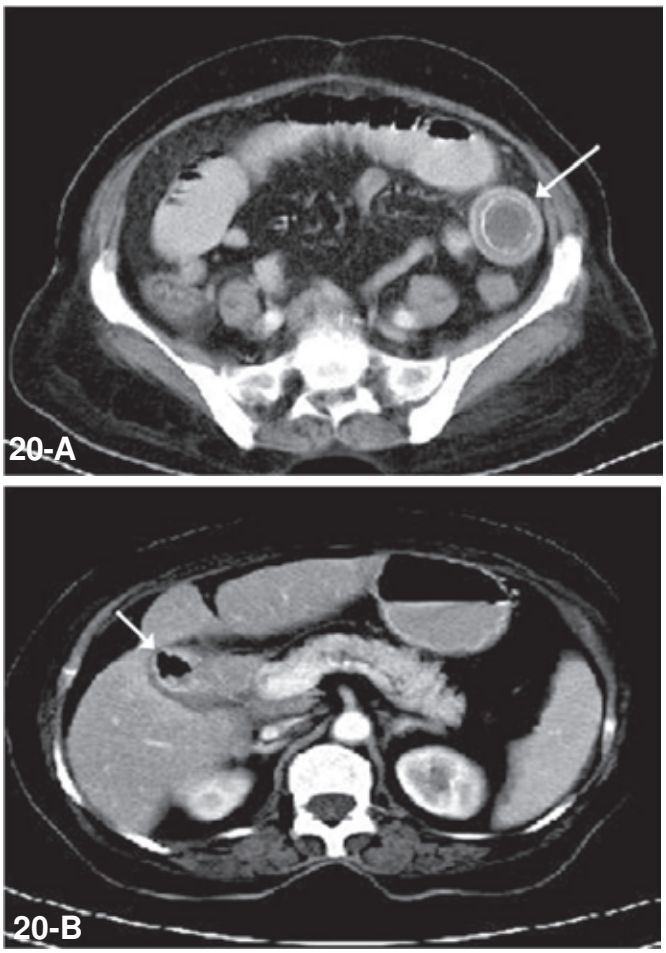


Figure 20: Gall stone ileus. (A) CECT Abdomen shows a hypodense, well defined rounded lesion of 3 x 3 cm. with rim calcification s/o calculus (arrow) in distal loop of jejunum causing obstruction with dilatation of proximal small bowel. (B) Associated air pocket is noted within the lumen of gall bladder (arrow).

body, prior history of abdominal surgery and bowel dysmotility disorders.[20,21,24,32] There is invagination of a proximal small bowel loop and part of its mesentery (intussusceptum) into the lumen of the distal small bowel or colon (intussuscepiens).[21] In early stages a dilated bowel loop containing an eccentric crescent of fat is seen on CT. In advanced disease a sausage shaped mass with alternating areas of low and high attenuation and features of SBO are seen (**Figure 18**). Delayed diagnosis results in a reniform mass with findings of ischemia and necrosis.[10]

Intraluminal causes

These include gallstones, foreign bodies, bezoars, worms (**Figure 19**) or meconium. Gallstone ileus usually occurs in elderly women. CT demonstrates the triad of ectopic gallstone, gas in the shrunken gallbladder or biliary tree, and mechanical bowel obstruction (**Figure 20**).[33]

Bowel obstruction caused by a foreign body usually occurs in children or mentally disturbed or disabled patients.[21] Bezoars are impacted luminal masses containing indigestible food and are usually seen in post gastrectomy patients. At CT, a bezoar is seen as an intraluminal mass with an ovoid shape and a mottled gas pattern.[34]

Conclusion

Small bowel obstruction is evaluated clinically on the basis of history, examination and laboratory results with conventional radiograph being the radiological investigation of first choice. CT is highly sensitive and specific in determining the presence of bowel obstruction. MDCT with its multiplanar reformatted images can accurately diagnose the level, severity and cause of obstruction. Complications like CLO and strangulation, which have important implications on patient management can also, be identified. CT should be considered in the evaluation of SBO, especially where the plain film findings are equivocal and complications are suspected.

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