



Small Bowel Perforations: What the Radiologist Needs to Know

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The incidence of small bowel perforation is low but can develop from a variety of causes including Crohn disease, ischemic or bacterial enteritis, diverticulitis, bowel obstruction, volvulus, intussusception, trauma, and ingested foreign bodies. In contrast to gastroduodenal perforation, the amount of extraluminal air in small bowel perforation is small or absent in most cases. This article will illustrate the main aspects of small bowel perforation, focusing on anatomical reasons of radiological findings and in the evaluation of the site of perforation using plain film, ultrasound, and multidetector computed tomography equipments. In particular, the authors highlight the anatomic key notes and the different direct and indirect imaging signs of small bowel perforation.

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Introduction

Small bowel perforation is an acute emergency condition due to a transmural lesion, which affects the full thickness of the bowel wall with the communication of the intestinal lumen with the abdominal cavity and the leakage of intestinal content.^{1,2} Early diagnosis, as well as prompt surgical treatment, are essential to reduce the morbidity and the mortality.^{3,4} However, perforation of the small bowel is not a common cause of acute abdomen and can have a traumatic or nontraumatic etiology.²⁻⁸ The traumatic perforations of small bowel are more frequent than nontraumatic ones.^{5-7,9-13} In particular, small bowel traumatic perforation is the third in frequency among abdominal traumatic perforations following liver and spleen ones; these lesions are rarely isolated.⁹⁻¹³

The origin of nontraumatic perforations may be infectious (typhoid fever, HIV, tuberculosis, hook worms; most common in developing countries) or noninfectious (ischemic conditions, Meckel diverticulitis, Crohn's disease, tumors, iatrogenic causes, foreign bodies, and mechanical conditions).⁸⁻¹² Clinical findings of small bowel perforation are usually not specific, sudden acute abdominal pain, vomiting, anorexia, and nausea. In this article, we report our experience, we retrospectively

evaluated all CT reports from 2011-2015 searching for "Intestinal Perforation" and reviewed all the images of exams in which small bowel perforation was diagnosed.

Anatomic Key Notes

The small bowel lies between the stomach and the large bowel and includes the duodenum, jejunum, and ileum. Embryologically, it develops mainly from the midgut; however, the proximal part of the duodenum develops from the caudal foregut.¹⁴ The junction of embryological foregut and midgut is marked by the site of the major duodenal papilla on the medial wall of the second part of the duodenum.¹⁴

The peritoneum is a thin serous membrane consisting of 2 layers that line the abdominal wall (parietal peritoneum) and cover some of the abdominal organs (visceral peritoneum).¹⁴ The peritoneal cavity is a virtual space between the parietal peritoneum and the visceral one.¹⁴ On the other hand, abdominal organs located behind the intraperitoneal space are called "retroperitoneal." The duodenum is intraperitoneal for the first 2-2.5 cm, whereas the remaining duodenum is retroperitoneal; jejunum and ileum are intraperitoneal organs.

Peritoneal ligaments, known as mesentery and omentum divide the peritoneum into 2 compartments, the greater and the lesser sac (Fig. 1).

The peritoneal cavity is divided by the transverse mesocolon in 2 great spaces: the supramesocolic and the inframesocolic spaces. The first is the one above the root of the transverse

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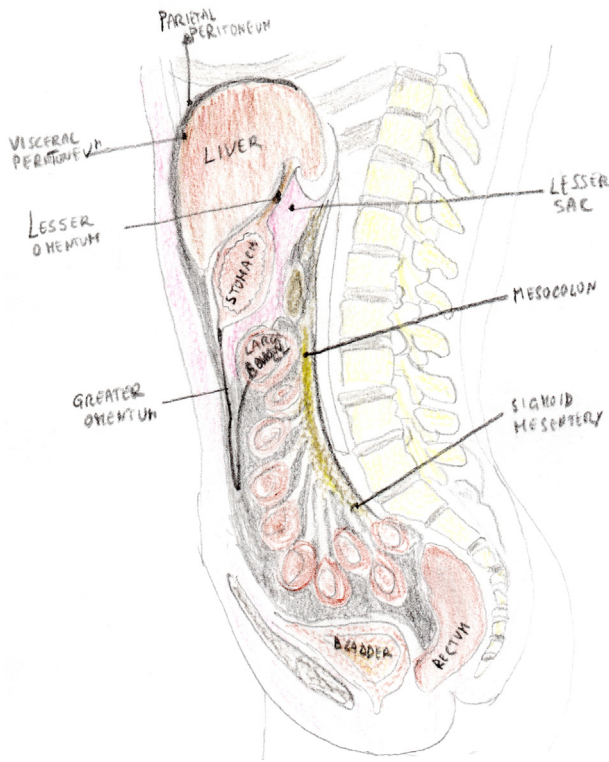


Figure 1 Sagittal view of the abdomen showing main abdominal key notes. (Color version of figure is available online.)

mesocolon and contains liver, stomach and spleen, whereas the latter is located below the root of the transverse mesocolon and contains the small bowel loops.

The supramesocolic space may also be divided into right and left supramesocolic spaces.¹⁴ The first includes the right subphrenic space, anterior right subhepatic space, posterior right subhepatic space (also known as Morrison pouch), and the lesser sac.¹⁴ The left supramesocolic space includes anterior and posterior left perihepatic space, anterior and posterior (or perisplenic) left subphrenic space.¹⁴

According to these anatomic key notes, it is important to keep in mind these useful tips and tricks^{14,15}:

- Gastric or duodenal perforation will result in air bubbles in the supramesocolic compartment. Air bubbles may travel first in the gastroduodenal ligament, then from the hepatoduodenal ligament into the fissure for ligamentum venosum and be detected adjacent to the portal vein.

The organs implied in supramesocolic perforation can be stomach and duodenum and the etiology are usually peptic ulcer disease, neoplasia, and postoperative anastomotic leaks. In particular, penetrating ulcers involving the anterior wall of the stomach or duodenum may perforate directly into the peritoneal cavity, although the ones posterior wall gastric ulcers perforate into the lesser sac.

The inframesocolic space is divided in 4 compartments: right paracolic gutter, right inframesocolic space (between mesentery and ascending colon), left inframesocolic space

(between mesentery and descending colon), and left paracolic gutter.¹⁴ The pelvis is the most lower space of the peritoneal cavity and contains bladder, rectum, sigma, and reproductive system. The pelvic space is composed of paravesical space, in men there is the rectovesical space, in woman there are uterovesical space and uterorectal space (Douglas's space)¹⁴:

- Air bubbles in the inframesocolic compartment may indicate a perforation of small or large bowel.¹⁴ However, the incidence of small bowel perforations is low and may be of various origin (ischemic, inflammatory, infectious, postoperative, bowel obstruction, volvulus, and intussusceptions)⁸⁻¹² and
- perforation of the second and third duodenum segments may result in gas bubbles located just in the retroperitoneal space. The most common location of retroperitoneal gas is the anterior pararenal space and, in this case, gas typically outlines the lateral border of the psoas muscle.

Retroperitoneal cavity contains suprarenal glands, aorta or inferior vena cava, duodenum (second and third part), pancreas, ureteres, colon (ascending and descending), kidneys, esophagus, and rectum.¹⁴

Imaging Findings

Patients with acute abdominal pain and clinical suspicion of bowel perforation, are usually firstly submitted to x-ray. The key direct radiographic sign of bowel perforation is free abdominal gas.¹ However, free air is differently distributed on plain films in the abdominal cavity according to patient positioning and to the perforation site.^{1,16-18}

The sensitivity of plain abdominal radiography ranges from 50%-70% for gastrointestinal perforation, though these rates are lower in cases of early perforations with less than 1 ml of gas.^{1,2}

Abdominal ultrasonography (US) is often performed in patients with abdominal pain, but it is less sensitive than computed tomography (CT) to reveal the cause and the site of the intestinal perforation.^{1,16,19}

Direct ultrasonographic signs of small bowel perforation are: strong reverberation anteriorly to the liver surface, shifting phenomenon and “scissors maneuver,” enhancement of peritoneal stripe. Indirect ultrasonographic signs of bowel perforation are: presence of intraperitoneal free fluid, decreased bowel motility.¹⁸⁻²⁰

CT is more sensitive compared to plain abdominal films to reveal small amounts of free air and multidetector row CT allows in many cases the identification of intestinal perforation site, may provide many suggestive diagnostic and prognostic features of the causing disease and other findings that may occur in emergency as hemoperitoneum.²¹⁻²⁷

Direct CT signs of intestinal perforations are: free gas in the abdominal cavity, visible transmural lesion of intestinal wall, extraluminal leakage of orally administered contrast

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