

Peritoneal and Retro-peritoneal Anatomy and Its Relevance for Cross-Sectional Imaging¹

ONLINE-ONLY CME

See www.rsna.org/education/r_g_cme.html

LEARNING OBJECTIVES

After completing this journal-based CME activity, participants will be able to:

- Discuss the importance of identifying peritoneal anatomy in assessing extent of disease.
- Describe the pathway for the spread of disease across the peritoneal spaces to several contiguous organs.
- Explain interfascial spread of disease across the midline in the retroperitoneum and from the abdomen to the pelvis.

©RSNA, 2012 • radiographics.rsna.org

TEACHING POINTS

See last page

Abbreviations: PACE = prospective acquisition correction, 3D = three-dimensional

RadioGraphics 2012; 32:437–451 • Published online 10.1148/rg.322115032 • Content Codes: **CT** **GI**

¹From the Department of Radiology and Clinical Sciences, Section of Abdominal Imaging, University of Indiana School of Medicine, 550 N University Blvd, Indianapolis, IN 46202. Presented as an education exhibit at the 2009 RSNA Annual Meeting. Received February 22, 2011; revision requested May 9 and received June 27; accepted August 5. For this journal-based CME activity, authors K.S. and F.M.A have disclosed various financial relationships (p 451); all other authors, the editor, and reviewers have no relevant relationships to disclose. **Address correspondence to** T.T. (e-mail: atirkes@iupui.edu).

Introduction

It has become essential that radiologists thoroughly understand the peritoneal spaces and the ligaments and mesenteries that form their boundaries in order to localize disease to a particular peritoneal space and formulate a differential diagnosis on the basis of that location. In this article, we describe in detail the normal anatomy of the peritoneal spaces and the appearance of pathologic involvement of the peritoneal spaces, ligaments, and mesenteries at cross-sectional imaging.

Imaging Modalities

Ultrasonography (US) may depict peritoneal collections or ascites and is used to guide drainage of ascites and large superficial fluid collections. A specific advantage of US is its portability, which allows patients who are ill and who cannot safely be moved from their hospital beds to be imaged. Compared with computed tomography (CT), other advantages of US are its lack of ionizing radiation and lower cost. However, US does not provide global assessment of abdominal or pelvic anatomy.

CT enables accurate evaluation of the complex peritoneal cavity anatomy, which is the key to understanding the pathologic processes that occur there. CT is the most common imaging modality used to detect diseases of the peritoneum. To fully delineate peritoneal anatomy and the extent of disease, we prefer to perform isotropic imaging with coronal and sagittal reformations.

Magnetic resonance (MR) imaging is increasingly used to depict peritoneal disease. Disadvantages of MR imaging include motion artifacts caused by respiration and peristalsis and chemical shift artifacts at the bowel-mesentery interface. In addition, the spatial resolution of MR imaging is lower than that of CT, a characteristic that may make it difficult to assess small peritoneal lesions. Patients who are ill and have peritoneal carcinomatosis, acute pancreatitis, or intraabdominal sepsis may not tolerate prolonged MR imaging examinations (which usually require 30–45 minutes to scan the entire

abdomen and pelvis) and the multiple breath-hold sequences that are required. In contrast, an isotropic CT examination of the abdomen and pelvis conducted with a multidetector scanner of 16 or more rows may be completed within 15 seconds. In addition, difficulties associated with the use of 3.0-T MR imaging in assessing peritoneal disease include increased susceptibility artifacts due to the presence of gas in the bowel and standing wave artifacts on T2-weighted images caused by ascites (1). However, MR imaging has better contrast resolution than CT and can help characterize the internal contents of peritoneal fluid collections (that have only homogeneous low attenuation at CT), a capability that is particularly helpful in the setting of pancreatitis-related fluid collections. Its lack of ionizing radiation is another advantage of MR imaging, making it suitable for use in children and young adults, particularly those who need repeated imaging. Newer MR imaging techniques such as diffusion-weighted imaging are reported to be useful in depicting small peritoneal metastases and metastatic disease in apparently normal-sized lymph nodes (2,3).

Anatomic Definitions

The peritoneum is a thin, translucent, serous membrane and is the largest and most complexly arranged serous membrane in the body. The peritoneum that lines the abdominal wall is called the parietal peritoneum, whereas the peritoneum that covers a viscus or an organ is called a visceral peritoneum. Both types of peritoneum consist of a single layer of simple low-cuboidal epithelium called a mesothelium. A capillary film of serous fluid (approximately 50–100 mL) separates the parietal and visceral layers of peritoneum from one another and lubricates the peritoneal surfaces (4).

The peritoneal cavity is a potential space between the parietal peritoneum, which lines the abdominal wall, and the visceral peritoneum, which envelopes the abdominal organs. In men, the peritoneal cavity is closed, but in women, it communicates with the extraperitoneal pelvis exteriorly through the fallopian tubes, uterus,

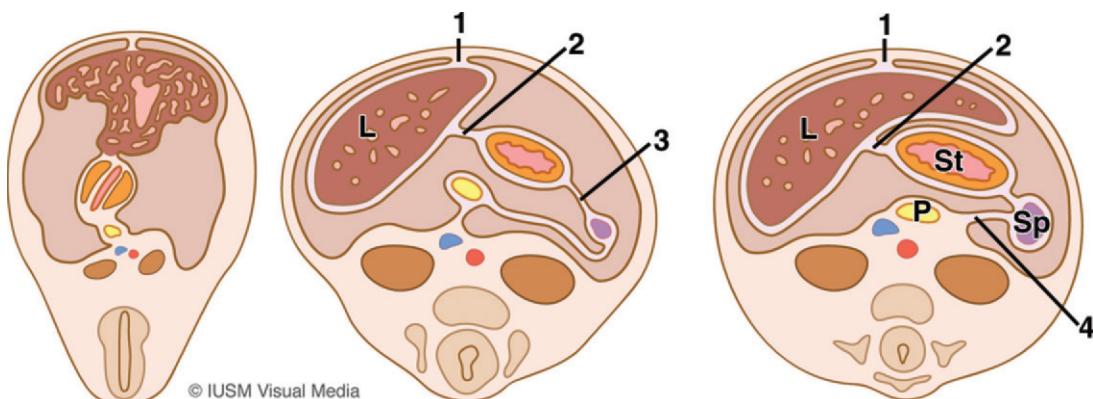


Figure 1. Illustrations show the embryologic development of the dorsal and ventral mesentery at weeks 4 (left), 5 (center), and 6 (right) of gestation, in which the ventral part of the ventral mesentery becomes the falciform ligament (1), the dorsal part of the ventral mesentery becomes the lesser omentum (2), the ventral part of the dorsal mesentery becomes the gastroplenic ligament (3), and the dorsal part of the dorsal mesentery becomes the splenorenal ligament (4). The liver (L) also arises in the ventral mesentery, whereas the stomach (St), spleen (Sp), and pancreatic tail (P) develop in the dorsal mesentery. As the liver expands in the 5th and 6th weeks of gestation, the stomach and spleen are pushed to the left, and the pancreatic tail fuses with the retroperitoneum.

and vagina. Peritoneal ligaments, mesentery, and omentum divide the peritoneum into two compartments: the main region, called the greater sac, and a diverticulum, omental bursa, or lesser sac (5). Peritoneal ligaments are double layers or folds of peritoneum that support a structure within the peritoneal cavity; omentum and mesentery are specifically named peritoneal ligaments. Most abdominal ligaments arise from the ventral or dorsal mesentery.

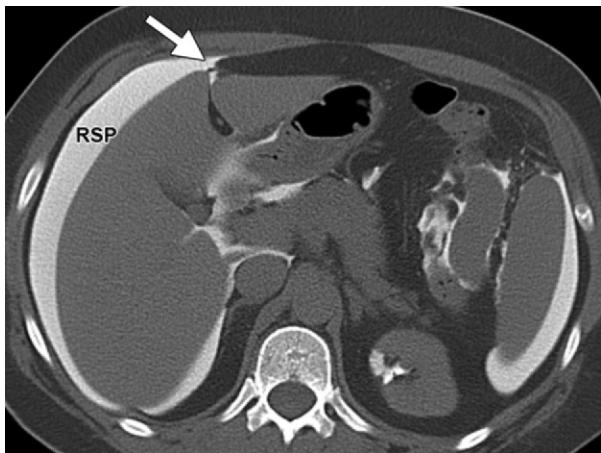
Omentum is a mesentery or double layer of peritoneum that extends from the stomach and duodenal bulb to adjacent organs. The lesser omentum, which is made of two contiguous components called the gastrohepatic and hepatoduodenal ligaments, attaches the stomach and duodenal bulb to the liver. The greater omentum is attached to the stomach and hangs like an apron from the transverse colon.

Mesentery is a double layer of peritoneum that encloses an organ and connects it to the abdominal wall. The mesenteric contents include blood vessels, lymph nodes, nerves, and fat. The most mobile parts of the intestine have a mesentery (eg, the small bowel attached to the retroperitoneum), and the retroperitoneal portions of the

colon may contain remnant mesocolon, a result of its failure to absorb embryonic mesentery.

Basic Embryologic Characteristics

The abdominal cavity provides room for the viscera to grow and shift in position. The primitive gut forms within the abdominal cavity and is suspended by a plane composed of two peritoneal reflections called the primitive mesenteries, which cover the extension of the subperitoneal space from the abdominal walls. The position of the gut within the primitive mesentery plane divides the primitive mesentery into ventral and dorsal portions, which undergo specialization throughout fetal life (Fig 1). Vascular and lymphatic vessels and nerves that supply the abdominal viscera are enfolded within the plane of the primitive mesentery. The liver grows ventral from the gut within the ventral plane. The spleen and pancreas and a major portion of the gut grow within the dorsal plane. The rotations, descents, and resorption of the mesenteric plane take place throughout fetal life. Regardless of the complexity of adult mesenteries, they are derived from a single plane and remain interconnected.



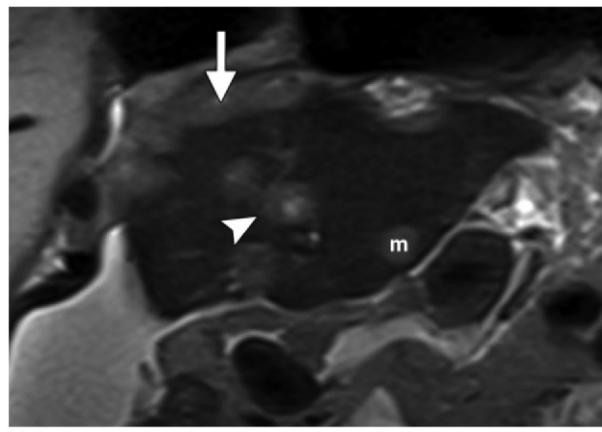
a.



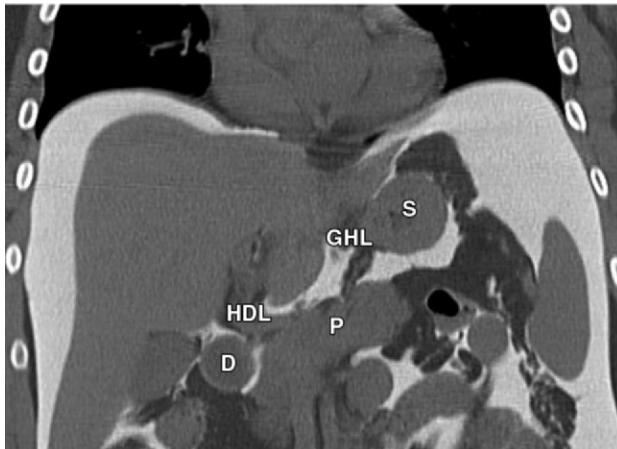
b.



c.



d.



e.



f.

Figure 2. Peritoneal ligaments in six patients. (a) Axial CT image, obtained in a 43-year-old man undergoing peritoneal dialysis, shows high-attenuation dialysate solution filling the right subphrenic space (*RSP*) and the falciform ligament (arrow), which is visible because of the fluid surrounding the liver. (b) Coronal MR image obtained in a 56-year-old man shows the falciform ligament (arrow) and extensive ascites, which demonstrate inhomogeneous signal intensity secondary to standing wave artifact. (c) Axial CT image, obtained in a 49-year-old woman with metastatic ovarian cancer, shows stage III metastases (black arrow) on the surface of the liver and another metastasis (white arrow) that appears to be in the liver but is actually in the falciform ligament. It is important to differentiate parenchymal liver metastases (stage IV disease) from peritoneal surface metastases (stage III disease), including those in the falciform ligament, because stage IV disease is primarily treated with chemotherapy, and stage III disease is primarily treated with surgical debulking followed by chemotherapy. (d) Coronal T2-weighted half-Fourier acquisition single-shot turbo spin-echo (HASTE) image, obtained in a 70-year-old woman with mucinous pancreatic carcinoma, ascites, and liver metastases, shows hyperintense metastatic lesions in the liver parenchyma (*m*) and peritoneal surfaces, including the subphrenic space (arrow) and falciform ligament (arrowhead). (e) Coronal CT image, obtained in a 51-year-old man undergoing peritoneal dialysis, shows high-attenuation dialysate solution filling the supramesocolic spaces and outlining the gastrohepatic (*GHL*) and hepatoduodenal (*HDL*) ligaments, stomach (*S*), pancreas (*P*), and duodenum (*D*). (f) Coronal CT image, obtained in a 49-year-old man with subacute pancreatitis, shows the route of disease spread to the liver by way of the gastrohepatic ligament. A hepatic pseudocyst (*) displaces the left gastric artery to the left. Pseudocysts should be differentiated from lesser sac fluid collections, which envelop the left gastric artery (arrow) or displace it to the right.

Peritoneal Ligaments

Suspensory Ligaments of the Liver

Triangular Ligaments.—The suspensory ligaments of the liver include the triangular and falciform ligaments. Triangular ligaments result from fusion of peritoneal reflections rather than remnant embryonic mesentery. The left triangular ligament is formed by the fusion of the inferior and superior reflections of the coronary ligaments. It is short and does not compartmentalize the left subphrenic space. The right triangular ligament is formed by the fusion of the superior and inferior reflections of the right coronary ligament. Unlike the left triangular ligament, the right triangular ligament is long and separates the right subphrenic space from the right subhepatic space. The triangular ligaments outline the bare area of the liver.

Falciform Ligament.—The falciform ligament is the remnant of the most ventral part of the ventral mesentery and contains the obliterated umbilical vein. It is a relative (incomplete) barrier to the transfer of fluid from the right subphrenic space to the left subphrenic space. It is

important to realize that subperitoneal tumor spread in the falciform ligament may mimic liver metastasis (Fig 2a–2d) (4). The recanalized paraumbilical vein is also found in the falciform ligament.

Peritoneal Ligaments of the Stomach

Lesser Omentum.—The gastrohepatic and hepatoduodenal ligaments are contiguous peritoneal ligaments that form the lesser omentum and are remnants of the dorsal portion of the ventral mesentery. The gastrohepatic ligament attaches the lesser curve of the stomach to the liver and contains the coronary vein and left gastric artery (Fig 2e, 2f). The hepatoduodenal ligament attaches the duodenum to the liver and contains the portal vein, hepatic artery, common hepatic ducts, and part of the cystic duct. Until the 8th embryonic week, this part of the ventral mesentery also contains the ventral anlage of the pancreas. Hence, the hepatoduodenal ligament is a route of spread of pancreatic disease to the porta hepatis and liver.

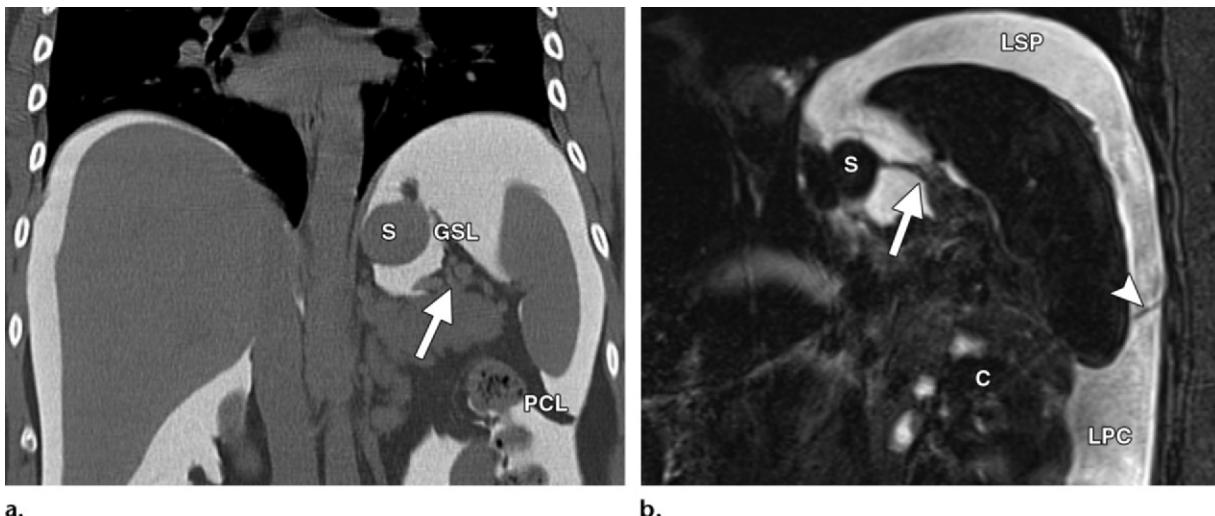
**a.****b.**

Figure 3. Gastrosplenic ligament in two patients. **(a)** Coronal CT image of the upper abdomen, obtained in a 51-year-old man, shows dialysate solution within the supramesocolic spaces and outlining the gastrosplenic ligament (GSL), which contains the short gastric vessels (arrow). The phrenicocolic ligament (PCL)—which is thought to be a good barrier to the spread of inflammation or tumor but often is not—is also seen. S = stomach. **(b)** Coronal T2-weighted three-dimensional (3D) navigator-triggered prospective acquisition correction (PACE) image of the left upper quadrant, obtained in a 70-year-old man with ascites, shows free fluid within the left subphrenic (LSP) and paracolic (LPC) spaces and outlining the gastrosplenic ligament (arrow) and stomach (S). C = splenic flexure of the colon, arrowhead = phrenicocolic ligament.

Gastrosplenic Ligament.—The ventral part of the dorsal mesentery extends between the greater curve of the stomach and the spleen (Fig 3). The superior part of this portion of the dorsal mesentery becomes the gastrosplenic ligament, which contains the short gastric vessels and a collateral route of venous flow after splenic vein thrombosis. The gastrosplenic ligament is a frequent route for subperitoneal spread of pancreatitis-related fluid. Although it is not connected to the peritoneal cavity, fluid within the gastrosplenic ligament is often mistaken for a lesser sac collection (6).

Greater Omentum.—Because of the growth and rotation of the stomach in utero, the inferior aspect of the ventral part of the dorsal mesentery becomes redundant, and its two layers fuse with one another to form the gastrocolic ligament, or the greater omentum (7). The greater omentum may become visible if it is diseased or if ascites

is present (Fig 4) (7). This expansive peritoneal structure is often used to surgically move radiosensitive bowel out of a pelvic radiation field.

Splenorenal Ligament.—The splenorenal ligament is the most dorsal aspect of the dorsal mesentery. It contains the pancreatic tail and splenorenal collateral vessels in patients with portal hypertension (Fig 5).

Transverse Mesocolon

The transverse mesocolon is a peritoneal fold that attaches the transverse colon to the retroperitoneum and contains the middle colic vessels (8). In patients with pancreatic head cancer, it is an important possible source of local extension. Because of its numerous vessels, vascular control is difficult, and extension into the mesocolon renders pancreatic cancer inoperable (Fig 6). The transverse mesocolon also may be a route for internal herniation after retrocolic Roux-en-Y gastric bypass surgery (Fig 7) (8).

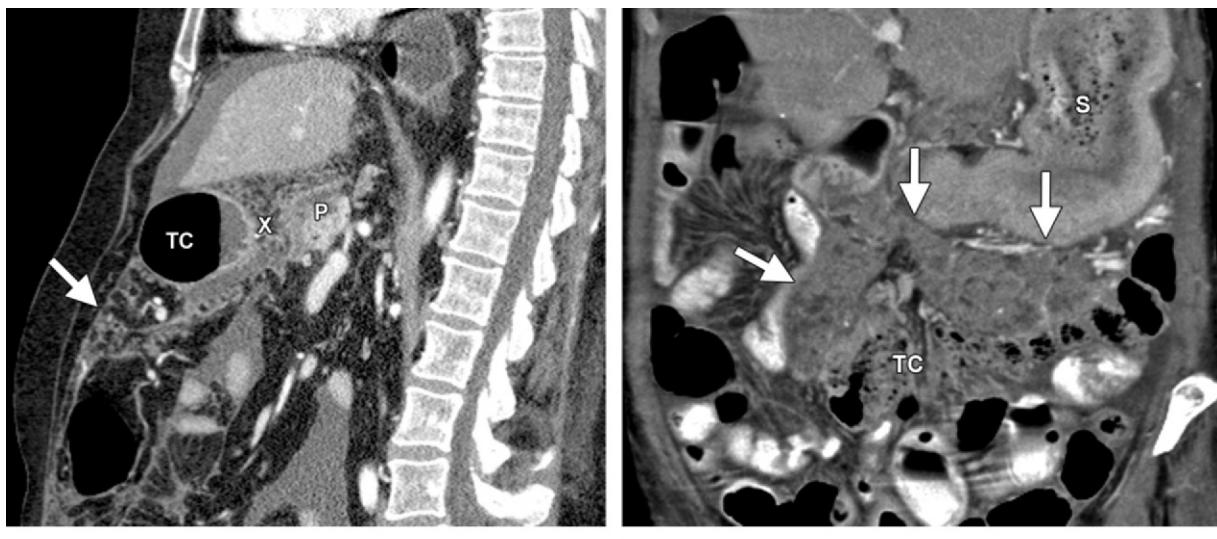
**a.****b.**

Figure 4. Omentum in two patients. **(a)** Sagittal reformatted CT image, obtained in a 65-year-old woman with pancreatic cancer and peritoneal carcinomatosis, shows the omentum, which is visible due to the presence of stranding (arrow), and the pancreas (*P*), which is edematous. The transverse colon (*TC*) is attached to the retroperitoneum by way of the transverse mesocolon (*X*), which is also involved by carcinomatosis. **(b)** Coronal reformatted CT image, obtained in a 75-year-old woman with ovarian carcinoma, shows abnormal omental metastases (arrows) in the area between the greater curvature of the stomach (*S*) and the transverse colon (*TC*).

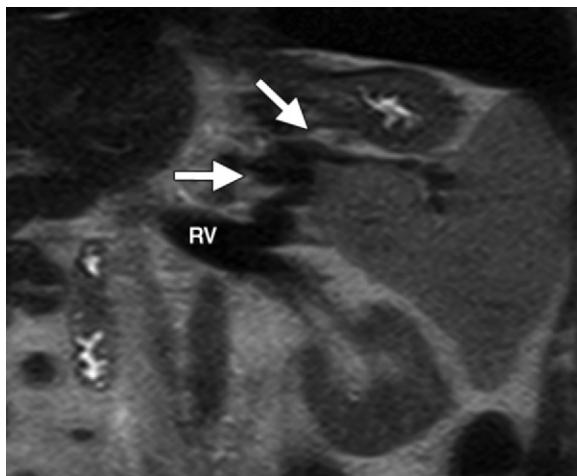


Figure 5. Splenorenal ligament and collateral vessels in a 58-year-old man with cirrhosis resulting from hepatitis C infection and spontaneous splenorenal shunt. Coronal T2-weighted MR image shows a tortuous splenorenal shunt (arrows) arising from the left renal vein (*RV*) and coursing within the splenorenal ligament toward the splenic hilum.

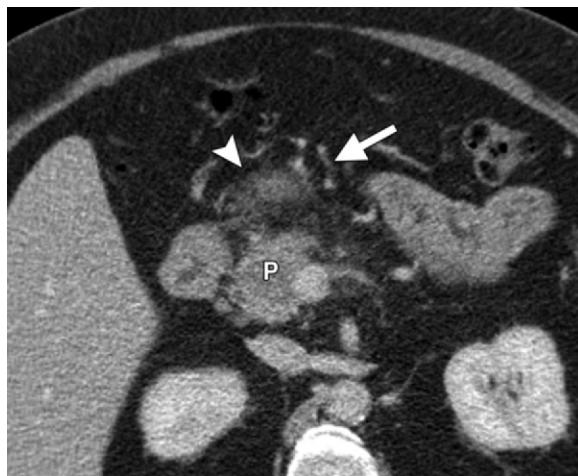
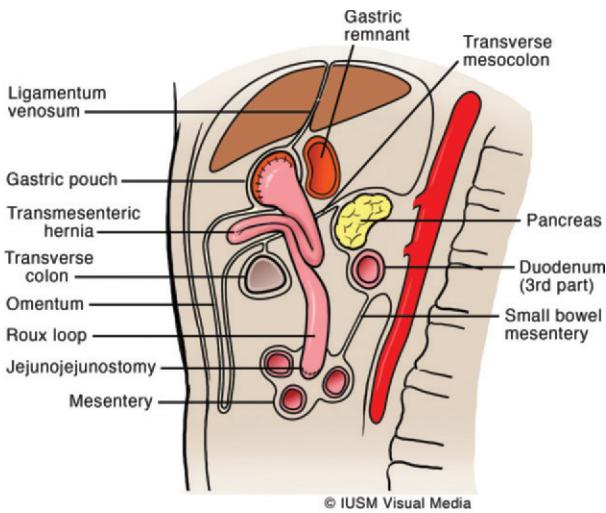


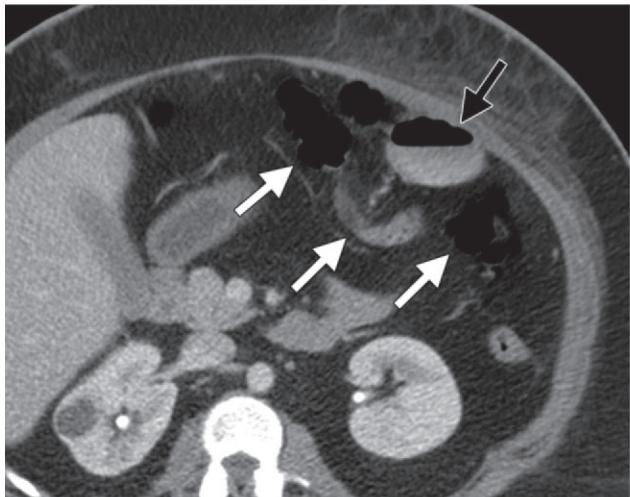
Figure 6. Transverse mesocolon metastasis in a 56-year-old man with pancreatic cancer. Axial CT image shows a pancreatic tumor (*P*) invading the transverse mesocolon (arrowhead). The tumor was deemed unresectable due to invasion and many small vessels (arrow) that make vascular control difficult.

Figure 7. Transmesocolic hernia. **(a)** Diagram in the sagittal plane shows the anatomy after Roux-en-Y gastric bypass. Note the potential site of transmesenteric hernia. **(b)** Axial CT image obtained in a 47-year-old woman shows dilated jejunal loops anteriorly (black arrow) and the transverse colon (white arrows), which demonstrates narrowing and distortion of the lumen secondary to herniating small bowel loops. The mesenteric vessels that supply the jejunal loops pass through the transverse mesocolon. **(c)** Coronal CT image obtained in the same patient shows herniation (arrow) of dilated jejunal loops through a surgically created defect in the transverse mesocolon (*TC*) and edema within the herniated small bowel mesentery (*sbm*). Oral contrast material also is seen within the gastric lumen (*S*) and herniated small bowel loops (dashed line).

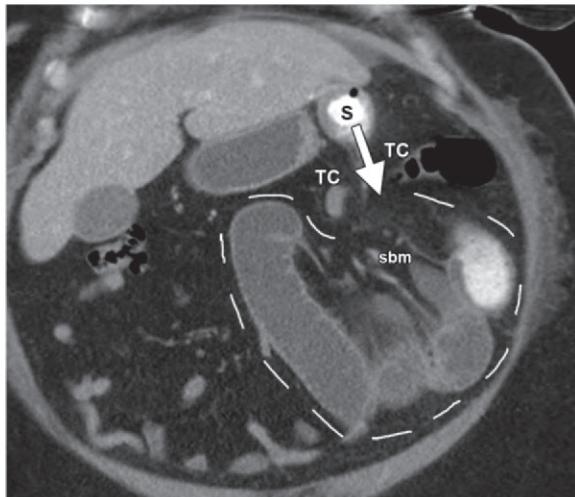


© IUSM Visual Media

a.



b.



c.

Small Bowel Mesentery

The small bowel mesentery attaches the small bowel to the retroperitoneum and extends from the ligament of Treitz to the ileocecal valve. It contains the superior mesenteric vessels and their branches, which mark its position at contrast-enhanced CT. Among the peritoneal structures, the small bowel mesentery is one of the most likely to be involved by metastatic disease. Inflammation and tumor may involve the mesentery directly (eg, from the pancreatic body or jejunum) or by way of the neurovascular plexus or lymphatic channels that run within it. Rarely, rotational and fusion anomalies of the mesentery may lead to volvulus or internal hernia (9).

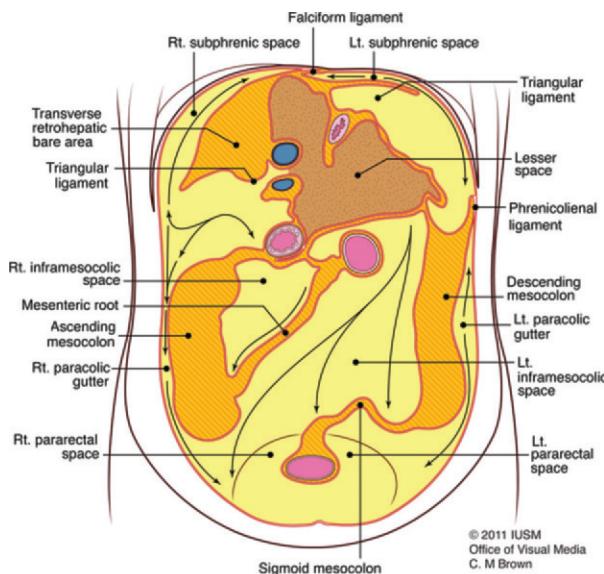
Sigmoid Mesocolon

The sigmoid mesocolon is a peritoneal ligament that attaches the sigmoid colon to the posterior pelvic wall and contains the hemorrhoidal and sigmoid vessels. The most common pathologic process involving this structure is acute diverticulitis. Perforated cancer and Crohn disease also may cause inflammation within the sigmoid mesocolon.

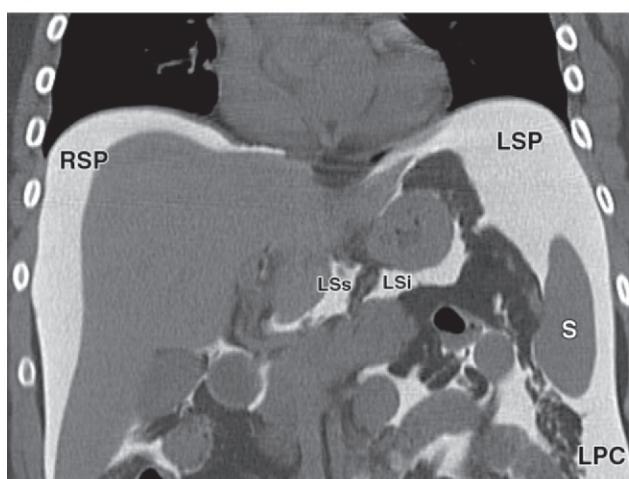
Peritoneal Spaces

Knowledge of the peritoneal spaces and the routes of communication between them is important. The transverse mesocolon divides the peritoneum into the supramesocolic and infra-mesocolic spaces; the bilateral paracolic and pelvic spaces are also peritoneal spaces (Fig 8a). Most of the time, slow fluid accumulation in the peritoneal cavity may be localized to one or two spaces. Rapid accumulation of fluid, such as oc-

Teaching Point



a.



b.

Figure 8. Supramesocolic peritoneal spaces. **(a)** Diagram shows the peritoneal spaces and the direction of flow (arrows) of the small amount of normal peritoneal fluid. **(b)** Coronal CT image obtained in a 51-year-old man shows the supramesocolic spaces outlined by dialysate solution. The left subphrenic space (*LSP*) freely communicates with the left paracolic space (*LPC*). The right subphrenic space (*RSP*) and the superior (*LSs*) and inferior (*LSi*) recesses of the lesser sac are separated by a peritoneal fold that contains the left gastric artery. *S* = spleen. **(c)** Coronal T2-weighted MR image, obtained in a 41-year-old woman who underwent cholecystectomy, shows a fluid collection with a thick wall (*) in the right subhepatic space between the liver and the right kidney (*RK*). The collection proved to be a biloma.



c.

curs in cases of trauma or acute pancreatitis, may overcome the natural boundaries of the peritoneal spaces and spill into multiple spaces.

Left Supramesocolic Spaces

The left and right supramesocolic spaces usually communicate freely with one another and include the perihepatic, left subphrenic, and perisplenic spaces (Fig 8a, 8b). The phrenicocolic ligament is a relative but incomplete impediment to the spread of pathologic processes from the left paracolic gutter to the left subphrenic space (Fig 3).

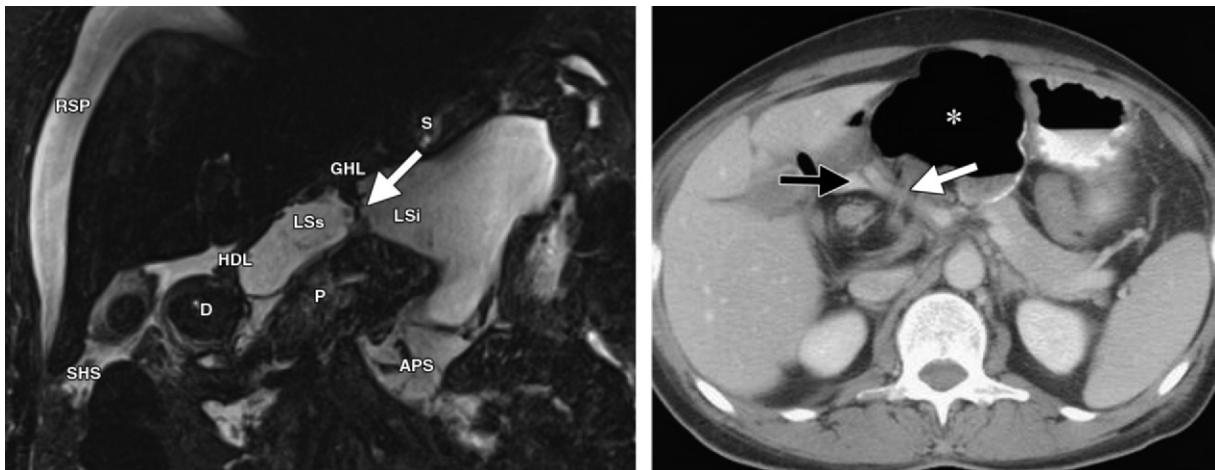
Right Supramesocolic Spaces

The right supramesocolic spaces include the right subphrenic (subdiaphragmatic) space, the Morison pouch (subhepatic or hepatorenal space), and the lesser sac (omental bursa). The

right subphrenic space is separated from the left perihepatic space by the falciform ligament, which varies in size and may not always serve as a barrier to the spread of disease (Fig 2). The right subhepatic space is an important site of fluid collections resulting from liver injuries because it is the most gravity-dependent space at this site (Fig 8c).

The lesser sac contains a superior recess (located above the peritoneal reflection of the left gastric artery) that is in close proximity to the caudate lobe and has a boomerang-shaped recess and a larger inferior recess that lies between the stomach and the pancreatic body. The superior and inferior recesses are separated by a peritoneal fold that accompanies the left gastric artery (Fig 9a).

Teaching Point



a.

b.

Figure 9. Lesser sac. (a) Coronal T2-weighted 3D PACE image, obtained in a 58-year-old woman with acute pancreatitis, shows the superior (*LS_s*) and inferior (*LS_i*) recesses of the lesser sac. The recesses are separated by the left gastric artery (arrow), and the foramen of Winslow allows communication between the lesser sac and the subhepatic space (*SHS*). Fluid is seen in the anterior pararenal space (*APS*), a common location for fluid collections in patients with acute pancreatitis. Linear hypointense MR imaging-related artifacts are seen in the anterior pararenal space, and the hepato-duodenal (*HDL*) and gastrohepatic (*GHL*) ligaments, two contiguous structures, are clearly depicted. *D* = duodenum, *P* = pancreas, *RSP* = right subphrenic space, *S* = stomach. (b) Axial CT image obtained in a 48-year-old woman shows the cecum (*) adjacent to the stomach, an unusual position, and passage of the right colic vessels (white arrow) across the foramen of Winslow, findings indicative of a foramen of Winslow hernia. The foramen is marked posteriorly by the hepatic vessels (black arrow). The presence of a foramen of Winslow hernia was confirmed at surgery.

Sometimes, the inferior recess communicates with a potential space between the leaves of the greater omentum. On the right side, the inferior recess communicates with the subhepatic space through the foramen of Winslow. Thus, it is possible for bowel to herniate into the lesser sac through the foramen of Winslow (Fig 9b).

Right and Left Inframesocolic Spaces

The right and left inframesocolic spaces are separated from the supramesocolic spaces by the transverse mesocolon and from the paracolic gutters laterally by the ascending or descending colon. The smaller right inframesocolic space is limited inferiorly by the attachment of the small bowel mesentery to the cecum; collections in this space generally do not extend into the pelvis (Fig 10). However, the larger left inframesocolic space communicates freely with the pelvis.

Paracolic Spaces

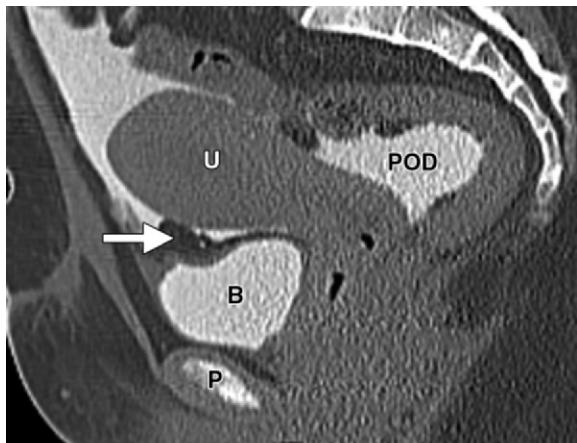
The paracolic spaces (gutters) are located lateral to the peritoneal reflections of the left and right sides of the colon (Fig 8a). The right paracolic gutter is larger than the left and communicates freely with the right subphrenic space. The connection between the left paracolic gutter and the left subphrenic space is partially limited by the phrenicocolic ligament. Both the right and left paracolic gutters communicate with the pelvic spaces.

Pelvic Spaces

In men, the most gravity-dependent site for fluid accumulation is the rectovesical space. In women, it is the retrouterine space (the pouch of Douglas) (Fig 11). Anteriorly, the medial umbilical folds, which contain the obliterated umbilical arteries, divide the pelvic spaces into lateral and medial compartments. On each side, the inferior epigastric artery divides the lateral pelvic compartments into lateral and medial inguinal fossae, the sites of direct and indirect inguinal hernias, respectively.

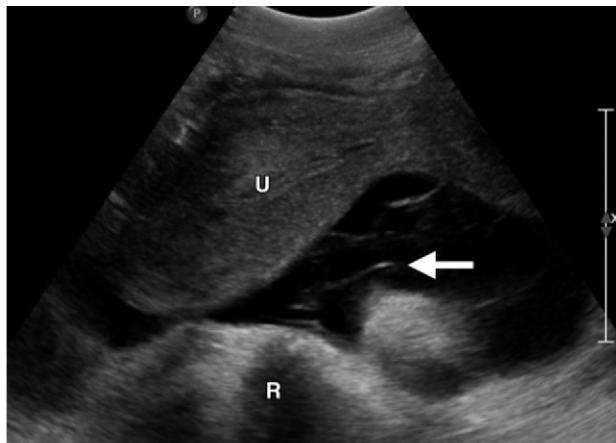


Figure 10. Inframesocolic peritoneal spaces. Coronal reformatted CT image, obtained in a 61-year-old man who underwent heart transplantation and subsequently developed retroperitoneal hemorrhage, shows the left (*LIMC*) and right (*RIMC*) inframesocolic spaces, which are separated by the small bowel mesentery (white arrow). The left inframesocolic space and the right (*RPC*) and left (*LPC*) paracolic spaces communicate with the pelvis (black arrows), whereas the right inframesocolic space does not. *TM* = transverse mesocolon.



a.

Figure 11. Retrouterine space (pouch of Douglas). (a) Sagittal unenhanced CT image obtained in a 39-year-old woman shows that the pelvic spaces are filled with dialysate solution. The retrouterine space (*POD*), the most gravity-dependent site for fluid accumulation in women, and the vesicouterine pouch (arrow) also are highlighted by dialysate solution. *B* = bladder, *P* = symphysis pubis, *U* = uterus.



b.

(b) Longitudinal endovaginal US image, obtained postpartum in a 24-year-old woman with pelvic pain, clearly shows a fluid collection with thin septations (arrow) between the uterus (*U*) and rectum (*R*), a finding indicative of a postoperative organized hematoma in the retrouterine space.

Retroperitoneal Spaces

The retroperitoneum is divided into three distinct compartments: the posterior pararenal space, bounded by the posterior parietal peritoneum; the anterior pararenal space, bounded by

the transversalis fascia; and the perirenal space, bounded by the perirenal fascia (Fig 12a, 12b). The anterior pararenal space is composed of structures that mainly develop from the dorsal

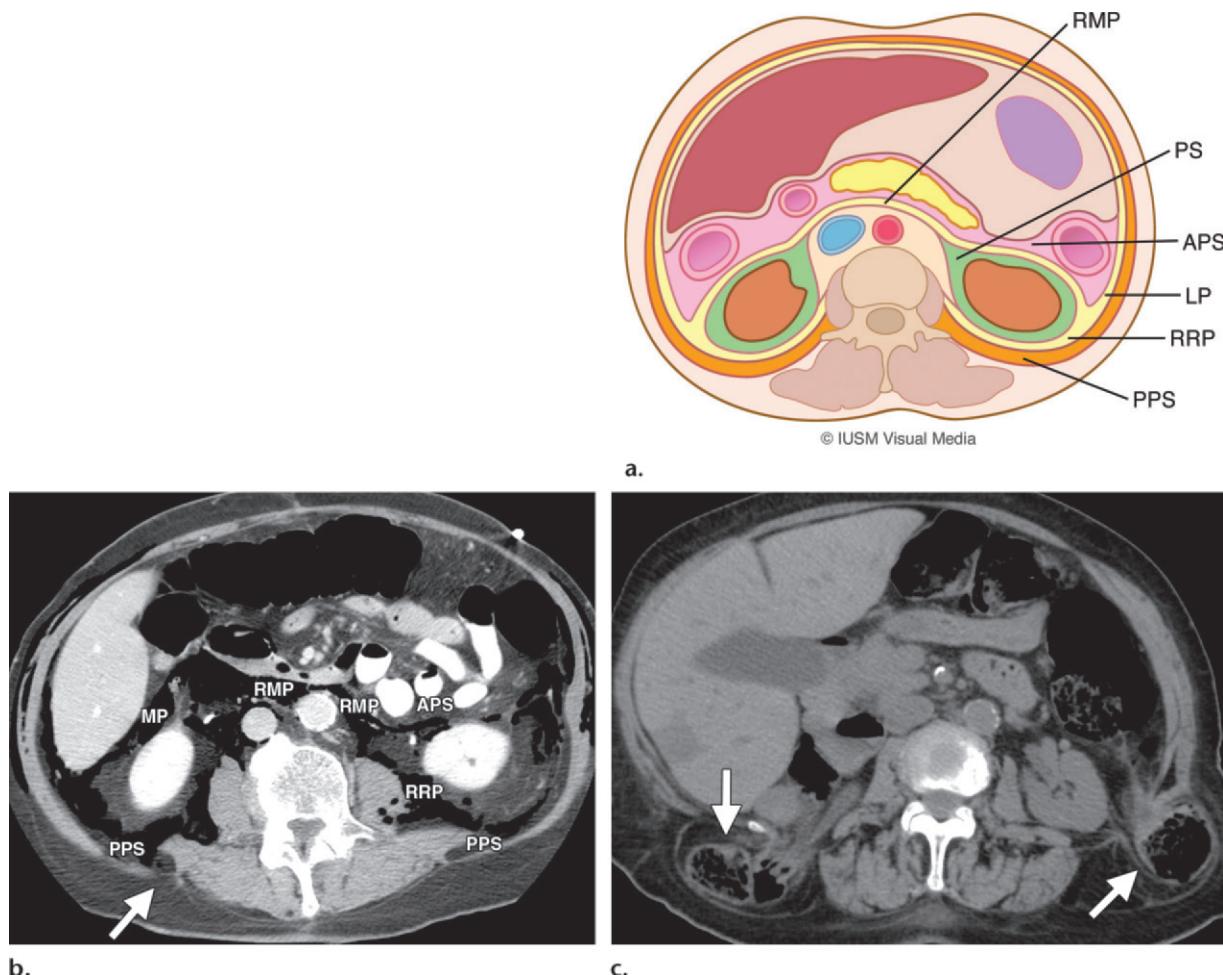


Figure 12. Retroperitoneal anatomy. (a) Diagram shows the anterior (APS) and posterior (PPS) pararenal spaces, perirenal space (PS), retromesenteric plane (RMP), retrorenal plane (RRP), and lateral conal (LP) planes. (b) Axial CT image, obtained in a 76-year-old man with duodenal perforation who underwent endoscopic retrograde cholangio-pancreatography, shows a large amount of dissected retroperitoneal air outlining the retromesenteric plane (RMP)—which connects across the midline—and retrorenal plane (RRP). The anterior pararenal space (APS) is mostly free of gas. Note that it is possible for disease to extend from the posterior pararenal space (PPS), through the quadratus lumborum muscle (arrow), and into the subcutaneous space, the site of an inferior lumbar hernia as well as the Grey-Turner sign, which manifests as lateral abdominal discoloration in patients with severe pancreatitis. Extravasated air has dissected into the Morison pouch (MP), a finding indicative of abrupt accumulation of air or fluid that crosses the peritoneal and retroperitoneal spaces. (c) Axial unenhanced CT image shows bilateral lumbar hernias arising from the superior lumbar triangles (arrows).

mesentery, namely the pancreas and the right and left portions of the colon. The perinephric space is outlined anteriorly by Gerota fascia and posteriorly by Zuckerkandl fascia and contains the kidneys and adrenal glands. The perinephric space contains bridging septa and a network of lymphatic vessels that allow the spread of disease to or from adjacent spaces. The perinephric space has an inverted cone shape caused by the

ascent of the kidneys from the pelvis. It is usually, but not always, cut off inferiorly by the fusion of Gerota and Zuckerkandl fascias and does not extend into the pelvis. The small posterior pararenal space is bound by the transversalis fascia posteriorly and the lateroconal fascia laterally. It contains two fat pads that lie ventral and posterolateral to the quadratus lumborum muscle. In patients with acute pancreatitis, the Grey-Turner sign is caused by spread of disease from the anterior pararenal space to the area between the leaves of the pos-

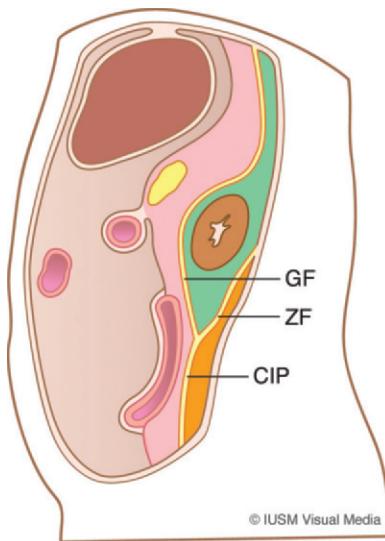
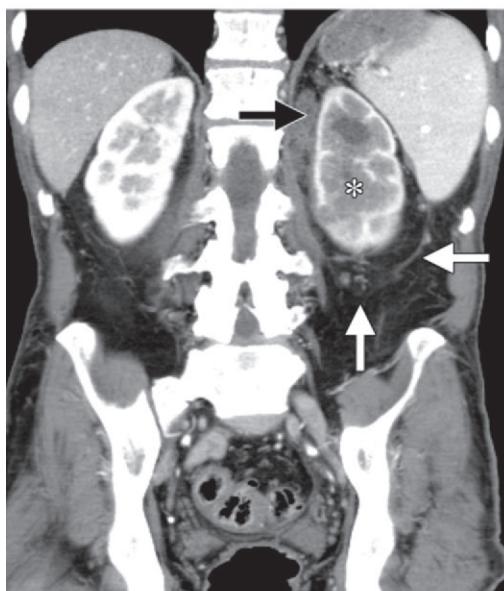


Figure 13. Interfascial spread. **(a)** Diagram drawn in the sagittal plane shows the inferior fusion of the Gerota (*GF*) and Zuckerkandl (*ZF*) fascias, which form the combined interfascial plane (*CIP*). Although the perirenal space is cut off by the fusion of Gerota and Zuckerkandl fascias inferiorly, it is possible for disease to extend along the combined interfascial plane. **(b)** Coronal reformatted CT image obtained in a 75-year-old man with non-Hodgkin lymphoma shows involvement of the left kidney (*) and perinephric space (black arrow) by tumor and thickening of Gerota fascia (white arrows). **(c)** Coronal CT image, obtained in the same patient, shows a nodule (arrow) in the combined interfascial plane (arrowhead), a finding indicative of interfascial spread of lymphoma.

a.**b.****c.**

terior renal fascia and, subsequently, the lateral edge of the quadratus lumborum muscle (10,11). Communication with the posterior pararenal space and the structures of the flank wall may be established. The superior and inferior lumbar triangles, sites of anatomic weakness in the flank wall, may structurally predispose this area to development of lumbar hernias (Fig 12c).

A fourth space surrounds the aorta and inferior vena cava. This space is limited laterally by the perirenal spaces and ureters and extends superiorly into the posterior mediastinum. Some diseases, such as retroperitoneal fibrosis, are predominantly confined to this space, whereas

others, such as hemorrhage from a leaking aortic aneurysm, extend interfascially (12).

Retromesenteric Plane

According to recent studies, the perirenal fascia is not made up of distinct unilaminated fascia; rather, it is composed of multiple layers of variably fused embryonic mesentery, creating potential spaces between the retroperitoneal spaces. These potential spaces are represented by the retromesenteric, retrorenal, lateral conal, and combined fascial planes (Fig 13) (13,14).

Teaching Point



a.

b.

Figure 14. Interfascial spread of fluid in a 60-year-old man with acute rupture of an abdominal aortic aneurysm. **(a)** Axial contrast-enhanced CT image, obtained at the level of the inferior pole of the left kidney (*LK*), shows a hematoma dissecting the anterior, posterior (white arrows), and lateral conal (black arrow) interfascial planes. **(b)** Axial contrast-enhanced CT image obtained at the level of the pelvic brim shows large hemorrhagic collections dissecting both sides of the combined interfascial plane (arrows). Interfascial spread allows communication between the abdomen and pelvic retroperitoneum.

The retromesenteric plane is a potentially expansile plane located between the anterior pararenal space and the perirenal space (Fig 12a). It communicates across the midline and is a major source of fluid spread in patients with pancreatitis. The presence of fluid in the retromesenteric plane is often erroneously attributed to the anterior pararenal space.

Retrorenal Plane

The retrorenal plane is a potentially expansile plane located between the perirenal space and posterior pararenal space (Fig 12a). It does not cross the midline because it is interrupted by the great vessel space. Fluid collections in the anterior pararenal space and the retromesenteric plane may extend to the retrorenal space. The retrorenal plane combines with the retromesenteric plane inferiorly to form the combined interfascial plane, which extends into the pelvic retroperitoneum (Fig 13) (14,15). The interfascial plane extends into the pelvis anterolaterally to the psoas muscle and is a route for the spread of some infections, such as tuberculosis. The lateral conal interfascial plane is a potentially expansile space between the layers of the lateroconal fascia that communicates with the retromesenteric and retrorenal interfascial planes at the fascial trifurcation.

The term *subperitoneal spread* refers to the spread of fluid or tumor from its site of origin along the peritoneal ligaments (eg, pancreatic inflammation or cancer that spreads along the peritoneal ligaments) (Figs 2, 6) (16,17). Tumors and fluid collections may spread across the peritoneal ligaments (subperitoneal spread) to involve several contiguous organs.

Subperitoneal Spread

The term *subperitoneal spread* refers to the spread of fluid or tumor from its site of origin along the peritoneal ligaments (eg, pancreatic inflammation or cancer that spreads along the peritoneal ligaments) (Figs 2, 6) (16,17). Tumors and fluid collections may spread across the peritoneal ligaments (subperitoneal spread) to involve several contiguous organs.

Teaching Point

Interfascial Spread
Interfascial spread is the spread of fluid within the layers of the retroperitoneal fascia and is a common route of disease spread across the midline within the retroperitoneum and from the abdomen to the pelvis, such as along the retromesenteric, retrorenal, and interfascial planes (Fig 14) (13,14). The right retromesenteric plane

Teaching Point

extends superiorly at the level of the right inferior coronary ligament and the bare area of the liver, and it communicates with the liver hilum through the subperitoneal space of the hepatoduodenal ligament. On the left side, the retrorenal plane and the perirenal space extend to the left diaphragm. As was mentioned earlier, fluid collections in the paracolic and left inframesocolic spaces may communicate with the pelvic spaces (Fig 10). Interfascial spread is another method of communication between the abdomen and pelvis and also allows communication across the midline through the retromesenteric plane.

Conclusions

A variety of pathologic conditions may demonstrate nonspecific radiologic features. Understanding the anatomic relationships and pathologic processes of the peritoneum is essential to provide accurate diagnosis. Multidetector CT studies performed with isotropic imaging with coronal and sagittal reformations fully delineate the peritoneal anatomy and extent of disease.

Disclosures of Potential Conflicts of Interest.—**F.M.A.:** Related financial activities: none. Other financial activities: consultant for Repligen. **K.S.:** Related financial activities: grants from Bayer Pharmaceuticals, Philips Medical Systems, and Siemens Medical Solutions; reviewer for Repligen. Other financial activities: consultant for Repligen.

References

1. Akisik FM, Sandrasegaran K, Aisen AM, Lin C, Lall C. Abdominal MR imaging at 3.0 T. RadioGraphics 2007;27(5):1433–1444.
2. Levy A, Medjhoul A, Caramella C, et al. Interest of diffusion-weighted echo-planar MR imaging and apparent diffusion coefficient mapping in gynecological malignancies: a review. J Magn Reson Imaging 2011;33(5):1020–1027.
3. Satoh Y, Ichikawa T, Motosugi U, et al. Diagnosis of peritoneal dissemination: comparison of 18F-FDG PET/CT, diffusion-weighted MRI, and contrast-enhanced MDCT. AJR Am J Roentgenol 2011;196(2):447–453.
4. Kim S, Kim TU, Lee JW, et al. The perihepatic space: comprehensive anatomy and CT features of pathologic conditions. RadioGraphics 2007;27(1):129–143.
5. DeMeo JH, Fulcher AS, Austin RF Jr. Anatomic CT demonstration of the peritoneal spaces, ligaments, and mesenteries: normal and pathologic processes. RadioGraphics 1995;15(4):755–770.
6. Oliphant M, Berne AS, Meyers MA. The subperitoneal space of the abdomen and pelvis: planes of continuity. AJR Am J Roentgenol 1996;167(6):1433–1439.
7. Yoo E, Kim JH, Kim MJ, et al. Greater and lesser omenta: normal anatomy and pathologic processes. RadioGraphics 2007;27(3):707–720.
8. Charnsangavej C, DuBrow RA, Varma DG, Herron DH, Robinson TJ, Whitley NO. CT of the mesocolon: part 1—anatomic considerations. RadioGraphics 1993;13(5):1035–1045.
9. Takeyama N, Gokan T, Ohgiya Y, et al. CT of internal hernias. RadioGraphics 2005;25(4):997–1015.
10. Gore RM, Balfe DM, Aizenstein RI, Silverman PM. The great escape: interfascial decompression planes of the retroperitoneum. AJR Am J Roentgenol 2000;175(2):363–370.
11. Meyers MA, Feldberg MA, Oliphant M. Grey Turner's sign and Cullen's sign in acute pancreatitis. Gastrointest Radiol 1989;14(1):31–37.
12. Hawkins AE, Mirvis SE. Evaluation of bowel and mesenteric injury: role of multidetector CT. Abdom Imaging 2003;28(4):505–514.
13. Aizenstein RI, Wilbur AC, O'Neil HK. Interfascial and perinephric pathways in the spread of retroperitoneal disease: refined concepts based on CT observations. AJR Am J Roentgenol 1997;168(3):639–643.
14. Lee SL, Ku YM, Rha SE. Comprehensive reviews of the interfascial plane of the retroperitoneum: normal anatomy and pathologic entities. Emerg Radiol 2010;17(1):3–11.
15. Mirilas P, Skandalakis JE. Surgical anatomy of the retroperitoneal spaces: part II—the architecture of the retroperitoneal space. Am Surg 2010;76(1):33–42.
16. Oliphant M, Berne AS, Meyers MA. Spread of disease via the subperitoneal space: the small bowel mesentery. Abdom Imaging 1993;18(2):109–116.
17. Pickhardt PJ, Bhalla S. Primary neoplasms of peritoneal and subperitoneal origin: CT findings. RadioGraphics 2005;25(4):983–995.

Peritoneal and Retroperitoneal Anatomy and Its Relevance for Cross-Sectional Imaging

Temel Tirkes, MD • Kumaresan Sandrasegaran, MD • Aashish A. Patel, MD • Margaret A. Hollar, DO • Juan G. Tejada, MD • Mark Tann, MD • Fatih M. Akisik, MD • John C. Lappas, MD

RadioGraphics 2012; 32:437–451 • Published online 10.1148/rg.322115032 • Content Codes: **CT** **GI**

Page 444 (Figure on page 445)

The transverse mesocolon divides the peritoneum into the supramesocolic and inframesocolic spaces; the bilateral paracolic and pelvic spaces are also peritoneal spaces (Fig 8a).

Page 445 (Figure on page 445)

The right subhepatic space is an important site of fluid collections resulting from liver injuries because it is the most gravity-dependent space at this site (Fig 8c).

Page 449

According to recent studies, the perirenal fascia is not made up of distinct unilaminated fascia; rather, it is composed of multiple layers of variably fused embryonic mesentery, creating potential spaces between the retroperitoneal spaces.

Page 450

Tumors and fluid collections may spread across the peritoneal ligaments (subperitoneal spread) to involve several contiguous organs.

Page 450 (Figure on page 450)

Interfascial spread is the spread of fluid within the layers of the retroperitoneal fascia and is a common route of disease spread across the midline within the retroperitoneum and from the abdomen to the pelvis, such as along the retromesenteric, retrorenal, and interfascial planes (Fig 14) (13,14).