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## **EDUCATION EXHIBIT**

# Evaluation of Bowel and Mesenteric Blunt Trauma with Multidetector CT<sup>1</sup>

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CME

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## LEARNING OBJECTIVES

After reading this article and taking the test, the reader will be able to:

■ Recognize the CT signs of bowel and mesenteric injuries from blunt trauma.

• Differentiate CT findings indicative of significant injury from those indicative of nonsignificant injury.

■ Identify CT features that may mimic bowel and mesenteric injuries in the setting of blunt abdominal trauma.

#### SUPPLEMENTAL MATERIAL

Movie clips to supplement this article are available online at radiographics .rsnajnls.org/cgi /content/full /26/4/1119/DC1.

## **TEACHING POINTS** See last page

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Bowel and mesenteric injuries are detected in 5% of blunt abdominal trauma patients at laparotomy. Computed tomography (CT) has been shown to be accurate for the diagnosis of bowel and mesenteric injuries and is the diagnostic test of choice in the evaluation of blunt abdominal trauma in hemodynamically stable patients. Specific CT findings of bowel and mesenteric injuries include bowel wall defect, intraperitoneal and mesenteric air, intraperitoneal extraluminal contrast material, extravasation of contrast material from mesenteric vessels, and evidence of bowel infarct. Specific signs of mesenteric injury are vascular beading and abrupt termination of mesenteric vessels. Less specific signs of bowel and mesenteric injuries include focal bowel wall thickening, mesenteric fat stranding with focal fluid and hematoma, and intraperitoneal or retroperitoneal fluid. When only nonspecific signs of bowel and mesenteric injuries are seen on CT images, correlation of CT features with clinical findings is necessary. A repeat CT examination after 6-8 hours if the patient's condition is stable may help determine the significance of these nonspecific findings.

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## Introduction

Bowel and mesenteric injuries are detected in 5% of blunt abdominal trauma patients at laparotomy (1-3) and are the third most common type of injury from blunt trauma to abdominal organs (4-7). Three basic mechanisms may cause bowel and mesenteric injuries of blunt trauma: Direct force may crush the gastrointestinal tract; rapid deceleration may produce shearing force between fixed and mobile portions of the tract; and a sudden increase in intraluminal pressure may result in bursting injuries (8).

The common sites of blunt trauma injury in the small bowel are the proximal jejunum, near the ligament of Treitz, and the distal ileum, near the ileocecal valve. In these regions, mobile and fixed portions of the gut are continuous and therefore are susceptible to shearing force (9).

Delayed diagnosis of bowel and mesenteric injuries results in increased morbidity and mortality, usually because of hemorrhage or peritonitis that leads to sepsis (10-15). Although abdominal pain from peritoneal irritation may be a clinical manifestation of bowel and mesenteric blunt trauma injuries, this symptom is nonspecific; in addition, it might not be present when the patient is initially evaluated. Furthermore, if the patient has concomitant head and spinal cord trauma, which make abdominal assessment difficult, the results of a physical examination may not be reliable. The use of results of clinical assessment as the sole indication for surgery has led to a negative laparotomy rate as high as 40% (7,16,17). Patients in whom abdominal injury is suspected can be evaluated with various diagnostic tests, including peritoneal lavage, ultrasonography (US), and computed tomography (CT) (8).

Diagnostic peritoneal lavage has a sensitivity greater than 90% for the detection of hemoperitoneum (18–20), but it is not specific and not reliable for the assessment of retroperitoneal injuries (17–21). In addition, like any invasive procedure, diagnostic peritoneal lavage carries some risks. Bowel perforation may be missed at lavage in up to 10% of cases in which the diagnostic procedure is performed soon after blunt abdominal trauma has occurred (22). Diagnostic peritoneal lavage performed before CT may compromise the interpretation of the CT study, since fluid and air may be present within the peritoneal cavity as a result of lavage.

Focused assessment with US in the trauma setting has a sensitivity of 86% and specificity of 98% for the detection of free intra-abdominal fluid (23), but it is nonspecific with regard to organ injury. Multidetector CT is more sensitive and specific than diagnostic peritoneal lavage, abdominal US, and clinical examination for the diagnosis of bowel and mesenteric injuries (9), and it has become the diagnostic test of choice for the evaluation of blunt abdominal trauma in he-



**Figure 1.** Jejunal perforation in a 66-year-old woman after a motor vehicle accident. Axial CT image shows hypervascular thickened jejunum with a suspicious defect (curved arrow) and with focal fluid, fat stranding, and extraluminal air (straight arrow) adjacent to jejunal loops. The patient later underwent resection of a 20-cm segment of the small bowel. No mesenteric injury was found at surgery.

modynamically stable patients (24). The results of various studies show sensitivities of 69%-95%and specificities of 94%-100% for the diagnosis of bowel and mesenteric injuries with CT (25– 28). The use of multidetector CT for evaluation of blunt abdominal trauma helps significantly reduce the amount of time required to perform the examination and the number and severity of motion artifacts and helps improve blood vessel opacification and solid organ enhancement (15).

Numerous CT signs of bowel and mesenteric injuries secondary to blunt abdominal trauma have been described in the literature. The main goal in evaluating these signs is to distinguish significant bowel and mesenteric injuries that require surgical intervention from those that can be managed nonsurgically.

#### Teaching Point

Significant bowel injury is defined as either a complete tear of the bowel wall or an incomplete tear that involves the serosa and that extends to but does not involve the mucosa. Nonsignificant bowel injuries include a hematoma and a tear limited to the serosa.

## Significant mesenteric injuries include active mesenteric bleeding, disruption of the mesentery, and mesenteric injury associated with bowel ischemia. An isolated mesenteric hematoma is considered nonsignificant.



Teaching

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Figure 2. Bowel injuries in a 37-year-old male pedestrian struck by a motor vehicle. (a) Axial CT image shows free air (curved arrow) and free oral contrast material in the left upper quadrant, adjacent to the jejunum (arrow). (b) Axial CT image at a level lower than a shows a thickened wall of the transverse colon with decreased enhancement (arrows). Traumatic devascularization of the left kidney (\*) also is visible on both images. The patient underwent a partial small-bowel resection and primary surgical repair for jejunal rupture and necrosis, a segmental resection for transverse colon necrosis, and repair of a colonic serosal tear distal to the necrotic transverse colon. No mesenteric injury was seen at surgery.

In this article, CT signs of bowel and mesenteric blunt trauma are described and correlated with surgical results. Although it is not often possible to separate bowel and mesenteric injuries, we discuss the performance of CT separately for each type of injury as well as for both types in combination.

The discussion is based on a blinded review of helical CT images acquired in 54 consecutive patients with bowel injury, mesenteric injury, or combined injuries and in 42 patients without bowel and mesenteric injuries between December 2000 and December 2003. In all cases, there was surgical confirmation of CT findings. All patients were imaged on a four-section multidetector CT scanner (LightSpeed QX/i; GE Medical Systems, Milwaukee, Wis). Our trauma CT protocol included the administration of an oral contrast medium (ioxithalamate, Telebrix; Mallinckrodt, Bloomington, Ind) with a 2.4% concentration (18 mL of Telebrix diluted with 750 mL of water) and of 120 mL of an intravenous contrast medium (iohexol, Omnipaque; GE Medical Systems) at a rate of 3 mL/sec. Scanning was performed with a 70-second delay and with a section thickness of 5 mm, pitch of 0.75, and overlap of 2.5 mm.

There were 44 patients with primary bowel injuries and 35 patients with mesenteric injuries. With respect to the location of bowel injuries, two patients (5%) had injuries to the stomach; five (11%), to the duodenum; 11 (25%), to the jejunum; three (7%), to the cecum or ascending colon; five (11%), to the transverse colon; one (2%), to the descending colon; two (5%), to the sigmoid colon; and 15 (34%), to multiple sites.

## **CT** Findings

Some bowel findings, such as bowel wall discontinuity, extraluminal contrast material, and free intraperitoneal or retroperitoneal air, are specific to bowel injury, whereas others may be seen also in mesenteric injury. Likewise, some mesenteric findings, such as hematoma, extravasation of intravenous contrast material, and abrupt termination and beading of vessels, are specific to mesenteric injury, whereas others may be seen also in bowel injury.

## Findings Specific to Bowel Injury

Bowel Wall Discontinuity.—This is an uncommon finding on CT images (8). Bowel wall discontinuity was present in only four (7%) of 54 patients with bowel and mesenteric injuries (Fig 1). The relative infrequency of observations of this feature is likely due to the small size of the discontinuities, which are evident at surgery only with careful inspection.

Extraluminal Contrast Material.—This sign was present in only three (6%) of 54 patients with bowel and mesenteric injuries (Fig 2). The infrequency of such findings may be due to a lack of



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Figure 3. Ruptured bladder in a 43-year-old female pedestrian who was struck by a car. (a) Axial abdominal CT image shows intraperitoneal areas of free contrast material (straight arrows) and free air (curved arrow). (b) Axial CT image shows a retroperitoneal area of extraluminal contrast enhancement (arrow). These features mimic those found in bowel injury but, instead, are secondary to a bladder rupture, which was found at surgery.

bowel distention during CT or to the transience of extraluminal contrast enhancement. There is also the potential for a false-positive finding when there is an intraperitoneal extension of contrast material because of a bladder injury (Fig 3).

Extraluminal Air.-Extraluminal intraperitoneal air is highly specific for a diagnosis of bowel perforation, but it also may be observed in the absence of bowel perforation (Fig 4). Despite the high specificity of this sign, its sensitivity is usually low. It was seen in only 11 (20%) of 54 patients with bowel and mesenteric injuries. In most patients with full-thickness bowel injury, pneumoperitoneum is not observed on CT scans at admission (29,30). Gas originating from a bowel rupture usually accumulates in locations deep to the anterior abdominal wall and may be seen also in the porta hepatis, mesentery or mesenteric veins, and portal vein (Fig 5) (31). Other causes of foci of intraperitoneal and extraluminal air include mechanical ventilation and pulmonary barotrauma (31), peritoneal lavage prior to CT, pneumothorax, chest injury, entry of air via the female genital tract (fallopian tubes), and intraperitoneal laceration of the bladder secondary to cystography (31,32). Pseudopneumoperitoneum, defined as the presence of air confined to the in-



Figure 4. False-positive findings of bowel injury in a 22-year-old woman who was a front-seat passenger and was wearing a seat belt during a motor vehicle accident. Axial CT image shows thickening of the wall of the ascending colon, with adjacent fat stranding (straight arrow), free air (curved arrows), and hematoma of the right oblique internus muscle (\*). Although the free air was initially attributed to bowel injury, no bowel or gastric injuries were found at diagnostic laparoscopy. The free intraperitoneal air may instead be attributable to traumatic pneumothorax.

ner layer of the abdominal wall and external to the parietal peritoneum, may mimic true pneumoperitoneum (32), and for this reason it represents a diagnostic pitfall (Fig 6).



Figure 5. Bowel and mesenteric injuries in a 70-year-old male pedestrian struck by a car. (a) Axial CT image shows a trace of fluid that extends from the cecum, with pericecal fat stranding and thickening of the lateroconal fascia (curved arrow) and focal retroperitoneal air (straight arrow). (b) Axial CT image shows air in the superior mesenteric vein (arrow) as well as contrast enhancement of the duodenal diverticulum (arrowhead), a finding that simulates duodenal injury. At surgery, full-thickness cecal and mesenteric tears were identified and repaired.



#### a.

Figure 6. Bowel and mesenteric injuries in a 56-year-old woman after a motor vehicle accident. (a) Axial CT image at the level of the lower abdomen shows a segment of the small bowel with decreased enhancement (straight arrow) and free fluid (curved arrow). (b) Axial CT image at the level of the middle abdomen shows mesenteric fat stranding (curved arrow), subcutaneous emphysema extending to the extraperitoneal space and producing pseudopneumoperitoneum (arrowheads), and hyperattenuating mesenteric nodes (straight arrows) that might be mistaken for foci of extravasated contrast material. At surgery, a 30-cm segment of the distal ileum that had been separated from its mesentery by shearing force, with resultant devascularization, was resected.

In addition to these bowel injury-related findings, there were two additional findings of free intraperitoneal air in patients in whom only serosal tears of the bowel were found. Both patients also had a Foley catheter in place because of intraperitoneal bladder rupture, and this fact helps explain the presence of the free air. The findings of extraluminal intraperitoneal air in these patients may be considered false-positive.

Figure 7. Splenic laceration with active bleeding in a patient after a fall from a height of 6 feet onto a pole. Axial CT image shows apparent thickening of the intestinal wall in several small-bowel loops (arrows), an appearance caused by insufficient bowel distention. At surgery, no small-bowel injury was identified, but splenic laceration with active bleeding was seen.





a.

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Figure 8. False-positive findings of bowel injury in a 52-year-old woman after a jump from a height of four stories. (a) Axial CT image shows a thickened cecal wall (straight arrow) and a posterior abdominal wall tear on the right side (curved arrow), findings suggestive of bowel injury. (b) Axial CT image shows the thickened cecal wall (arrows) with attenuation similar to that of water, a finding suggestive of shock bowel. No bowel injuries were found at emergent laparotomy, and the cecal wall thickening was probably related to hypoperfusion complex.

## Findings Less Specific to Bowel Injury

Bowel Wall Thickening.—Twelve (55%) of 22 patients with small-bowel injury and four (19%) of 21 patients with large-bowel injury had bowel wall thickening. Isolated, localized, unequivocal bowel wall thickening in the context of trauma usually indicates bowel wall contusion and may not be associated with significant injury (24). Our false-positive findings of small-bowel wall thickening could represent a lack of bowel distention (Fig 7). Diffuse small-bowel wall thickening is

atypical for contusion and may represent bowel edema secondary to systemic volume overload or to hypoperfusion complex (shock bowel) (33) (Fig 8). Hypoperfusion complex is usually associated with other findings of shock, such as a flat inferior vena cava, increased enhancement of adrenal glands and bowel, and pancreatic and retroperitoneal edema (Fig 8). However, systemic volume overload, in most cases after intravenous overhydration, may manifest as bowel wall thickening alone (Fig 9).

Abnormal Bowel Wall Enhancement.-Increased bowel wall enhancement may represent bowel injury with vascular involvement (Fig 10) or may be part of the hypoperfusion complex (Fig 11). A possible cause is increased vascular

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Figure 9. Axial CT image in a 25-year-old man after a motor vehicle accident shows evidence of shock bowel (arrowheads) likely related to fluid resuscitation, without flattening of the inferior vena cava (arrow). At surgery, hepatic laceration with active bleeding, renal laceration, and aortic dissection were noted. No small-bowel injury was identified.



a.

Figure 10. Bowel and mesenteric injuries in a 32-year-old woman after a motor vehicle accident. Axial (a) and coronal (b) CT images show abnormal hypervascular thickened jejunal loops (arrows in b) and high-attenuation foci of intraperitoneal fluid (arrowheads in a) consistent with blood. No free or focal air was visible on CT images. At surgery, mesenteric tears in a middle segment of the jejunum and a distal segment of the ileum were found, with bleeding mesenteric vessels and multiple areas of perforation in the middle segment of the jejunum and the proximal and middle segments of the ileum. The affected segments of small bowel were resected.



Figure 11. Bowel injury in an 18-year-old man with severe head trauma from a motor vehicle accident. Axial CT image shows hypervascular thickened jejunal loops with mucosal feathering (arrows), features characteristic of shock bowel. The patient died 1 day after hospital admission.





**Figure 12.** Bowel and mesenteric injuries in a 37-year-old woman after a motor vehicle accident in which she was a rearseat passenger. CT images show hypervascular thickened segments of small bowel, especially evident in the left upper quadrant (\*). Axial source images also show a tear in the abdominal wall on the right side (arrow in **a**) and mesenteric fat stranding (arrow in **b**). Oblique coronal image also shows unenhanced small-bowel loops in the lower abdomen (arrow in **c**). At surgery, shearing injury to the small-bowel mesentery was found, with active bleeding and with complete devascularization and necrosis of a 90-inch (229-cm) segment of the distal jejunum and ileum and a perforation of the middle jejunum.

permeability due to hypoperfusion, which may result in interstitial leakage of contrast material (31). Patchy or irregular increases in bowel wall enhancement after the administration of intravenous contrast material are suggestive but not diagnostic of full-thickness injury (24). On the other hand, areas of decreased or absent contrast enhancement are indicative of ischemic bowel (Fig 12). Lack of enhancement was uncommon in this series; it was present in only seven (13%) of 54 patients. However, the finding was specific, with only one false-positive case.

*Mesenteric Features.*—Mesenteric foci of fluid, air, or fat stranding may be secondary to bowel injury alone (Fig 13). Retroperitoneal air is seen





c.

with duodenal injury or injury to the retroperitoneal aspect of the ascending or descending colon (Fig 5).

## Findings Specific to Mesenteric Injury

**Mesenteric Extravasation.**—This sign has a specificity of 100% for the diagnosis of significant mesenteric injury, but it was seen in only nine (17%) of 54 patients with bowel and mesenteric injuries (Fig 14). A finding of mesenteric extravasation is usually an indication for urgent laparotomy.



Figure 13. Bowel injury in a 77-year-old man after a motor vehicle accident. Axial CT images show a defect in the proximal jejunum (arrow in **a**) and a mesenteric hematoma in the left upper quadrant (arrow in **b**). Although no free air was seen on CT images, a blowout perforation in the antimesenteric aspect of the proximal jejunum was found at surgery. No mesenteric injury was described in the surgical report.

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Figure 14. Bowel and mesenteric injuries in a 52year-old woman who was a front-seat passenger during a motor vehicle accident. (a) Coronal CT image shows an unenhanced segment of small bowel, a feature consistent with a bowel infarct (arrow). (b, c) Axial images show mesenteric extravasation (arrow in **b**), mesenteric hematoma (arrow in c), and thickening and hypervascularity of the proximal jejunum (\*). At surgery, an extensive small-bowel mesenteric tear was found, with active bleeding from a jejunal branch of the superior mesenteric artery and with ischemia in a 20-cm-long segment of jejunum; the segment was resected. A small serosal tear also was found in the jejunum proximal to the margin of resection and in the cecum and was repaired.



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Figure 15. Mesenteric injuries due to a motor vehicle accident. (a) Axial CT image shows a change in caliber, or beading, of some mesenteric vessels in the area of injury (arrows). At surgery, a tear was found in the ileocecal mesentery that warranted resection of the terminal ileum, cecum, and ascending colon. (See Movie 1 at radiographics .rsnajnls.org/cgi/content/full/26/4/1119/DC1.) (b) Axial CT image from another patient shows beading of a mesenteric vessel in the area of injury (arrows). At surgery, a hematoma was found in the jejunal mesentery. (See Movie 2 at radiographics.rsnajnls.org/cgi/content/full/26/4/1119/DC1.)

Mesenteric Vascular Beading.—This feature appears on CT images as an irregularity in mesenteric vessels (Fig 15). Like mesenteric extravasation of contrast material, it is indicative of vascular injury. In our patient series, the finding of mesenteric vascular beading was sensitive for the diagnosis, and it was present in 21 (39%) of 54 patients with bowel and mesenteric injuries; in other words, it was observed more frequently than was active extravasation of contrast material.

Termination of Mesenteric Vessels.—Abrupt termination of a mesenteric artery or vein is also an indication of vascular injury. It was seen in 19 (35%) of 54 patients and thus was more common than extravasation of contrast material. The finding was false-positive in only one patient; therefore, it was highly specific for significant mesenteric injury in our patient series (Figs 16, 17).

## Less Specific Findings

*Mesenteric Infiltration.*—Haziness and fat stranding in the mesentery may indicate mesenteric injury with or without bowel wall injury. This finding had the highest sensitivity for mesenteric injury and was seen in 37 (69%) of 54 patients but is nonspecific. Retractile mesenteritis may simulate mesenteric injury, but it can be differentiated from mesenteric infiltration by the well-defined contour of the abnormally thickened mesentery and the presence of flat mesenteric lymph nodes surrounded by halos (Fig 18).



Figure 16. Multiple injuries in a 58-year-old man after a 25-foot fall from a roof. Sagittal reformatted image from abdominal CT shows lesser sac stranding (arrow) and abrupt termination of the left gastric artery (arrowhead) at the level of stranding. (See Movie 3 at radiographics .rsnajnls.org/cgi/content/full/26/4/1119/DC1.)

Mesenteric Hematoma.-Well-defined mesenteric hematoma indicative of laceration of a mesenteric vessel was present in 21 (39%) of 54 patients. This finding was false-positive in only two cases. Although specific to mesenteric injury, mesenteric hematoma does not always indicate a need for surgery. In four of our patients with mesenteric hematoma, the mesentery was not repaired surgically because there was no active bleeding (Fig 19).



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**Figure 17.** Bowel and mesenteric injuries in a 23-year-old man who was ejected from a car during a motor vehicle accident. At surgery, three small-bowel mesenteric tears were found. The most proximal tear was repaired, but the two more distal ones were larger and warranted resection of the affected small-bowel segment. No primary injury to the small bowel was found. Three subserosal tears in the colon also were found, one in the rectosigmoid segment and two in the ascending colon, and were repaired. (a) Coronal CT image at the level of the middle abdomen shows a mesenteric hematoma that extends to the right upper quadrant (arrows). (b) Oblique coronal CT image shows abrupt termination of the left-sided tributaries (arrowhead) of the superior mesenteric vein (*SMV*).



**Figure 18.** Retractile mesenteritis mimicking mesenteric injury in a 63-year-old man after a motor vehicle accident. Axial CT image shows a significant and welldefined increase in attenuation and fat stranding in the root of the mesentery (arrows) associated with flat lymph nodes surrounded by halos of hypoattenuation (arrowheads). At surgery, no mesenteric or bowel injury was found.

**Bowel Features.**—Bowel wall thickening and abnormal enhancement may be secondary to mesenteric injury, indicating vascular compromise (Fig 14). Seventeen (49%) of 35 patients with mesenteric injury had bowel wall thickening (Figs 12, 14) and 12 (35%) of 34 had abnormal bowel wall enhancement (Figs 12, 14). Bowel ischemia secondary to mesenteric injury may not be evident on initial CT images.



**Figure 19.** Mesenteric injury in a 57-year-old man after a fall from a scaffold. Axial CT image shows a hematoma surrounded by fat stranding (arrow) in the splenic flexure mesocolon, with no evidence of active bleeding. At surgery, a nonexpanding mesenteric hematoma was found that did not require repair.

## Common Features in Bowel and Mesenteric Injuries

**Intraperitoneal and Retroperitoneal Fluid.**— Fifty (93%) of 54 patients with either bowel or mesenteric injury had intraperitoneal fluid. However, the specificity is low for both intraperitoneal and retroperitoneal fluid because of other concomitant injuries. The location of the fluid may RadioGraphics



**Figure 20.** Mesenteric lacerations in a 45-year-old man after a head-on automobile collision. Axial CT images show a retroperitoneal hematoma near the cecum (arrow in **a**) and omental fat stranding on the left side of the abdomen (arrowhead in **b**). At surgery, a mesenteric tear with active bleeding was found in the midjejunal area. Despite the absence of obvious jejunal injury, this finding resulted in resection of a short (15-cm) segment of the small bowel. A second mesenteric tear was found near the cecum, with a retroperitoneal hematoma (repaired) and omental bleeding. No bowel injuries were found.

indicate the location of injury. Retroperitoneal fluid may indicate injury of a retroperitoneal segment of bowel. Retroperitoneal blood tends to localize at the site of injury (Fig 20). Hemoperitoneum in the absence of solid organ injury should raise the possibility of bowel or mesenteric injury (24,31).

**Abdominal Wall Injury.**—There is a significant association between abdominal wall injury (tear, hematoma, or "seat belt" sign [subcutaneous fat stranding along the course of the fastened seat belt]) and bowel and mesenteric injuries (34) (Fig 21). Nine (17%) of 54 patients with bowel and mesenteric injuries had abdominal wall injury, compared with three (7%) of 42 patients without bowel and mesenteric injuries.

## Conclusions

Bowel and mesenteric injuries may be significant and require immediate surgery or may be nonsignificant and permit nonsurgical treatment. A number of CT signs are specific to, or indicative of, significant injury. These signs include bowel wall defects; intraperitoneal, mesenteric, or retroperitoneal free air (after other causes of extraluminal air have been excluded); intraperitoneal presence of bowel contrast material; extravasation of contrast material from mesenteric vessels; and evidence of bowel infarct. However, the sensitivity of these signs is low.



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## Two additional signs of

mesenteric injury—mesenteric vascular beading and the abrupt termination of mesenteric vessels—had high specificities in our patient series and were more frequently seen than were signs previously reported to be specific.



**Figure 21.** Mesenteric injuries in a 19-year-old man after a motor vehicle accident. Axial CT image shows a sigmoid mesenteric hematoma (arrow) and a normal appearance of the sigmoid colon (arrowhead). A complete tear of the abdominal wall (\*) is visible in the right lower quadrant. Avulsion of the sigmoid colon mesentery associated with an ischemic sigmoid colon segment (subsequently resected) was found at surgery.

#### Focal bowel

wall thickening and mesenteric hematoma are less specific signs and may be indicative of nonsignificant bowel or mesenteric injury. Focal mesenteric fluid and fat stranding are nonspecific findings and could be due to other injuries. If there is no other explanation for intraperitoneal fluid, bowel or mesenteric injury should be considered.

When nonspecific features of significant bowel or mesenteric injury are the only CT findings, the need for surgical intervention is highly dependent on clinical judgment. Reevaluation with CT within 6-8 hours after the initial evaluation may help to elucidate the significance of such findings. **Acknowledgment:** We thank Carole Leduc for her assistance in the preparation of the manuscript.

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## **Evaluation of Bowel and Mesenteric Blunt Trauma with Multidetector CT**

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Numerous CT signs of bowel and mesenteric injuries secondary to blunt abdominal trauma have been described in the literature. The main goal in evaluating these signs is to distinguish significant bowel and mesenteric injuries that require surgical intervention from those that can be managed nonsurgically.

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Significant bowel injury is defined as either a complete tear of the bowel wall or an incomplete tear that involves the serosa and that extends to but does not involve the mucosa.

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Significant mesenteric injuries include active mesenteric bleeding, disruption of the mesentery, and mesenteric injury associated with bowel ischemia.

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A number of CT signs are specific to, or indicative of, significant injury. These signs include bowel wall defects; intraperitoneal, mesenteric, or retroperitoneal free air (after other causes of extraluminal air have been excluded); intraperitoneal presence of bowel contrast material; extravasation of contrast material from mesenteric vessels; and evidence of bowel infarct.

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Two additional signs of mesenteric injury—mesenteric vascular beading and the abrupt termination of mesenteric vessels—had high specificities in our patient series and were more frequently seen than were signs previously reported to be specific.