

Imaging of the Small Bowel

Pantongrag-Brown L

Small bowel is the longest tubular organ in the body, about 18-22 feet. It is anchored to the body by a 15 cm mesentery, folded between ligament of Treitz and ileocecal junction. Rule of “3” is usually applied to images of normal small bowel, which includes <3 mm wall thickness, <3 cm diameter, and <3 air-fluid levels.

Imaging modalities used in small bowel include plain radiographs, barium study of small bowel, US, CT, PET CT and MRI. However, the most common modalities used in standard practice are plain radiographs and CT. Small-bowel, follow-through study is

mostly replaced by CT because of CT ability to visualize both intraluminal and extraluminal abnormalities. Air within the small bowel makes other modalities sub-optimal for good quality images. In this article, several small bowel abnormalities will be demonstrated, using case-based approach, and emphasizing on imaging findings.

Case 1. A 63-year-old man presented with abdominal pain, nausea and vomiting.

Supine plain radiograph shows multiple dilated loops of small bowel, lying layer by layer, similar to

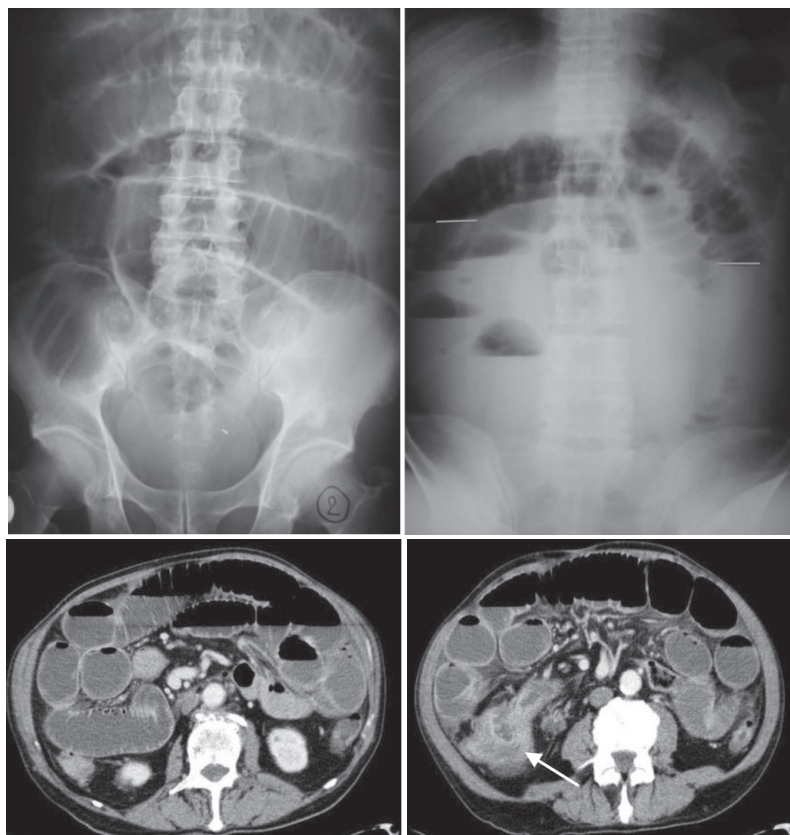


Figure 1. Case 1.

Advanced Diagnostic Imaging Center, Ramathibodi Hospital, Bangkok, Thailand.

Address for Correspondence: *Linda Pantongrag-Brown, M.D., Advanced Diagnostic Imaging Center, Ramathibodi Hospital, Bangkok, Thailand.*

multiple steps of the ladder (step ladder pattern sign). The dilated air-filled bowel loops are more than 3 cm in diameter. Upright radiograph shows multiple air-fluid levels and different height of air in the same loop (red horizontal lines). Marked small bowel dilatation with absence of colonic air is indicative of small bowel obstruction (SBO). Axial views of CT abdomen show cecal mass (arrow) causing distal SBO. This mass is surgically proved to be cecal adenocarcinoma.

Causes of small bowel obstruction are numerous and could be categorized as following⁽¹⁾:

1. Intrinsic conditions

1.1 Inflammatory diseases such as Crohn's, TB, and eosinophilic gastroenteritis

1.2 Neoplasms such as GIST, adenocarcinoma, lymphoma, and metastasis

1.3 Vascular diseases such as ischemia, vasculitis, and radiation enteropathy

2. Extrinsic conditions

2.1 Adhesion

2.2 Volvulus

2.3 Hernias

2.4 Endometriosis

2.5 Hematoma

3. Intraluminal causes

3.1 Gallstones

3.2 Bezoars

3.3 Foreign bodies

The 3 most common etiologies in developed countries are adhesion, Crohn's disease, and neoplasms. The 3 most common etiologies in developing countries are adhesion, hernia, and neoplasms⁽¹⁾.

Case 2. A 58-year-old man presented with abdominal pain, nausea, and vomiting.

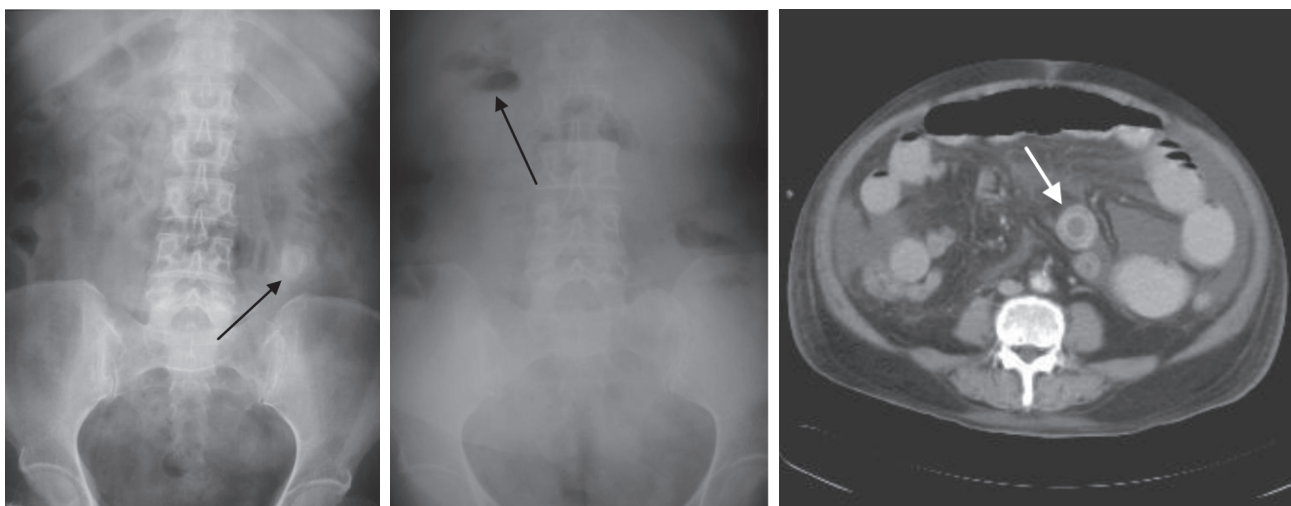


Figure 2. Case 2.

Supine plain radiograph shows a large calcification (arrow) at the duodenal jejunal junction causing partial obstruction and mild dilatation of the proximal duodenum. Upright radiograph shows air-containing, branching tubular structure at the RUQ with central predilection (arrow), indicative of aerobilia. Combination of findings are consistent with gallstone ileus. Axial view of CT abdomen shows a lamellar ectopic gallstone (arrow).

Gallstone ileus is an unusual complication of chronic cholecystitis. Cholecystoenteric fistula may occur, as a result of chronic gallbladder (GB) perfora-

tion and fistulous communication with bowel. Once a fistula is established, air may pass from bowel to the GB and biliary tract, and stone may pass from the GB to bowel. This stone may cause mechanical bowel obstruction, hence the term "gallstone ileus".

"Rigler triad", named after Leo George Rigler, who described this triad in 1941⁽²⁾. It is the imaging triad help for diagnosis of gallstone ileus. The triad is found in about 25% of gallstone ileus and includes pneumobilia, SBO, and gallstone in ectopic location. The gallstone that causes bowel obstruction is relatively large, at least 2 cm in size. It is usually impacted at the

ileum or ileocecal valve. However, rarely, the stone may be impacted at the duodenum resulting in gastric outlet obstruction. This unusual site of gallstone impaction is termed “Bouveret syndrome”. This syndrome was first described by Leon Bouveret in 1896⁽³⁾.

Case 3. A 72-year-old man presented with abdominal pain, and fever.

Supine plain radiograph shows abnormal collection of extraluminal bubbly air at the RLQ, best shown at the magnified view (arrows). Mixed pattern of localized ileus and partial SBO is observed. Axial view of CT abdomen confirms collection of abnormal air, indicative of abscess. Surgery proves the presence of

RLQ abscess, caused by infarcted small bowel perforation.

Abscess at the RLQ may cause mixed pattern of partial SBO and reflex ileus. The most common cause of RLQ abscess is ruptured appendicitis. Other etiologies include ruptured diverticulitis, infarcted small bowel perforation, and colonic cancer perforation.

Distinguishing abnormal bubbly air from feces within the colon by plain radiograph may be difficult. A clue that may help to diagnosis in this particular case is lacking of stool in other part of the colon, as well as dilatation of small bowel loops surrounding the bubbly air collection. If there is any suspicion, CT should be performed to confirm the diagnosis.

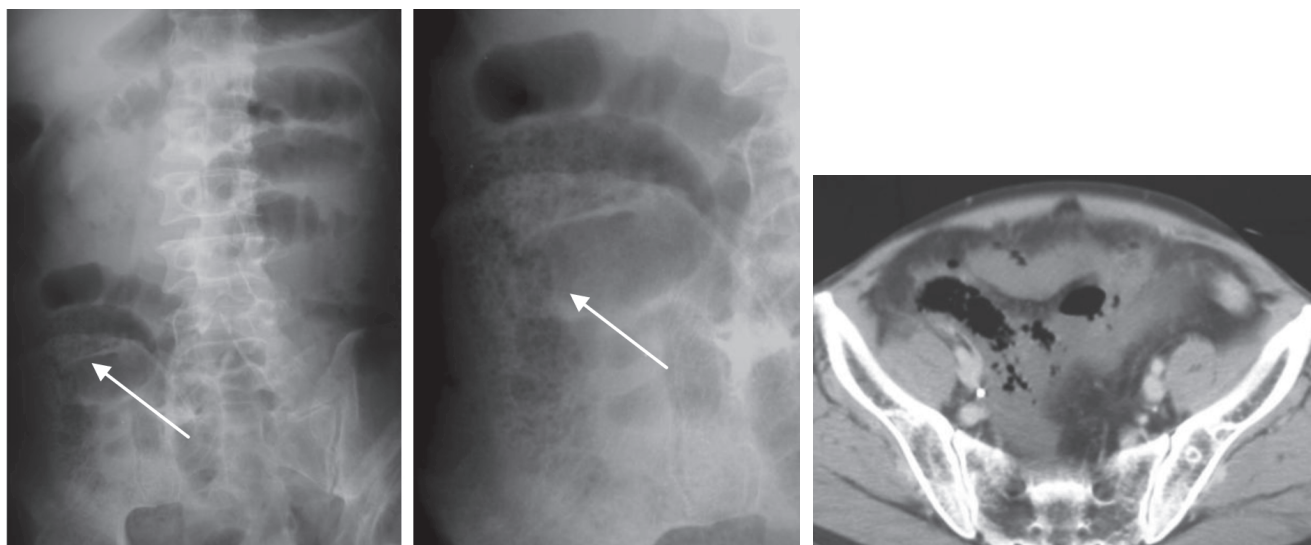


Figure 3. Case 3.

Case 4. A 58-year-old man presented with abdominal pain.

Barium study of the small bowel shows relatively regular, thickened small bowel folds with some nodularity, giving the “stack coin” or “picket fence” pattern (arrows). Findings are indicative of submucosal deposition. Axial views of CT scan shows SMV thrombosis (arrow) and diffuse small bowel edema. Findings are consistent with small bowel ischemia secondary to SMV thrombosis.

Barium study of the small bowel is good for determining its mucosal folds. The pattern of relatively

smooth, thickened folds (such as in this case) implies even distribution of the submucosal depositions. It is usually caused by edema or hemorrhage. Etiologies of edema are usually systemic and diffuse, which include hypoproteinemia (such as from cirrhosis, nephrotic syndrome, or protein losing enteropathy), congestive heart failure and portal hypertension. Etiologies of hemorrhage include coagulopathies, ischemia (such as from SMA/SMV thrombosis, or hypoperfusion), and vasculitis. CT is the best imaging modality to identify vascular thrombosis⁽⁴⁾.

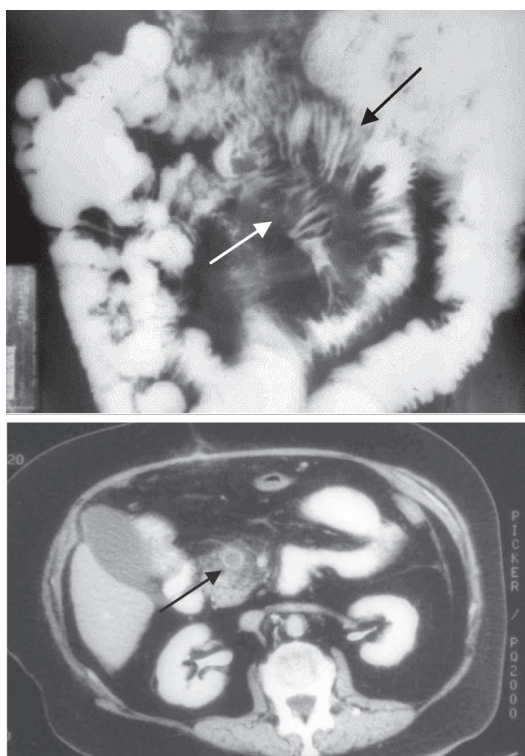
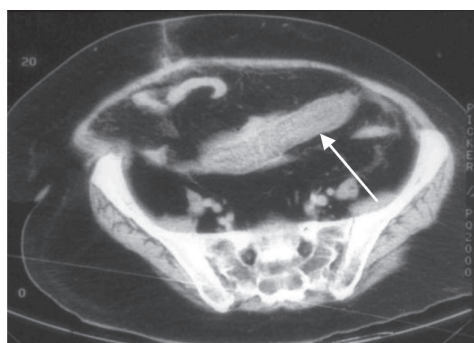


Figure 4. Case 4.



Case 5. A 58-year-old male presented with abdominal distension and pain.

Supine and upright plain radiographs show dilatation of proximal small bowel with “string of pearls” appearance on the upright view, and absence of air within the distal small bowel and colon. Findings are consistent with proximal SBO. Barium small bowel follow-through study shows evidence of string sing (white arrow) and coil-spring appearance (red arrow) of the jejunum, indicative of intussusception. Surgery confirms intussusception and the leading point is lym-

phoma.

Intussusception in the adult is not common and usually has a leading point. Leading point could be neoplastic or inflammatory process⁽⁵⁾. Etiologies are numerous, including GI malignancy (such as carcinoma, lymphoma, or metastasis), benign neoplasms (such as GIST, lipoma, or polyps), inflammation (such as Crohn, and Sprue), hematoma from trauma, and congenital abnormalities (such as Meckel diverticulum, ectopic pancreas, or duplication cyst).

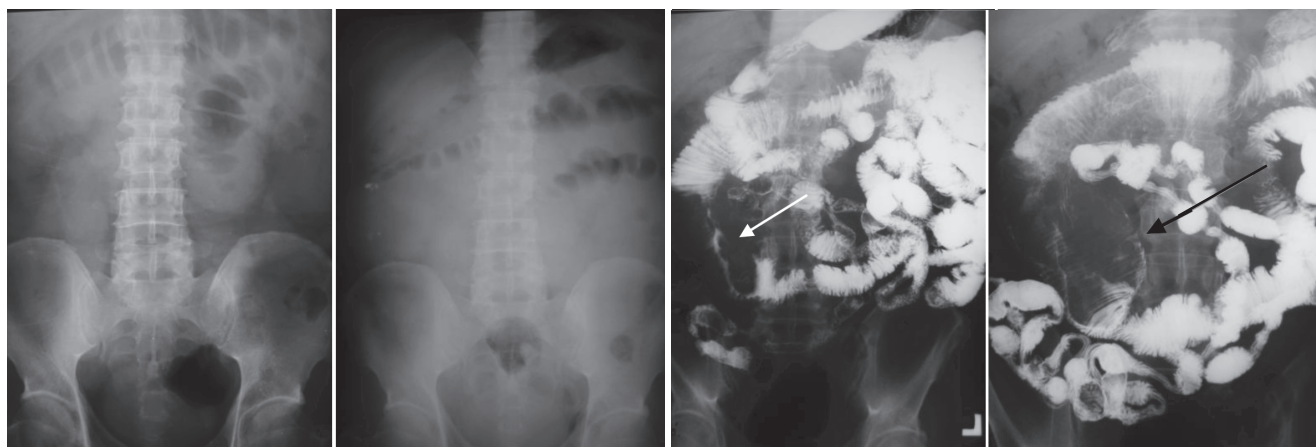


Figure 5. Case 5.

Case 6. A 74-year-old man presented with abdominal pain and fever.

Axial and coronal views of CT abdomen show several jejunal diverticulosis (black arrow, coronal view) and multiloculated fluid collections surrounding the jejunum, indicative of jejunal diverticulitis. Several extraluminal air bubbles (white arrows in axial and coronal views) are consistent with perforation, a complication of diverticulitis.

Jejunal diverticulosis is rare and usually asymptomatic⁽⁶⁾. Complication, such as diverticulitis or perforation, may result in high morbidity and mortality, particularly in elderly patients. CT appearance of diverticulosis as outpouching lesions are similar to those found in colon. Therefore, imaging diagnosis is not difficult. However, awareness of this rare disease is important to reach the right investigative tool and correct diagnosis for the patient.

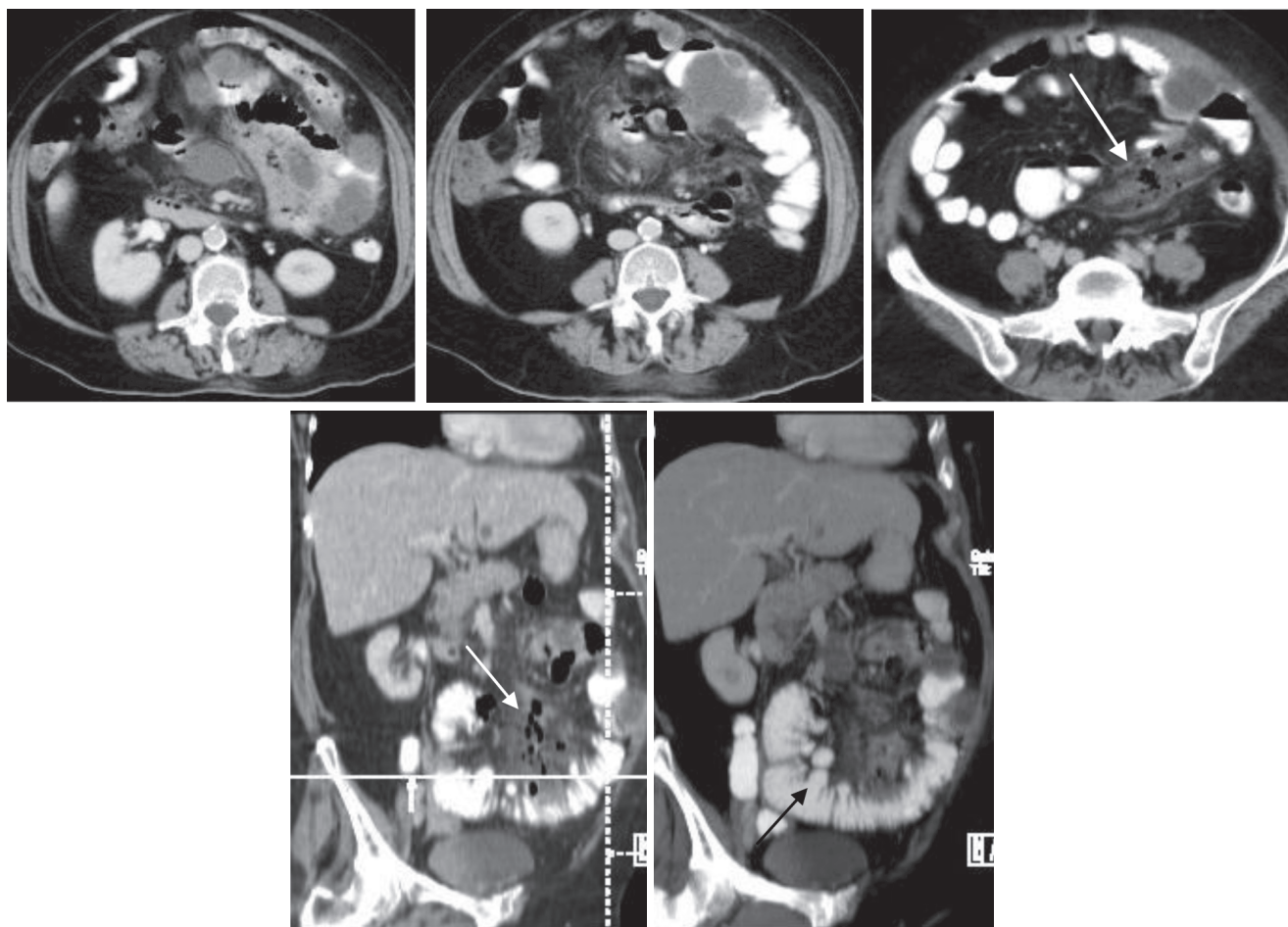


Figure 6. Case 6.

Case 7. A 41-year-old woman presented with acute abdominal pain.

Axial views of CT abdomen show thin wall of the distal small bowel with poor enhancement (white arrow), suggestive of small bowel arterial ischemia. Feces-like material within the small bowel is suggestive of necrotic material. On magnified sagittal and axial views, an intraluminal thrombus within the SMA

is noted (red arrows). Surgery confirms long segment of small bowel infarction.

Mesenteric arterial thrombosis is a life threatening condition. Thin-walled small bowel with poor enhancement is secondary to loss of muscular tone and lack of arterial blood supply. CT is the best imaging modality to identify clot within the lumen⁽⁷⁾.

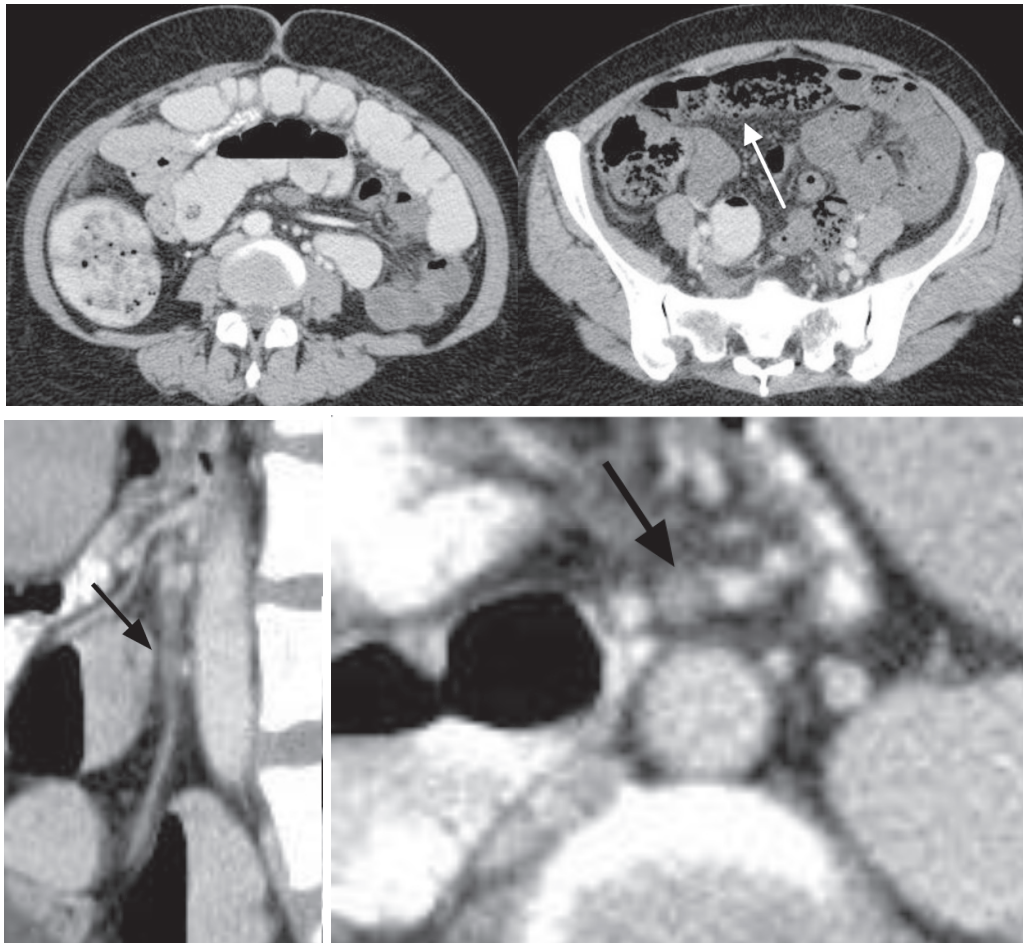


Figure 7. Case 7.

Case 8. A 43-year-old man, post cardiac valvular replacement with anticoagulant medication, presented with acute abdominal pain.

Axial and coronal views of CT abdomen show thickening of jejunum with soft-tissue encasement of mesenteric vessel (arrows). There is marked enhancement of the mucosa of the involved jejunum. Combination of history and CT findings are consistent with mesenteric venous ischemia secondary to mesenteric

hematoma. Patient is improved after symptomatic treatment.

Mesenteric venous ischemia is less common than arterial ischemia⁽⁸⁾. Hyper-enhancement of the mucosa is secondary to venous engorgement. This is opposite to hypo-enhancement from arterial ischemia. Diffuse bowel wall thickening is also a common finding in mesenteric venous ischemia, which is opposite to thin bowel wall secondary to arterial ischemia.

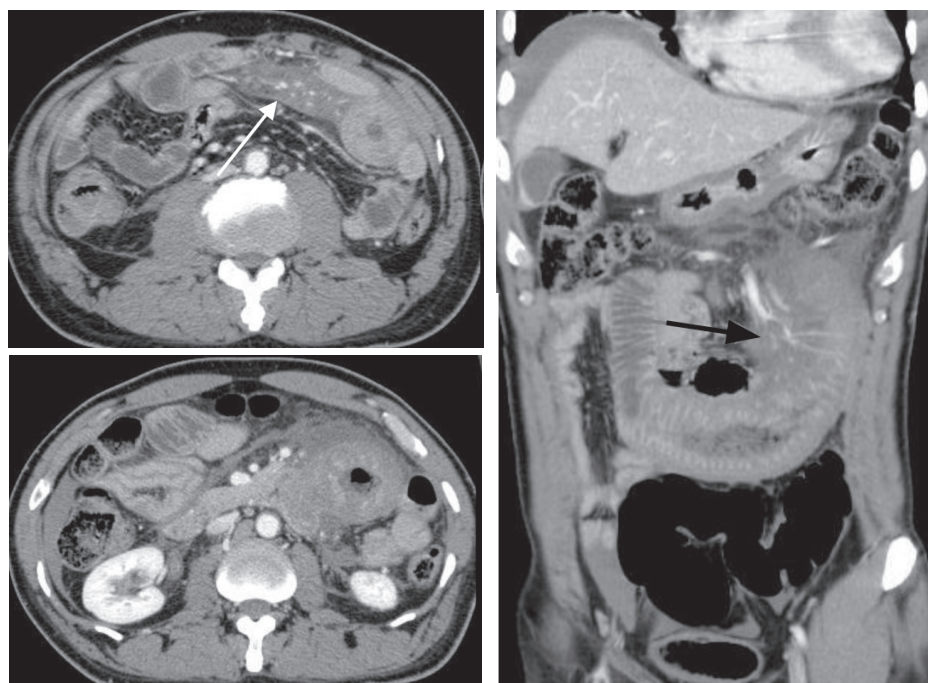


Figure 8. Case 8.

Case 9. A 45-year-old man presented with anemia.

US shows an intra-abdominal mass. Axial and coronal views of CT abdomen give more information that the 7.5 cm mass is exophytic from the jejunum, suggestive of jejunal neoplasm. Lacking of lymphadenopathy makes jejunal GIST the most likely diagnosis. Surgery confirms the diagnosis of GIST.

Small bowel GIST is second most common site, after stomach. It is usually more aggressive than gastric GIST. The tumor originates from the submucosal or intramural layer of the GI tract and tend to show exophytic growth with cavitation and necrosis. D/Dx of exophytic bowel mass should include lymphoma, adenocarcinoma, and metastasis⁽⁹⁾.

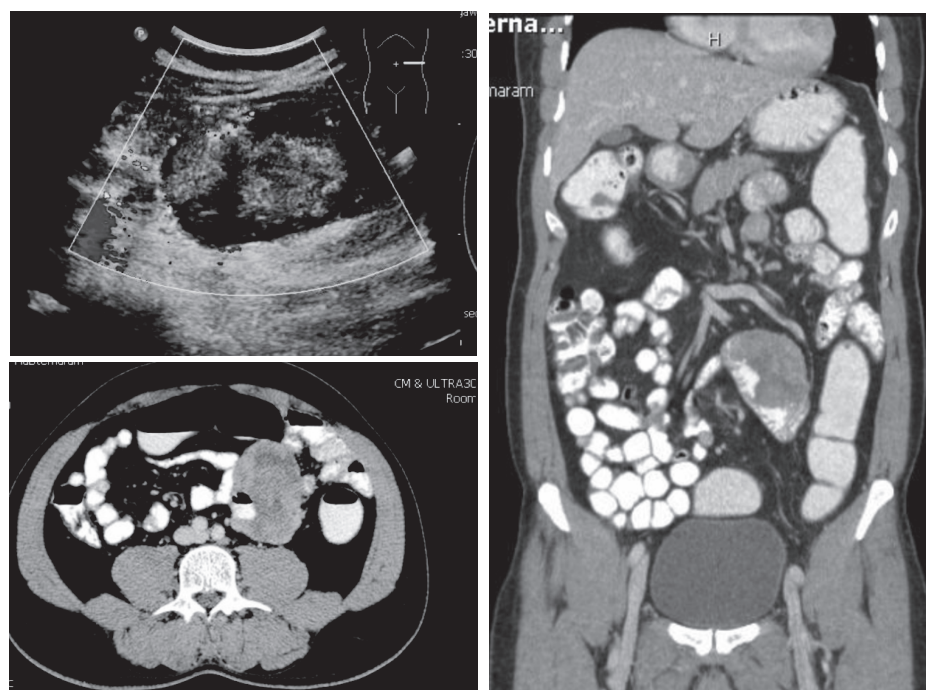


Figure 9. Case 9.

CONCLUSIONS

Nine cases of small bowel with various diseases are illustrated, emphasizing on the imaging appearances. These diseases are as following:

1. Small bowel obstruction: secondary to cecal carcinoma, GS ileus, RLQ abscess from SB perforation, and intussusception from lymphoma
2. Neoplastic pathology: jejunal GIST
3. Inflammatory pathology: jejunal diverticulitis with perforation
4. Vascular pathology: mesenteric venous ischemia from SMV thrombosis and hematoma encasing the mesenteric venous branches, and mesenteric arterial ischemia from SMA thrombosis.

REFERENCES

1. Silva AC, Pimenta M, Guimares LS. Small bowel obstruction: what to look for. *RadioGraphics* 2009;29:423-39.
2. Rigler LG, Borman CN, Noble JF. Gallstone obstruction: pathogenesis and roentgen manifestations. *J Am Med Assoc* 1941;117:1753-9.
3. Bouveret L. Stenose du pylore adherent a la vesicule. *Rev Med (Paris)* 1896;16:1-16.
4. Furukawa A, Kanasaki S, Kono N, *et al.* CT diagnosis of acute mesenteric ischemia from various causes. *AJR Am J Roentgenol* 2009;192:408-16.
5. Choi SH, Han JK, Kim SH, *et al.* Intussusception in adults: from stomach to rectum. *AJR Am J Roentgenol* 2004;183:691-8.
6. Tsiotos GG, Farnell MB, Ilstrup DM. Nonmeckelian jejunal or ileal diverticulosis: An analysis of 112 cases. *Surgery* 1994; 116:726-32.
7. Schieda N, Fasih N, Shabana W. Triphasic CT in the diagnosis of acute mesenteric ischaemia. *Eur Radiol* 2013;23:1891-900.
8. Warshauer DM, Lee JK, Mauro MA, *et al.* Superior mesenteric vein thrombosis with radiologically occult cause: a retrospective study of 43 cases. *AJR Am J Roentgenol* 2001; 177:837-41.
9. Levy AD, Remotti HE, Thompson WM, *et al.* Gastrointestinal stromal tumors: radiologic features with pathologic correlation. *RadioGraphics* 23:283-304, 456.