Imaging of Ischemia, Obstruction and Infection in the Abdomen

Kevin P. Murphy, MB[a,b], Maria Twomey, MB[a], Patrick D. McLaughlin, MB BCh BAO, FFR RCSI, FRCPC[c], Owen J. O'Connor, MD[a,b], Michael M. Maher, MD[a,b,*]

KEYWORDS

• Intestinal obstruction • Intestinal ischemia • Computed tomography • Acute abdomen • Bowel • Colon

KEY POINTS

- Computed tomography (CT) is the modality of choice in investigation of the acute abdomen in nonpregnant adults but ultrasonography and MR imaging in particular are increasing being used.
- In suspected bowel ischemia, multiphase CT imaging with the use of negative oral contrast in place of positive oral contrast, where possible, is recommended.
- Complete mesenteric arterial occlusion without reperfusion results in bowel thinning and minimal mural enhancement, whereas other causes of intestinal ischemia lead to bowel wall thickening, intramural hemorrhage, and mural hyperenhancement.
- Key findings to interpret regarding bowel obstruction are the location and cause of transition, grade of obstruction, the presence of closed-loop obstruction, and the presence of ischemia.

INTRODUCTION

Intestinal obstruction and intra-abdominal infection associated with the gastrointestinal tract account for a huge proportion of emergency surgical admissions with abdominal symptoms. The former alone accounts for approximately 20% of admissions in this category.[1–3] Intestinal ischemia is uncommon but still carries a mortality in excess of 70%.[4] As a result of the frequency and gravity of the conditions, timely diagnosis of these entities by emergency radiologists is of key importance. This article examines the imaging approach in patients suspected of having the aforementioned conditions, shows key findings, and discusses potential complications.

NORMAL ANATOMY AND IMAGING TECHNIQUES

Important Anatomic Considerations

Knowledge of the vascular supply and drainage of the gastrointestinal tract is of key importance in understanding intestinal ischemia. The celiac trunk, superior mesenteric artery, (SMA) and smaller infraduodenal inferior mesenteric artery (IMA) must be scrutinized routinely on abdominal imaging studies. The celiac trunk supplies the foregut, from the distal esophagus to the midpart of the descending duodenum. The SMA, the artery of the midgut, supplies the gastrointestinal tract from the middle of the second part of the duodenum to the junction of the middle and distal

[a] Department of Radiology, University College Cork, Cork University Hospital, Wilton, Cork, Ireland; [b] Department of Radiology, Mercy University Hospital, Grenville Place, Cork, Ireland; [c] Department of Emergency and Trauma Radiology, Vancouver General Hospital, 899 West 12th Avenue, Vancouver, BC V5Z 1M9, Canada

* Corresponding author. Department of Radiology, University College Cork, Cork University Hospital, Wilton, Cork, Ireland.

E-mail address: m.maher@ucc.ie

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thirds of the transverse colon, with the IMA, the hindgut artery, supplying the remainder. Collateralization between the SMA and IMA via the marginal artery of Drummond is variable. In contrast, there is a rich plexus of collaterals between the celiac trunk and SMA. The bowel receives approximately 20% of cardiac output with the mucosa receiving two-thirds of this,[5,6] thus explaining why the mucosa and submucosa are most sensitive to changes in supply in the setting of ischemia.

The relative locations of small and large bowel loops are of significance in assessing for internal hernia, a challenging diagnosis that is frequently a closed-loop obstruction. It is important to carefully evaluate the anatomic relationships of the small bowel loops in relation to the ascending/descending colon or transverse colon respectively. In addition, the paraduodenal spaces should be devoid of extra bowel loops. Intestinal malrotation, which is associated with midgut volvulus and internal herniation, may occur when the small bowel mesentery is short, as signified by finding that the third part of the duodenum does not cross the midline. In such cases the small bowel is characteristically located on the right side of the abdomen and the colon principally left sided. In addition, the SMA and superior mesenteric vein relationship may be reversed.[7]

Malrotation with nonrotation also results in an appendix that lies to the left of midline, a finding that is also present in situs inversus.

The vermiform appendix measures a mean of 11 cm and the tip is most commonly retrocecal (74%), although the remainder have a variable location.[8] Meckel diverticulum is an anatomic variant that results from persistence of part of the omphalomesenteric duct, is present in 2% of the population, and is located approximately 60 cm (2 feet) from the ileocecal valve on the antimesenteric border.[9]

Normal bowel diameter may measure 2.5 cm for the small intestine, 9 cm for the cecum, and 6 cm for the remainder of the colon.[10,11]

Imaging Techniques

Radiography

Abdominal radiography is frequently used in assessment of the acute abdomen. It has a reported sensitivity of 69% to 80% for bowel obstruction[12–15] but is insensitive in assessing for complications or cause. In addition, abdominal radiographs are neither sensitive nor specific for detection of intestinal ischemia or infectious/inflammatory conditions such as diverticulitis, colitis, or appendicitis. The erect chest radiograph remains an essential part of assessment and detection of pneumoperitoneum in suspected hollow viscus perforation.

Computed tomography

Multidetector (MD) computed tomography (CT) is the main modality for the diagnosis of bowel obstruction and ischemia because of its availability, speed, sensitivity, and specificity.[1,2,5,16–24] MD CT has a sensitivity in excess of 80% for intestinal ischemia detection.[5] MD CT accuracy of 95% is reported for detection of high-grade small bowel obstruction, although accuracy is decreased for low-grade obstruction.[25] Sensitivity in excess of 90% is reported for large bowel obstruction.[26,27] Sensitivity and specificity for appendicitis are also in excess of 90%.[20,28]

MR imaging

MR imaging is being increasingly used in detection of bowel obstruction, ischemia, and infection. MR imaging has a sensitivity that is similar to CT in assessing bowel obstruction[29,30] and ischemia.[31,32] In addition, MR imaging is comparable with CT in infectious/inflammatory conditions such as appendicitis and diverticulitis.[20,33,34]

Ultrasonography

In children and pregnancy, ultrasonography is the first-choice modality in assessment of suspected appendicitis. Ultrasonography has a complimentary role to CT and MR imaging in assessing small bowel obstruction and suspected ischemia; however, its main strengths include ready availability in most hospitals, avoidance of exposure to ionizing radiation, and the portable nature of the modality, which means that it can be performed at the bedside in critically ill patients.[30,35,36]

Fluoroscopy

Angiography is rarely used currently for diagnosis in intestinal ischemia but is used during endovascular therapy. In the past, contrast enemas and barium follow-through studies were used as part of large and small bowel obstruction evaluation but current practice means that use has been superseded.

Many investigators advocate a 3-phase protocol for assessing suspected acute mesenteric ischemia. The unenhanced phase can be valuable if mural hyperdensity related to intramural hemorrhage is identified. This finding is a specific indicator of ischemia but is not required in all cases for the diagnosis of bowel ischemia.[37] The absence of positive oral contrast is essential for detection of bowel wall enhancement in suspected ischemia. Intraluminal fluid acts as a good negative oral contrast agent in cases of bowel obstruction. Positive oral contrast in the setting of