

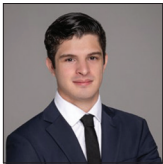


Review Article *Diagnostic Radiology*

Retroperitoneal anatomy with the aid of pathologic fluid: An imaging pictorial review

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ABSTRACT

The retroperitoneum, a complex anatomical space within the abdominopelvic region, encompasses various vital abdominal organs. It is compartmentalized by fascial planes and contains potential spaces critical in multiple disease processes, including inflammatory effusions, hematomas, and neoplastic conditions. A comprehensive understanding of the retroperitoneum and its potential spaces is essential for radiologists in identifying and accurately describing the extent of abdominopelvic disease. This pictorial review aims to describe the anatomy of the retroperitoneum while discussing commonly encountered pathologies within this region. Through a collection of illustrative images, this review will provide radiologists with valuable insights into the retroperitoneum, facilitating their diagnostic proficiency to aid in appropriate patient clinical management.

Keywords: Retroperitoneum, Retroperitoneal spaces, Extraperitoneal spaces, Pathologic fluid, Anatomy

INTRODUCTION

The retroperitoneum is a space within the abdominal cavity between the posterior parietal peritoneum and the transversalis fascia of the posterior abdominal wall.^[1-3] It is bounded superiorly by the diaphragm and inferiorly by the pelvic inlet. Abdominal organs are retroperitoneal if not suspended by mesentery and are within this space.^[4] The retroperitoneum contains further sub-compartments delineated by fascial planes. These fascial planes allow the spaces to communicate with the pelvis.^[5] Organs and vessels within the retroperitoneum are labeled as primary or secondary retroperitoneal. Primary retroperitoneal organs remain in the retroperitoneal space throughout the development.^[4,6] Primary retroperitoneal structures include the kidneys, adrenal glands, ureters, abdominal aorta, and the inferior vena cava.^[4,6] Secondary retroperitoneal structures were initially suspended by mesentery and, later in development, migrated to space. These structures include the pancreas, duodenum, and ascending/descending colon.^[4,6]

Pathologies such as trauma, infection, pancreatitis, and neoplasm may manifest within these retroperitoneal spaces. For a radiologist, it is essential to clearly understand such structural anatomy and the communication between spaces within the retroperitoneum. In this article, we describe the interpretation of imaging studies and disease extent concerning these anatomical compartments.

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BASIC RETROPERITONEAL EMBRYOLOGY

First, a brief discussion of retroperitoneal embryology is warranted to understand fluid's anatomic intricacies and distribution within the retroperitoneal spaces. It is essential to consider that the retroperitoneum forms in multiple discrete fascial layers representing opposed embryonic mesentery.^[7-9] The outermost layer of a developing embryo, the primary body wall, is formed by mesenchyme, which develops the paraspinal muscles, vertebral bodies, and the psoas musculature.^[7] Transversalis fascia and fat layer these structures anteriorly.

Renal tissue initially develops within the first 4 weeks of gestation.^[10] The kidneys originate at the sacral level in the embryo, ascend superiorly, and rotate medially to their adult positioning.^[10] Due to this movement pattern, the fascia surrounding the kidneys takes on a tapered cone shape. This fascia fuses posterolaterally at the retroperitoneal fat.^[7] At this point in development, the perirenal and posterior pararenal spaces (PPSs) are formed. Each space and its contents will be described in their respective sections below. A potential area is formed between these fused layers termed the retrorenal plane.^[7,8,11]

The embryologic development of the gut and dorsal explains how several retroperitoneal spaces are formed. The anterior pararenal space (APS) and retro mesenteric plane result from the folding and rotation of the duodenal, pancreatic, and colon mesentery.^[7] The developmental rotation of the colon and its mesentery create the APS, lateroconal fascia, and a potential space called the anterior interfascial plane. Further, discussion of this process is beyond the scope of this article.

RETROPERITONEAL COMPARTMENTS

The retroperitoneum is divided into three main compartments, termed the perirenal space (PRS), the APS, and the PPS [Figure 1]. Each compartment is described in its section below, focusing on fluid collections and their potential etiologies.

PRS

The PRSs are the largest of the three retroperitoneal compartments. The anterior and posterior renal fascia bounds this space, with dense collagenous sheaths surrounding the structures within the space.^[1,12-14] Superiorly, the bare area of the liver bounds the space and inferiorly opens into the pelvic retroperitoneal spaces^[5] [Figures 1 and 2].

Direct communication of the right and left PRSs is a controversial topic. Initially, it was thought that the two spaces were connected medially.^[15-17] However, more recent literature demonstrated that the perirenal fascia also fuses medially, effectively creating an anatomical barrier between

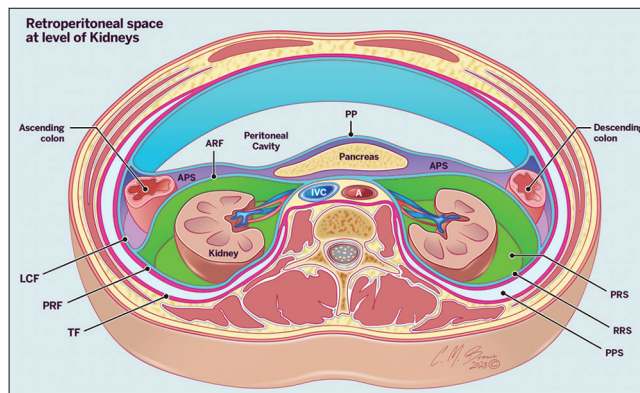


Figure 1: Illustration of the retroperitoneum at the level of the kidneys demonstrating the retroperitoneal compartments (PP: Parietal peritoneum, APF: Anterior pararenal fascia, LCF: Lateroconal fascia, APS: Anterior pararenal space, PRS: Perirenal space, PPS: Posterior pararenal space, RRS: Retrorenal space, PPS, TF: Transversalis fascia).

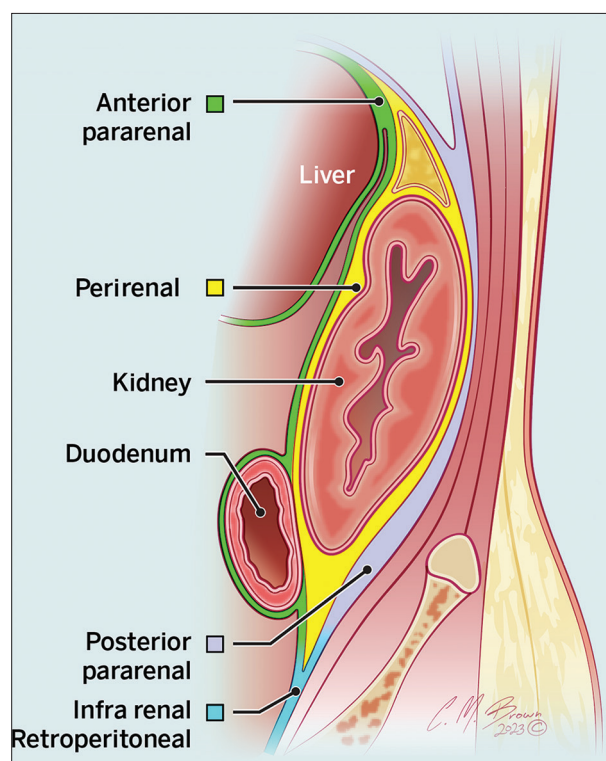


Figure 2: Illustration of the retroperitoneal space at and below the level of kidneys.

the two spaces.^[11,18] The PRS contains the kidneys, adrenals, proximal ureters, hilar vessels, and perirenal fat.^[2,13,19] The PRS is divided into small compartments and bridging septa by thin fibrous lamellae, which pierce the perirenal fat and connect the renal capsule to the anterior and posterior renal fascia.^[7,20-22] Septa are continuous with interfascial planes and allow for the movement of pathologic fluid between the PRSs and fascial planes.^[7]

Fluid collections within the PRS may be traumatic (hemorrhage and urinoma) or infectious [Figures 3-5]. A perinephric hematoma is typically described as a blood product confined within the anterior and posterior renal

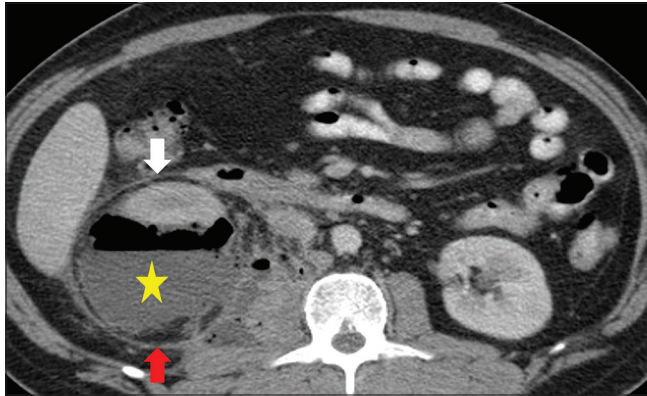


Figure 3: A 40 year old woman with sepsis. Computed tomography (CT) axial image at the level of the kidneys demonstrates a perirenal abscess (star) contained by the anterior (white arrow) and posterior (red arrow) perirenal fascia.

fascia.^[19,23] Trauma is the most common cause of perirenal hemorrhage and can happen following blunt injury, penetrating injury, or iatrogenic, following lithotripsy, biopsy, or surgery.^[24] Rarely, spontaneous perirenal hemorrhage may occur.^[25,26] Urine leaks or urinomas occur following abdominal injury and result from disrupting the urinary collecting system.^[27] Urine leaks result from 1% to 7% of renal injuries and over a quarter of patients with grade four renal injuries.^[23,28-30]

Neoplasms encountered in this space are based on the organs or tissue that occupies it such as sarcomas, pheochromocytomas, renal angiomyolipomas, lymphoproliferative tumors, or metastatic disease.^[31,32] Renal cell carcinoma can spread locally through perinephric fat and adjacent viscera and organs.^[33] Benign tumors, such as myelolipomas, may be encountered in this space.^[34]

APS

The APS contains six borders consisting of the posterior parietal peritoneum anteriorly, the anterior renal fascia

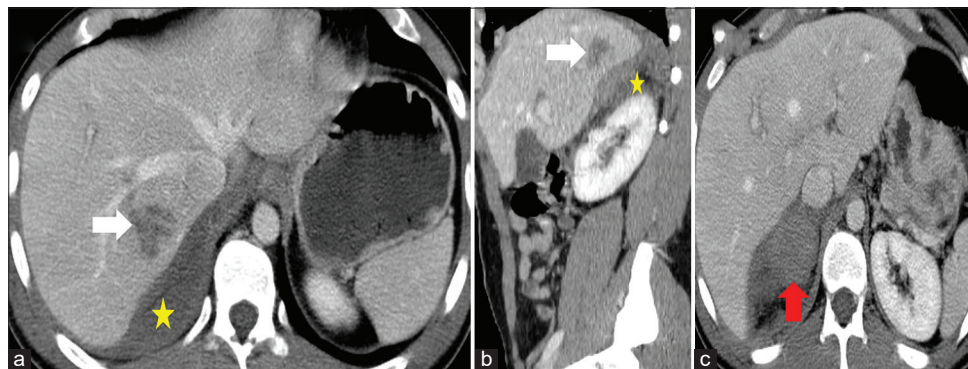


Figure 4: A 49 year old man with blunt abdominal trauma. Computed tomography (CT) of the abdomen (a, c) axial, (b) sagittal reformatted images demonstrating injury to the bare area of the liver (white arrow) with superior perirenal hematoma (star) and adrenal hematoma (red arrow).

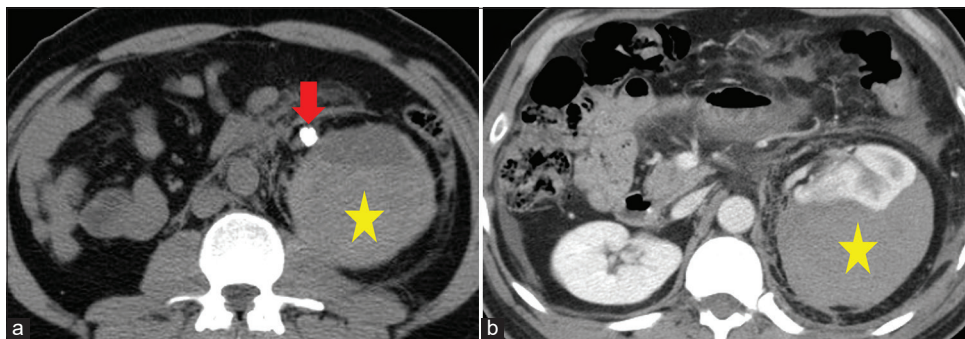


Figure 5: A 40 year old man with acute flank pain. Contiguous axial abdomen computed tomography (CT) images (a, b) demonstrating a left subcapsular urinoma/hemorrhage (star) secondary to obstructing stone (red arrow).

posteriorly, the lateroconal fascia laterally, the inferior point of the renal cone inferiorly, and the moment in which the anterior renal fascia and the peritoneum meet is the superior border [Figures 1 and 2]. The APS contains the ascending and descending colon, the duodenum, and the pancreas.^[35] Both pararenal spaces communicate behind the duodenum and pancreas. The pelvis is connected through the potential space between the parietal peritoneum anteriorly and the anterior renal fascia posteriorly along the path of the ureter.^[2] No communication exists between the intraperitoneal spaces, but communication is present between the infrarenal space and other extraperitoneal spaces within the pelvis.^[5]

Fluid collections are more commonly encountered and more accessible to visualize on the left side due to associated pancreatic disease of the tail, extending from the APS to a space between the laminae of the posterior renal fascia [Figures 6-8].

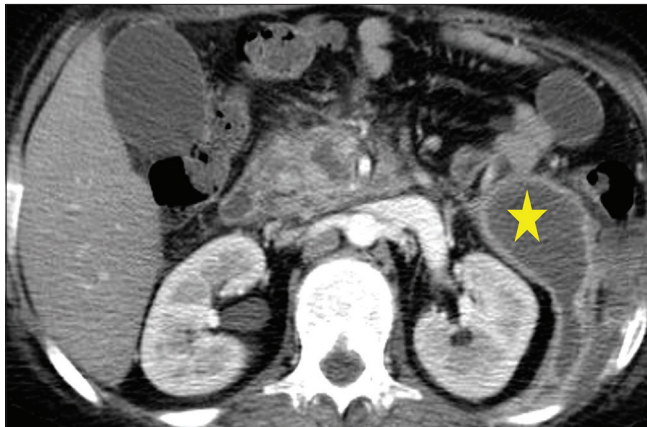


Figure 6: A 63 year old man with hemorrhagic pancreatitis. Computed tomography (CT) abdomen axial image demonstrating an abscess in the anterior pararenal space with extension into the lateral conal space (star).

Collections on the right side tend commonly to be a sequela of pancreatitis or bowel perforation. These collections are challenging to identify.^[22,36] Schwannomas may be encountered in the pararenal space, as per Liu *et al.*, with a round or oval shape rather than a spindle.^[37]

PPS

The PPS is bordered by the diaphragm superiorly, the posterior renal fascia anteriorly, and the transversalis fascia posteriorly. The posterior renal fascia borders anteriorly to the PPS and lateroconal fascia [Figures 1 and 2]. The PPS extends to the pelvis by following the path of the ureter to the bladder and ends at the potential space between perivesical peritoneal folds. The space communicates with the preperitoneal fat along the lateroconal fascia that fuses with the parietal peritoneum. The PPS communicates to the femoral sheath, prevesical, APS, and PRS through the infrarenal space.

Fluid collections are rarely observed in this space. It is mainly composed of fat.^[2,35] Hemorrhage may be encountered in patients with bleeding disorders by the femoral vessels on anticoagulation or catheterization procedures^[22,38] [Figures 9 and 10]. Neoplasms may also be encountered in this space. Peng *et al.* reported a schwannoma located in the PPS.^[39]

The posterior pararenal and previously described APS and PRSs communicate with the infrarenal space. The communication of this space and the subsequently explained interfascial planes allow pathologic fluid to spread into the pelvis.

Interfascial planes

As stated previously, the retroperitoneum can be divided into three main compartments. It is known that the perirenal fascia is single, multi-laminated structures. The capacity of

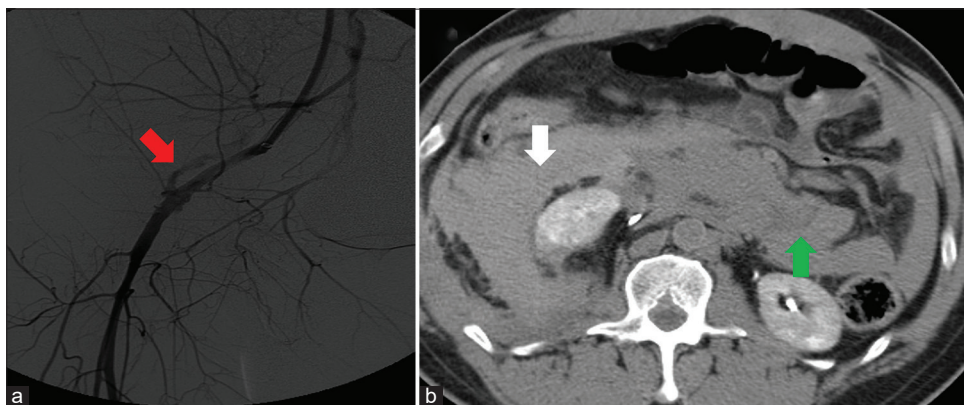


Figure 7: A 65 year-old-man with complications from cardiac catheterization procedure. (a) Arterial angiogram and (b) axial computed tomography (CT) image of the abdomen demonstrating active extravasation from the right external iliac artery (red arrow). Hemorrhage is seen in the right anterior pararenal space (white arrow), which extends into the left anterior pararenal space (green arrow).

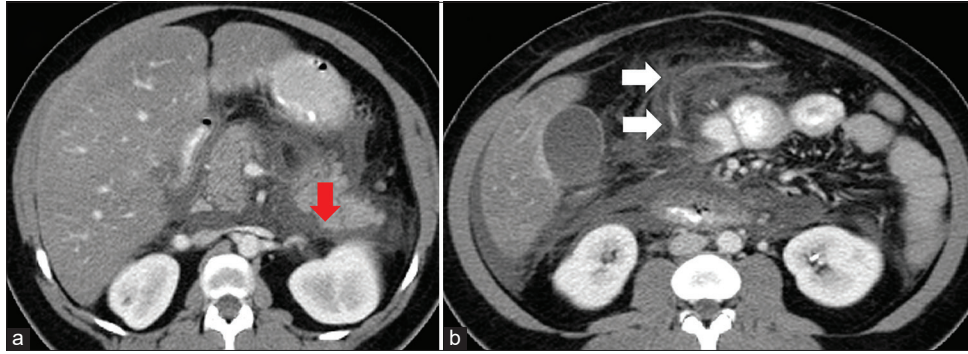


Figure 8: A 39 year old man with acute pancreatitis. Contiguous computed tomographic (CT) abdomen axial images demonstrating inflammatory fluid in the left anterior pararenal space (red arrow), which extends along the root of the mesentery and mesocolon (white arrows).

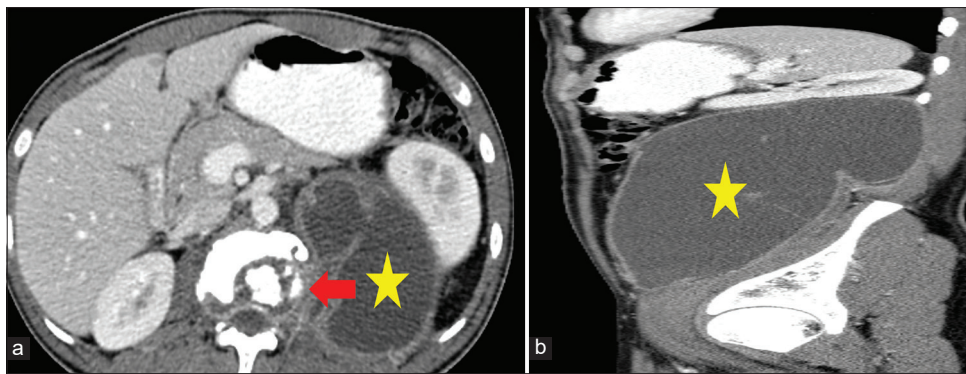


Figure 9: A 40 year old man with Pott Disease. Abdominal computed tomography (CT) (a) axial and (b) sagittal images demonstrating a large iliopsoas abscess with extension into the posterior pararenal space (star). Also noted is a destruction of an adjacent vertebral body (red arrow).

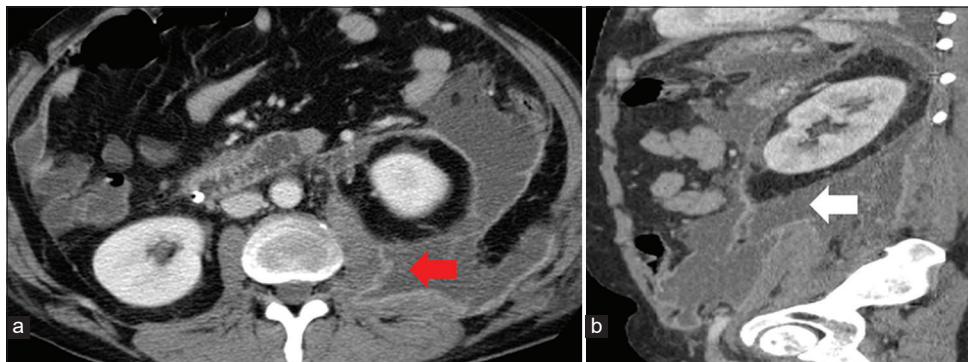


Figure 10: A 53 year old woman with pancreatitis. Abdominal computed tomography (CT) (a) axial and (b) sagittal images demonstrating inflammatory fluid in the posterior pararenal space (red arrow), which extends into the pelvic retroperitoneum (white arrow).

this space is limited and, once overwhelmed with fluid, may communicate with the interfascial planes. The interfascial planes consist of the retro mesenteric, retrorenal, lateroconal, and a combined plane. These planes are connected with the perinephric bridging septa, through which pathologic fluids can spread.^[2,40,41]

The retro mesenteric plane is along the midline between the APS and PRS. It extends superiorly on the right side up to the right inferior coronary ligament connecting to the liver hilum via the subperitoneal space of the hepatoduodenal ligament. On the left, it follows posteriorly to the tail of the pancreas, anteriorly to the fascia of the adrenal gland,

and superiorly to the dome of the diaphragm, a posterior segment of the esophagus and phrenoesophageal ligament.^[42] The plane is to be described with multiple communications that can eventually reach a trifurcation consisting of between the laminae of the anterior renal fascia, posterosuperior renal fascia, and lateroconal fascia. The surrounded PRS creates the lateroconal and posterior interfascial decompression planes.^[2]

The retrorenal plane is a potential space between the PRS and PPS that communicates with the aorta and inferior vena cava.^[2] The lateroconal interfascial plane is located between the layers of the lateroconal fascia and communicates the retro mesenteric with the retrorenal interfascial planes at their trifurcation.^[20,42] There is a suggestion of an additional plane between the pararenal space and transversalis fascia called the subfascial plane, which allows a narrow communication with the retrorenal plane.^[36] The combined

interfascial plane is between the anterior and posterior renal fasciae. This potential space extends inferiorly along the psoas muscle and reaches the mesorectal interfascial plane or prevesical space.^[42] The disease can spread from the abdominal retroperitoneum into the pelvis through this route.

Multiple pathologic entities can be observed along the fascial planes: necrotizing fasciitis, pancreatitis-related effusions, hematomas, urinomas, bowel inflammation, or perforation^[42-44] [Figures 11 and 12].

In pancreatitis, inflammatory effusions may involve the interfascial planes and spread inferiorly into the pelvic retroperitoneum. Ishikawa, *et al.* created a classification that determined the computed tomography (CT) severity of pancreatitis using the concept of interfascial planes and

Table 1: Retroperitoneal compartments and associated pathologies.	
Perirenal space	Hemorrhage Urinomas Abscess Hemangiomas Lymphomas Pheochromocytomas Renal carcinomas Liposarcomas
Anterior pararenal space	Neurogenic tumors Hematomas Pancreatic effusions Abscess Neurogenic tumors Fibroblastic tumor Adipocytic tumors
Posterior pararenal space	Hematomas Neurogenic tumors Fibroblastic tumor Adipocytic tumors
Interfascial planes	Necrotizing fasciitis Hematomas Urinomas Perforations Effusions Metastasis
Pelvic spaces	Hematomas Urinomas Effusions Colon cancer Bladder cancer Bladder ruptures Prostate cancer Uterine cancer Ovarian cancer

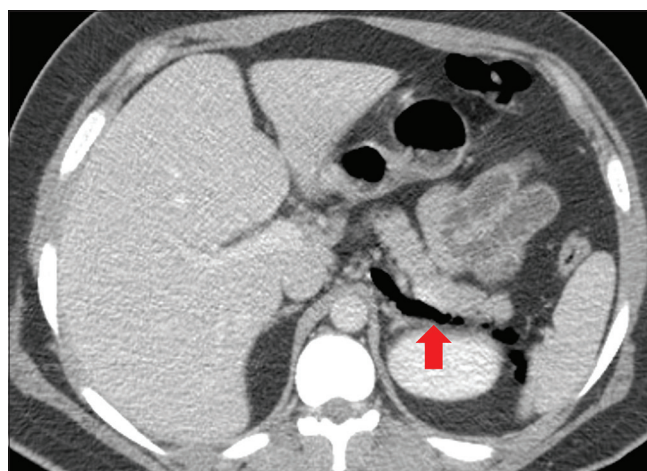


Figure 11: A 41 year old woman with perforated diverticulitis of the descending colon. Computed tomography (CT) abdomen axial image demonstrating air tracking in the retro mesenteric space (red arrow).

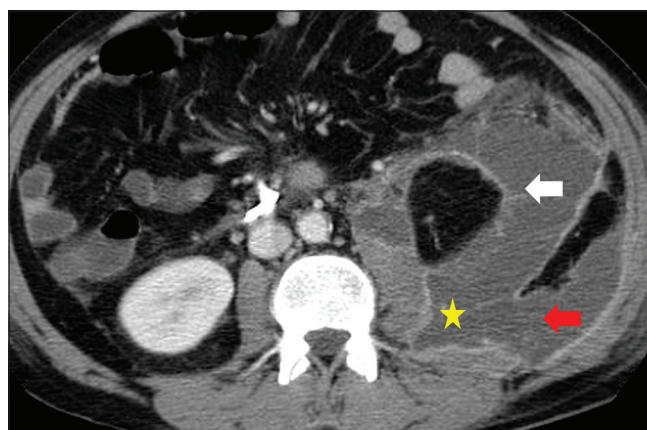


Figure 12: A 37 year old man with acute pancreatitis. Computed tomography (CT) abdomen axial image demonstrating inflammatory fluid in the lateral conal plane (red arrow) communicating with the retro mesenteric (white arrow) and retrorenal (star) spaces.

explained the low position of the Grey-Turner sign with pancreatitis.^[44] The Grey-Turner sign is spread from the APS to between the two leaves of the posterior renal fascia and lateral edge of the quadratus lumborum muscle.^[45] The rupture of great vessels such as the aorta or inferior vena cava is more involved with the retrorenal interfascial planes or combined interfascial planes, but the retro mesenteric is less involved.^[42] Thick retroperitoneal fascia may suggest retroperitoneal organ disease and an early manifestation of the checkmark sign is indicative of a severe medical condition.^[46]

Through periaortic and pericaval retroperitoneal lymph nodes, metastatic spread of malignant tumors may propagate to the perinephric space along the retro mesenteric and retrorenal planes. Not just metastasis, but primary infiltrating colonic tumors can spread across these planes due to their fused layers with the mesocolon. Pleural and transdiaphragmatic lymphatics provide an alternate route for metastatic disease to the perinephric space through these interfascial planes.^[42]

Pelvic spaces

The pelvis is the compartment between the peritoneum and the transversalis fascia within the extraperitoneal space.^[47] The pelvic space consists of two compartments, anterior and posterior, separated by the rectovesical fascia of Denonvillier in males or rectovaginal fascia in females.^[47,48] The anterior pelvic space is divided by the umbilicovesical fascia, which extends from the umbilicus downward in a triangular fashion enveloping the bladder, umbilical artery, and urachus.^[49] The potential space within the umbilicovesical fascia is called the perivesical space, which is not perceptible on imaging.^[47,49] Anterior and lateral to the umbilicovesical fascia lies the prevesical space, which is much larger and clinically relevant. The prevesical space also runs posterior to the transversalis.

It surrounds the lateral walls of the bladder.^[17] The prevesical space is the largest potential space within the retroperitoneal pelvic compartment.^[50] Between the pubis and the bladder, there is a space called the space of Retzius, which is contiguous with the prevesical space^[48] [Figure 13].

The posterior pelvic compartment is divided into perirectal and presacral spaces. The perirectal space is laterally bordered by the mesorectal fascia and posteriorly by the posterior pelvic fascia. Its anterior border comprises the rectovesical fascia in males and the rectovaginal space in females.^[51] The presacral space is bordered anteriorly by the posterior rectal fascia, superiorly by the peritoneal reflection of the sigmoid colon, inferiorly by the rectosacral (Waldeyer's) fascia, and posteriorly by the parietal fascia.^[52] A potential space known as the pararectal space between the mesorectal fascia and parietal pelvic fascia exists.^[47] The infrarenal space communicates inferiorly with the prevesical, perivesical, and presacral spaces. This extension of fluid occurs through medial extension or a route adjacent to the iliac vasculature [Figure 14].

Among the fluid collections, hemorrhage and bladder ruptures are the most commonly found in the prevesical space. Based on location of the bladder injury, the extravasation of urine may be intraperitoneal, extraperitoneal, or both. The importance of this distinction is that intraperitoneal injury is managed surgically, while extraperitoneal injury is managed conservatively. Injury to the dome of the bladder may lead to extravasation into the intraperitoneal space or space of Retzius resulting in extravasation into paracolic gutters, rectovesical, or rectouterine pouch and surrounding loops of bowel.^[53,54] Extraperitoneal bladder ruptures are limited to the perivesical space and visualized in imaging as a "molar tooth" appearance. The "crown" of the "tooth" is anterior to the bladder, while its "root"

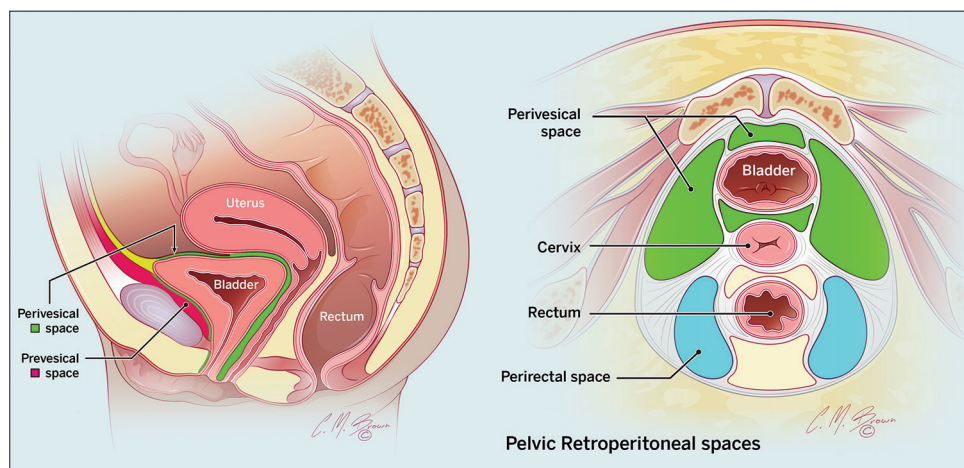


Figure 13: Illustration of the pelvic retroperitoneal spaces on sagittal and axial views.

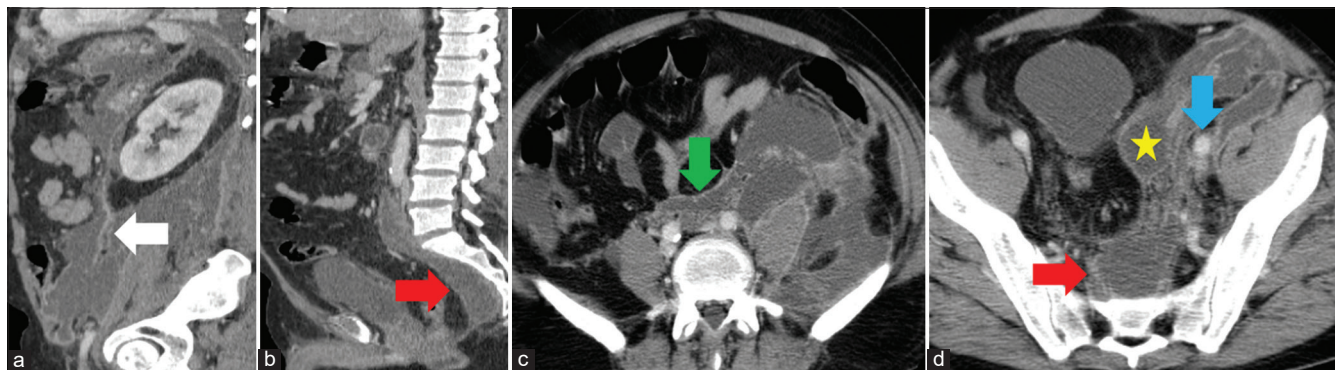


Figure 14: A 40 year old man with acute pancreatitis. Contiguous (a and b) sagittal reformat and (c and d) axial abdominopelvic images demonstrating an inflammatory fluid collection in the infrarenal space (white arrow) with extension into the pelvis prevesical (star) and presacral (red arrows) spaces. Both medial (green arrow) and iliac vascular (blue arrow) modes of spread are seen.

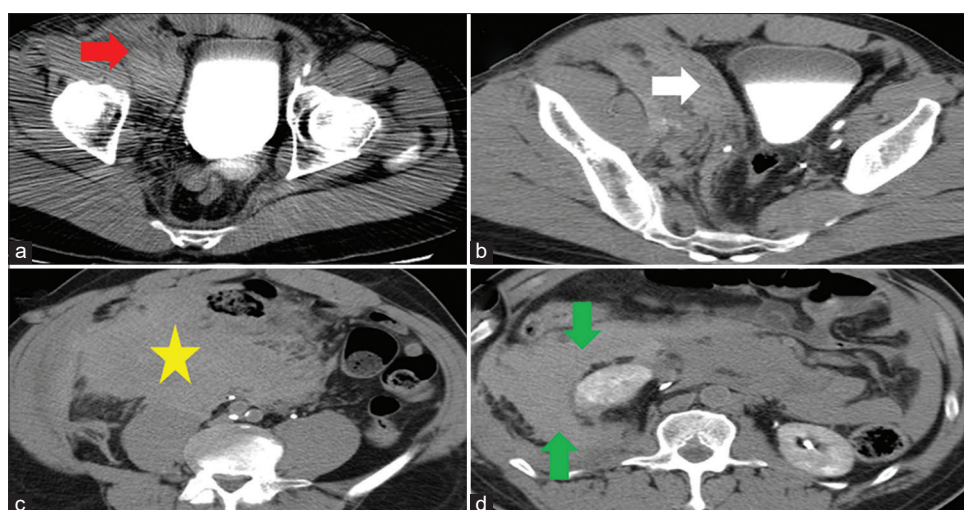


Figure 15: A 65 year old woman following right femoral catheterization. Contiguous abdominopelvic computed tomography (CT) axial images demonstrating a hematoma surrounding the femoral sheath 9 (red arrow). Hematoma is seen in the prevesical space (white arrow) with retrograde extension into the right infrarenal (star) and anterior and posterior pararenal spaces (green arrows).

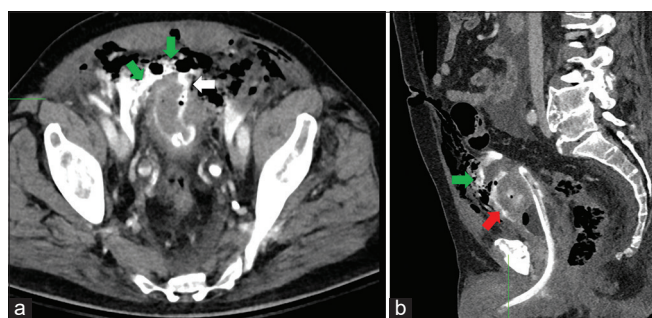


Figure 16: A 69 year old man with blunt abdominal trauma. Pelvic computed tomography (CT) (a) axial and (b) sagittal images demonstrating injury to the anterior bladder wall with contrast seen in the perivesical (red arrow) and prevesical (green arrow) spaces via direct communication.

extends posteriorly. The bladder may be displaced midline when large extraperitoneal pelvic fluid collections occur. The prevesical space is continuous with the rectus sheath, presacral space, and femoral sheath, which is clinically significant with retroperitoneal hematomas after femoral catheterization^[22,48,55] [Figures 15-17].

Pelvic tumors are commonly encountered and can arise from gastrointestinal or genitourinary organs as primary lesions or metastatic disease.^[56] Pelvic tumors may be intraperitoneal or extraperitoneal. Extraperitoneal tumors may arise from anterior, middle, and posterior compartments of the pelvis.^[56] Colorectal cancer may reach to the pelvic space through lymphatic spread and vascular distribution of the colonic vessels.^[33]

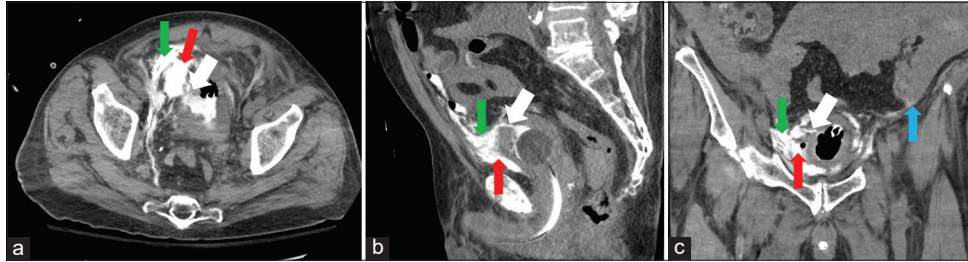


Figure 17: A 67 year old man with iatrogenic bladder injury during transurethral resection of the bladder tumor. Computed tomography (CT) cystogram (a) axial, (b) sagittal, and (c) coronal images demonstrating an injury to the anterosuperior bladder wall (white arrow). Contrast extravasation is seen with the perivesical (red arrow) and prevesical (green arrow) spaces. Contrast is seen with the large volume ascites (blue arrow) consistent with intraperitoneal urinoma.

CONCLUSION

Understanding the intricacies of retroperitoneal anatomy and relevant pathological imaging manifestations is essential in the radiologist's toolbelt. Describing the extent of abdominopelvic disease requires a thorough understanding of retroperitoneal anatomy, its compartments, and means of intercommunication. This knowledge allows radiologists to accurately characterize the extent of disease within the abdomen and pelvis. In addition, this anatomic insight aids in identifying possible pathologic sources and predicting disease spread, ultimately impacting patient management.

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Declaration of patient consent

Patient's consent not required as patients identity is not disclosed or compromised.

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Conflicts of interest

There are no conflicts of interest.

Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

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