CT imaging of blunt and penetrating bowel and mesenteric injury

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Learning objectives

1. To identify the signs of bowel and mesenteric trauma on multi-detector computed tomography (MDCT) imaging.

2. To identify injuries which require surgical intervention as opposed to those that can be treated conservatively.

3. To review the common pitfalls in image interpretation in acute trauma setting.
Background

Bowel and mesenteric injuries are less common compared to solid organ injuries in abdominal trauma. However, they are still the 3rd most common type of injury, detected in 5% of blunt abdominal trauma patients on laparotomy.

Clinical examination in the context of severe trauma can be unreliable as abdominal pain is non-specific. Patients may have other distracting injuries or may be sedated and intubated, making clinical evaluation virtually impossible. Imaging has an important role in the management of bowel and mesenteric injuries, as delay in diagnosis and management results in significant morbidity and mortality.

MDCT is now the standard for imaging in patients with trauma, including penetrating injury, which would have previously resulted in the patient undergoing laparotomy without any imaging. MDCT allows for quick evaluation with less degradation of images due to motion artefact. It has a high negative predictive value ruling out injuries in patients with significant mechanisms of injury, allowing for a quicker discharge. It has developed an important role both in the initial evaluation and follow-up in patients with trauma.
Bowel Injury

1. In penetrating trauma, any segment of the gastrointestinal tract in the path of the injury can be injured. Colonic injuries are more common in penetrating trauma compared with blunt trauma, particularly in transverse colon due to its close approximation to the anterior abdominal wall. Stomach lacerations are also more commonly associated with penetrating trauma (Fig 1).

2. In blunt trauma, the mechanisms of injury can include crush injury from direct trauma, shearing injury between fixed and mobile segments of bowel or bursting injury as a result of increased abdominal pressure. Small bowel is more commonly affected and injuries are more common in proximal jejunum, near the ligament of Treitz, the distal ileum and near the ileocaecal valve (Fig 2 & 3).

3. Significant bowel injury is defined as a complete tear of the bowel wall or an incomplete tear extending from the serosa to the mucosa but not involving the mucosa. These injuries, which result in disruption or perforation, require surgical management. Non-significant bowel injuries include a haematoma or a tear limited to the serosa, which can be treated conservatively.

4. **Highly specific signs of bowel injury include:**
   - Bowel discontinuity - this is an uncommon finding, particularly in blunt trauma where the bowel wall disruption may be small.
   - Extra-luminal air - this is a highly specific sign of significant bowel injury but is not sensitive (Fig 4)
   - Contrast extravasation - leakage of contrast from the bowel is a highly specific sign of significant bowel injury (Fig 5 & 6). However, oral contrast is usually not administered in acute trauma setting and there might not be a contrast leak due to poor bowel distension.

Mesenteric Injury

1. Significant mesenteric injuries include active mesenteric bleeding, disruption of the mesentery and mesenteric injury associated with bowel ischemia. Isolated mesenteric stranding or haematomas are considered non-significant and can be treated conservatively.

2. **Highly specific signs of mesenteric injuries include:**
   - Active contrast extravasation - this is a highly specific sign of significant mesenteric injury and requires surgical intervention (Fig 7 & 8).
   - Termination of mesenteric vessel - abrupt termination of a vessel whether arterial or venous in origin is a specific sign of mesenteric injury and requires evaluation of bowel wall enhancement pattern to rule out bowel ischemia (Fig 9 & 10).
• Mesenteric vascular beading - this feature presents as irregularity of the mesenteric vessels and is indicative of vascular injury which may result in bowel ischemia (Fig 11).
• Mesenteric haematoma - well-defined haematomas without any evidence of bowel involvement is highly specific for mesenteric injury, though it can be treated conservatively (Fig 12).

Non-specific Signs Of Injury For Bowel And Mesentery

Bowel wall thickening

1. Localized bowel wall thickening in the context of trauma usually indicates a bowel wall contusion or haematoma, which may not be associated with significant injury and can be treated conservatively. However, mesenteric vascular injuries may also result in bowel wall thickening. It is important to evaluate the bowel enhancement to exclude ischemia.

2. Diffuse bowel wall thickening is atypical for contusion and may represent fluid overload or hypoperfusion complex. Hypoperfusion complex, or shock bowel, may demonstrate other findings such as flattening of the IVC and increased bowel and adrenal enhancement (Fig 13 & 14).

Mesenteric stranding

1. Haziness and streaking of the mesentery may be secondary to bowel injury, particularly if there is associated bowel wall thickening (Fig 15 & 16). However, it may also result in isolation due to mesenteric injury. Mesenteric injuries may also cause bowel wall thickening due to vascular compromise.

Common Signs of Bowel and Mesenteric Injury

Intra-abdominal fluid

• Presence of intra-peritoneal fluid is non-specific and may be present in mesenteric or bowel injury, particularly if it is in keeping with haemoperitoneum and there is no solid organ injury (Fig 17).

• Retroperitoneal fluid indicates injury to retroperitoneal segment of the bowel and tends to localize to the site of injury. Fluid around the duodenum is strongly suggestive of bowel injury (Fig 18).

Abdominal wall injury

• Abdominal wall injuries can be seen in significant blunt and penetrating trauma and are evident as fat stranding within the subcutaneous tissues, haematomas and defects in abdominal wall musculature (Fig 19 & 20).

Common Interpretation Pitfalls
1. The specific signs of significant bowel injury such as extra-luminal gas or contrast leak from the bowel are not present in the majority of cases and may be subtle in early stages (Fig 21,22 & 23). If oral contrast is administered, there may not be contrast leak from the bowel if the bowel is not well-distended. It is therefore very important to be vigilant and look for secondary signs of bowel injury such as bowel wall thickening and free fluid, particularly in the absence of solid organ injury.

2. Presence of free intra-peritoneal gas may indicate bowel disruption. However, free pockets of intra-peritoneal gas may also be present secondary to diagnostic peritoneal lavage, urinary catheterization in a patient with intra-peritoneal bladder rupture, due to mechanical ventilation or barotrauma. It is important to keep the above causes in mind when evaluating images of patients with trauma.

3. Intra-peritoneal bladder rupture with subsequent cystography may result in contrast extravasation within the peritoneal cavity. The appearances may mimic contrast leakage from bowel if oral contrast is administered (Fig 24).

4. Most bowel or mesenteric injuries are associated with injuries to other intra-abdominal organs. Therefore all intra-abdominal structures need to be evaluated for possible injury (Fig 25).
Fig. 1: Penetrating injury to the stomach with a defect in the anterior gastric wall (red arrow), associated with a small haematoma (blue arrow).

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Fig. 2: Blunt trauma to the abdomen with thickening of the small bowel near the ligament of Treitz (blue arrow) and high-density fluid within the proximal jejunum in keeping with haemorrhage (yellow arrow). There is also presence of free intra-peritoneal gas in keeping with perforation (red arrow).

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Fig. 3: Caecal haematoma following blunt abdominal trauma (yellow arrow). The patient was managed conservatively.

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Fig. 4: Patient with blunt abdominal trauma with thickening of the duodenum (green arrow) and pocket of gas in keeping with perforation (red arrow).

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Fig. 5: Patient with penetrating injury to the rectum. Scan performed after rectal contrast insertion demonstrates contrast extravasation (blue arrow). A tiny pocket of gas is also visible in keeping with further evidence of full thickness bowel wall perforation (red arrow)

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Fig. 6: Patient with penetrating injury to the rectum. Scan performed after rectal contrast insertion demonstrates contrast extravasation (blue arrow). A tiny pocket of gas is also visible in keeping with further evidence of full thickness bowel wall perforation (red arrow).

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**Fig. 7:** Patient with gun shot injury to the abdomen. There is a mesenteric haematoma with contrast extravasation in keeping with haemorrhage (yellow area). Patient also had significant bowel injury, with pockets of free intra-peritoneal gas visible in keeping with perforation (red arrow).

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**Fig. 8:** Patient with gun shot injury to the abdomen. There is a mesenteric haematoma with contrast extravasation in keeping with haemorrhage (yellow area). Patient also had significant bowel injury, with pockets of free intra-peritoneal gas visible in keeping with perforation (red arrow).

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Fig. 9: Patient involved in a high speed road traffic accident. There is traumatic avulsion of the coeliac axis with absence of contrast at the origin of the vessel (blue arrow). There is retrograde filling of the vessel from the superior mesenteric artery (red arrow).

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**Fig. 10:** Patient involved in a high speed road traffic accident. There is traumatic avulsion of the coeliac axis with absence of contrast at the origin of the vessel (blue arrow). There is retrograde filling of the vessel from the superior mesenteric artery (red arrow).

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**Fig. 11:** Patient with gun shot injury to the abdomen. There is impression of beading of the mesenteric vessel in keeping with mesenteric injury (red arrow). There is also bowel perforation with pockets of free intraperitoneal gas visible (yellow arrow).

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Fig. 12: Patient with blunt trauma to the abdomen. There is a small mesenteric haematoma present with minor streaking (blue arrow). The adjacent loops of bowel are unremarkable.

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Fig. 13: Patient with blunt abdominal trauma. There are signs of shock bowel syndrome with hyperenhancement of the adrenal glands, flattening of the IVC (red arrow) and diffuse bowel wall thickening and hyperenhancement of the small bowel (yellow arrow). There is also significant injury to the ascending colon with perforation (blue arrow).

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Fig. 14: Patient with blunt abdominal trauma. There are signs of shock bowel syndrome with hyperenhancement of the adrenal glands, flattening of the IVC (red arrow) and diffuse bowel wall thickening and hyperenhancement of the small bowel (yellow arrow). There is also significant injury to the ascending colon with perforation (blue arrow).

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Fig. 15: Patient with blunt abdominal trauma. There is localized bowel wall thickening associated with mild mesenteric streaking (blue arrows). The appearances are in keeping with bowel injury which was treated conservatively.

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Fig. 16: Patient with blunt abdominal trauma. There is localized bowel wall thickening associated with mild mesenteric streaking (blue arrows). The appearances are in keeping with bowel injury which was treated conservatively.

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Fig. 17: There is increased stranding around the pancreatic head and duodenum in keeping with injury secondary to blunt trauma (red arrow). Free fluid is present in the upper abdomen (yellow arrow).

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**Fig. 18:** There is thickening of the 2nd part of the duodenum with fluid and streaking around it, in keeping with small bowel injury (yellow arrow). Periduodenal haematoma is a sensitive sign for duodenal injury

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**Fig. 19:** Penetrating injury to the left side of the abdomen. The skin defect is visible (yellow area) and there is a haematoma with active bleeding (red arrow) in the anterior abdominal wall.

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**Fig. 20:** Patient with seatbelt injury following an RTA. There is streaking and haematoma of the subcutaneous fat of the anterior abdominal wall (yellow arrow).

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Fig. 21: Penetrating injury to the anterior abdominal wall demonstrating the site of injury and the defect within the musculature (yellow arrow). There is some thickening of the adjacent transverse colon with a tiny pocket of extra-luminal gas (red arrow). This was the only evidence of perforation on the initial CT and was missed. The patient was treated conservatively. Subsequent CT scan performed 24 hours later demonstrates more extra-luminal gas (green arrow), increased mesenteric changes and gas within the anterior abdominal wall (blue arrow). The patient was subsequently taken to theatre for surgical intervention.

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Fig. 22: Penetrating injury to the anterior abdominal wall demonstrating the site of injury and the defect within the musculature (yellow arrow). There is some thickening of the adjacent transverse colon with a tiny pocket of extra-luminal gas (red arrow). This was the only evidence of perforation on the initial CT and was missed. The patient was treated conservatively. Subsequent CT scan performed 24 hours later demonstrates more extra-luminal gas (green arrow), increased mesenteric changes and gas within the anterior abdominal wall (blue arrow). The patient was subsequently taken to theatre for surgical intervention.

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Fig. 23: Penetrating injury to the anterior abdominal wall demonstrating the site of injury and the defect within the musculature (yellow arrow). There is some thickening of the adjacent transverse colon with a tiny pocket of extra-luminal gas (red arrow). This was the only evidence of perforation on the initial CT and was missed. The patient was treated conservatively. Subsequent CT scan performed 24 hours later demonstrates more extra-luminal gas (green arrow), increased mesenteric changes and gas within the anterior abdominal wall (blue arrow). The patient was subsequently taken to theatre for surgical intervention.

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**Fig. 24:** Patient with severe blunt trauma and contrast within the peritoneal cavity outlining the bowel loops. The contrast was present secondary to bladder rupture and cystography. Similar appearances may be present if there is administration of oral contrast and a significant bowel perforation.

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**Fig. 25:** Patient with penetrating injury. There is a defect within the posterior wall of the stomach (yellow area) and a pocket of free gas is visible. There is also a splenic injury evident (red arrow).

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Conclusion

Bowel and mesenteric injuries, though uncommon, can result in significant morbidity and mortality. The specific signs of injury, particularly with respect to the bowel, are not seen in majority of the cases. It is important to evaluate the images for any secondary signs of bowel and mesenteric injury, particularly if there is absence of solid organ injury. Common causes of misinterpretation, resulting in free air or contrast within the abdomen, should be borne in mind when evaluating the images to prevent misdiagnosis and unnecessary surgical intervention.
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