PICTORIAL REVIEW / Gastrointestinal imaging

Radioanatomy of the retroperitoneal space

A. Coffin*, I. Boulay-Coletta, D. Sebag-Sfez, M. Zins

Radiology department, Paris Saint-Joseph Hospitals, 185, rue Raymond-Losserand, 75014 Paris, France

KEYWORDS
Retroperitoneal space; Kidneys; Cross-sectional anatomy

Abstract The retroperitoneum is a space situated behind the parietal peritoneum and in front of the transversalis fascia. It contains further spaces that are separated by the fasciae, between which communication is possible with both the peritoneal cavity and the pelvis, according to the theory of interfascial spread. The perirenal space has the shape of an inverted cone and contains the kidneys, adrenal glands, and related vasculature. It is delineated by the anterior and posterior renal fasciae, which surround the ureter and allow communication towards the pelvis. At the upper right pole, the perirenal space connects to the retrohepatic space at the bare area of the liver. There is communication between these two spaces through the Kneeland channel. The anterior pararenal space contains the duodenum, pancreas, and the ascending and descending colon. There is free communication within this space, and towards the mesenteries along the vessels. The posterior pararenal space, which contains fat, communicates with the preperitoneal space at the anterior surface of the abdomen between the peritoneum and the transversalis fascia, and allows communication with the contralateral posterior pararenal space. This space follows the length of the ureter to the pelvis, which explains the communication between these areas and the length of the pelvic fasciae.

© 2014 Éditions françaises de radiologie. Published by Elsevier Masson SAS. All rights reserved.

An accurate understanding of the anatomy of the retroperitoneum is essential in order to understand most of the pathological phenomena that occur in this space and how they spread within the various retroperitoneal compartments. As well as knowledge of the retroperitoneal compartments, an accurate understanding of the interconnections between the retroperitoneum, peritoneal cavity, and other extra-peritoneal spaces is crucial in order to understand the spread of inflammatory pathological processes or tumours.

Abbreviations: APR, Anterior Pararenal Space; PPR, Posterior Pararenal Space; ARf, Anterior Renal Fascia; PRf, Posterior Renal Fascia.
* Corresponding author.
E-mail address: alex_surikat@yahoo.fr (A. Coffin).

http://dx.doi.org/10.1016/j.diii.2014.06.015
2211-5684/© 2014 Éditions françaises de radiologie. Published by Elsevier Masson SAS. All rights reserved.
This review is based on the description and interpretation of imaging findings aimed to review the radiological anatomy of the retroperitoneum, with emphasis on the theory of interfascial spread to explain the various communications between this space and the peritoneal cavity.

**Review of anatomy**

The retroperitoneal space is an anatomical structure delineated by the parietal peritoneum and the transversalis fascia. It is divided into five compartments (Fig. 1). a) The lateral compartments: these are an asymmetrical pair containing the kidneys and other organs. Each lateral compartment is divided by the fasciae into three separate spaces: the anterior pararenal (APR), perirenal, and posterior pararenal (PPR) spaces. The APR space contains part of the ascending colon, descending colon, and the duodenum and pancreas. The perirenal spaces contain the kidneys, adrenal glands, ureters, blood vessels and lymphatics. The PPR space only contains fat. b) A central vascular compartment, extending from T12 to L4-L5, located between the two perirenal spaces, behind the anterior perirenal space, and in front of the spine. This contains the abdominal aorta and its branches, the inferior vena cava and its afferent vasculature, lymphatic chains and the abdominal sympathetic trunk. c) Two symmetrical posterior compartments, containing the psoas major, which joins the iliacus muscle and sometimes the psoas minor, terminating at the arch of the hip bone. The psoas major extends from T12 to the lesser trochanter, and it is covered with transversalis fascia, which is known as iliaco fascia in this area. The ilio-psoas compartment is generally considered to be retroperitoneal even though it is behind the transversalis fascia because it is frequently involved in processes that begin in the retroperitoneum.

The mesenchyme is the posterior part of the embryo, and it develops into the elements of the body wall [1]. It is covered by the transversalis fascia, a lamina of continuous connective tissue that separates its components from the abdominal cavity. Fig. 2a summarizes the embryological organization of the retroperitoneal space. The intermediary mesoderm forms the primordium of the genitourinary system, and it is shown in Fig. 2b and c. The mesonephros develops into the secretory urinary apparatus, and from here the initially caudal renal primordia will ascend in a posterior and caudo-rostral direction, in parallel with the descent of the excretory urinary apparatus and gonads.

Fig. 3 summarizes the organization of the retroperitoneum after the ascension of the renal primordia.

This is a key moment in the formation of the retroperitoneum, delineating a fat-containing space into different spaces bordered by fasciae. The fasciae are lamina of connective tissue approximately 2 mm thick that will make up the partitions between the various compartments of the retroperitoneum [1].

**Perirenal space**

**The fasciae**

The perirenal space has the shape of an inverted cone with the point directed at the pelvis, and the base resting on the diaphragm [5]. Fig. 4 summarizes the borders of the perirenal space. The PRF is in fact made up of two apposed lamina, one superficial and one deep, which explains why it is more easily visible on imaging [1]. The superficial lamina of the PRF is made up of the lateroconal fascia, which extends in front and attaches to the peritoneum. Fig. 5 summarizes the anatomy of the PRF. Fig. 6 shows invasion of the renal fasciae secondary to acute pancreatitis.

**Superior border of the perirenal space**

The right perirenal space has an unusual feature. Here, the perirenal space is in direct contact with the posterior surface of the right kidney, and has no peritoneal covering: this is the bare area of the liver. This feature is explained by the

---

**Figure 1.** Mapping the retroperitoneum. a): view of the retroperitoneal space on an axial CT cross-section passing through both kidneys: the retroperitoneal space (in red) is located between the parietal peritoneum (in green) and the transversalis fascia (in brown). b): the five retroperitoneal compartments: Lateral retroperitoneal compartments (in blue), median “vascular” retroperitoneal compartment (in red), posterior “ilio-psoas” retroperitoneal compartments (in orange). c): three spaces of the lateral compartment: APR (in blue), perirenal (in yellow), PPR (in purple).
formation of peritoneal folds at the posterior part of the liver, creating the falciform, coronary, right triangular and left triangular ligaments, and it directly exposes the liver to the retroperitoneal space behind. Fig. 7 summarizes the anatomy of the bare area of the liver. On the left, the ARF fuses with the diaphragm leaving a free space above the adrenal gland, which is in fact part of the perirenal space (Fig. 8) shows that the bare area of the liver is visible on a CT scan.

Midline extension of the perirenal fasciae

The PRF fuses with the fascia of the quadratus lumborum muscle at the posterior part of the perirenal space, as shown in Fig. 10. The ARF adheres to the connective tissue that surrounds the large vessels at L3 – L5 [3]. Here, there is a theoretical conduit between the two perirenal spaces known as the "Kneeland channel!", and it is thought to allow free diffusion within the trabecula of the connective tissue, in front of the aorta and the vena cava (Fig. 11).

Inferior extension of the perirenal fasciae

The fusion of the PRF and ARF around the ureter borders the inferior part of the cone of renal fascia. Among the theories contested, there has for a long time been a lack of certainty over the inferior part of this space, with some describing free communication to this area [5], which would allow for a connection between the APR and PPR space, as if the cone was opened into the other retroperitoneal spaces; other articles describe the inferior part of the perirenal space as being a true anatomical border, while sometimes allowing for an extension towards the pelvis, without giving any further details about how this communication operates [5].

We have used the results of a number of cadaver studies [1–4], as well as the embryology of the renal and urinary system, with the metanephros (renal primordium) attaching to the ureteric bud that forms the ureter, and both ascending towards the lumbar fossae surrounded by their fasciae, to explain the anatomical relationships in the inferior part of the perirenal space. The authors of cadaver studies injected tracer dyes into different spaces in the retroperitoneum in order to observe how they diffused between the layers of fasciae and to explain the communications between them and the pelvis. Everything passes around the ureter as summarized in Fig. 12. On MRI, the anterior and posterior fasciae are perfectly visualized as they surround the ureter, then fuse together with the connective tissue surrounding it that delineates the inferior part of the cone of perirenal fascia. Behind, the fatty PPR space passes laterally to the ureter, which is closer to the midline, and in this way, continues without fusion between the peritoneum and the transversalis (or iliac) fascia.

Bridging septa of the perirenal space

There is a network of septa that supports the kidneys. Three types have been described, depending on where they attach, as summarized in Fig. 13 [3].

Anterior pararenal space: APR

Contents

The APR space is bordered anteriorly by the posterior parietal peritoneum, posteriorly by the ARF, and laterally by the lateroconal fascia. This means that it contains sections
of the ascending colon, descending colon, duodenum and pancreas [6] (Fig. 14).

**Review of peritoneal radioanatomy**

Three fundamental events change the initial embryological arrangement of the peritoneum: the gastric primordium shifts by 90° and the primitive gut rotates around the superior mesenteric artery towards the viscera; the omental bursa and greater omentum are formed; and the spleen and pancreas develop. The primitive gut develops outside the abdominal cavity. When the intestinal loops are reintegrated into the abdominal cavity, the colon is pushed back as a result, and in the majority of cases its peritoneum fuses with the posterior part of the underlying connective tissue through a process of mechanical change that leads to the formation of the fasciae of Toldt, which leads to the ascending and descending colons settling in their final positions, and becoming fixed in the abdominal cavity. Where there is abnormal intestinal rotation, variant positions may be seen for the ascending or descending colons, which can become mobile within the abdomen if the fasciae of Toldt are missing. Radiological anatomy considers an organ to be intraperitoneal when its whole outline is covered with peritoneum, which means that the ascending and descending colons are considered to be "retroperitoneal" because of the posterior fusion of their peritoneum with the underlying connective tissue that leaves them in communication with the APR space. We see examples of this relationship, especially in retrocaecal appendicitis or ruptured posterior colonic diverticulitis causing pneumoretroperitoneum with no communication with the peritoneal cavity [7]. The development of the spleen and pancreas, due to the growth of the spleen and its displacement into the left hypochondrium, explains how the head of the pancreas comes to be found in a retroperitoneal position, and this is summarized in Fig. 15. The formation of the omental bursa and greater omentum also involves this same phenomenon of fusion between
Posterior pararenal space

The borders of the PPR space are summarized in Fig. 18. At its upper part, the PPR space is bordered by the diaphragm, the PRF in front and the transversalis fascia behind. There is a weaker area at the lumbar triangle between the quadratus lumborum muscle and the lateral abdominal muscles, where there is only a single layer of transversalis fascia, which means that this area has less resistance to expanding lesions.

Theory of interfascial spread

The retroperitoneum forms when the renal primordia and the surrounding fasciae ascend, delineating the retroperitoneum into different spaces. The fusion of the various fasciae, or of the peritoneum, creates potential spaces between the various compartments that slide against each other. If large volumes of fluid accumulate quickly, the storage capacity of the retroperitoneal spaces may be overwhelmed, causing the fluid to seek decompression planes within these sliding potential spaces [1].

This has been observed in a number of cadaver studies, with direct observation of the spread of dyed fluid along these potential spaces, between the compartments of the retroperitoneum.

Anterior interfascial or retromesenteric plane

The mesoduodenum is found pressed against the posterior wall of the peritoneal cavity, due to intestinal rotation and the formation of the spleen. Its laminae eventually fuse with the parietal peritoneum and the fatty posterior structures, creating a potential space that can become a site for

---

Figure 4. Perirenal space. a: diagram of the ‘‘renal cone’’. The anterior border of this cone is the anterior renal fascia (ARF) or Gerota’s fascia (in blue), and the posterior border is the posterior renal fascia (PRF) or Zuckerkandl’s fascia (in red) [2]. These two fasciae are continuous with each other and constitute the walls of the cone. Kidney (star), adrenal gland (white arrow), ureter (black arrow). b: axial contrast-enhanced CT view, passing through the left renal hilum. Kidney (star), ARF (blue), and PRF (red).

Figure 5. Posterior renal fascia. a: axial CT view at the left renal hilum. The deep lamina of the PRF (in pink) is continuous with the ARF (in blue). The superficial portion of the PRF (in purple) is continuous with the lateroconal fascia (in purple), which will itself fuse (black arrow) with the parietal peritoneum (in green) in front and form the lateral border between the APR and PPR spaces. Perirenal space (star). b: lateral border of the retroperitoneum. The lateroconal fascia delineates the lateral portion of the retroperitoneum. Border of the APR space (in blue) in front and laterally, fusing (thin white arrow) with the parietal peritoneum. Anterointernal border of the PPR space (in purple) fusing with the transversalis fascia, which it runs along laterally. It delineates the preperitoneal space, located between the transversalis fascia (wide black arrow)—which forms the external border of this space—and the fusion of the lateroconal fascia and the peritoneum (thin white arrow) (which forms the internal border of this space). Because of this, there is the possibility of communication between the PPR spaces, passing through this preperitoneal space to the anterior part of the abdomen (purple arrow). ARF (thin black arrow) and PRF (wide white arrow).
fluid collections. For example, in their study, Gore et al. [1] found that a fluid injected at the pancreas spread into a space located behind the APR space and in front of the ARf. They described the various communications of the interfascial retromesenteric plane, which are shown in Fig. 19. The fluid eventually spreads to the fascial trifurcation: between the laminae of the ARf, superficial PRf, and lateroconal fascia, around the perirenal space, creating the lateroconal and posterior interfascial decompression planes.

**Combined interfascial plane**

This is a potential space between the laminae of the ARf and the PRf around the ureter, into which fluid collections from the perirenal space can spread to reach the pelvis.

**Posterior interfascial plane**

This space is related to the formation of the PRf and it consists of two laminae of fused connective tissue, and it is summarized in Fig. 20a.

**Lateroconal interfascial plane (Fig. 20b)**

This is described as being a potential space that is able to expand within the laminae of the connective tissue of the lateroconal fascia (which is made up of multiple layers of connective tissue).
mesocolon, in front of the iliac vessels (Fig. 23). In the pelvic cavity, the ureter with its surrounding renal fasciae passes between the sigmoid mesocolon, the rectal mesentery, and the fasciae surrounding the neurovascular bundles as shown in Fig. 24a, allowing for interfascial passage to the presacral space. Finally, it is possible that anterior spread may occur along the umbilical prevesical fascia as described in Fig. 24b. All of these fasciae are easily visible on MRI. Fig. 25 illustrates spread from the perivesical space to the retroperitoneum during a traumatic bladder lavage in a 54-year-old patient.

Perirenal space

There is a midline passage between the two perirenal spaces in the form of the Kneeland channel [4].

Mindell describes in his study one case in which a contrast medium was blocked from spreading between the perirenal spaces through this channel by a voluminous abdominal aortic aneurysm, and it was displaced in front of the bifurcation of the iliac vessels [4]. There is also the possibility of upward spread: towards the bare area of the liver, but also the mediastinum and the sub-pleural space, via the lesser apertures of the crura of the diaphragm, and multiple lymphatics [1,3]. The perirenal space communicates with the pelvis [4] along the combined interfascial plane (seen in 100% or 5 cases in Mindell’s study [4]).

Posterior pararenal (PPR) space

This space communicates with the preperitoneal fat by running along the lateroconal fascia, which, in fusing with the parietal peritoneum, leaves a space for communication between the lateroconal fascia medially and the transversalis fascia laterally. From here, the two PPR spaces can communicate with each other [3]. Another communication route is towards the pelvis, following the ureter in the same way as in the APR space.

MRI clearly demonstrates the pathway from the fatty PPR space along the length of the ureter between the fascia of the iliac perivascular spaces and the sigmoid mesocolon, then allowing spread into the perivesical space medially, towards the sigmoid mesocolon behind and along the perivascular spaces laterally.

Communication routes

APR space

The various midline communication routes of the APR space with the mesenteries and the pelvis are summarized in Fig. 21. Fig. 22 illustrates the communication of a pancreatic pseudocyst with the descending colon. The ureter runs towards the pelvis passing under the parietal peritoneum, crossing in front of the iliac vessels, and then once again meeting the bladder at the perivesical space. On the left the ureter runs under the primary root of the sigmoid mesocolon, in front of the iliac vessels (Fig. 23). In the pelvic cavity, the ureter with its surrounding renal fasciae passes between the sigmoid mesocolon, the rectal mesentery, and the fasciae surrounding the neurovascular bundles as shown in Fig. 24a, allowing for interfascial passage to the presacral space. Finally, it is possible that anterior spread may occur along the umbilical prevesical fascia as described in Fig. 24b. All of these fasciae are easily visible on MRI. Fig. 25 illustrates spread from the perivesical space to the retroperitoneum during a traumatic bladder lavage in a 54-year-old patient.

Perirenal space

There is a midline passage between the two perirenal spaces in the form of the Kneeland channel [4].

Mindell describes in his study one case in which a contrast medium was blocked from spreading between the perirenal spaces through this channel by a voluminous abdominal aortic aneurysm, and it was displaced in front of the bifurcation of the iliac vessels [4]. There is also the possibility of upward spread: towards the bare area of the liver, but also the mediastinum and the sub-pleural space, via the lesser apertures of the crura of the diaphragm, and multiple lymphatics [1,3]. The perirenal space communicates with the pelvis [4] along the combined interfascial plane (seen in 100% or 5 cases in Mindell’s study [4]).

Posterior pararenal (PPR) space

This space communicates with the preperitoneal fat by running along the lateroconal fascia, which, in fusing with the parietal peritoneum, leaves a space for communication between the lateroconal fascia medially and the transversalis fascia laterally. From here, the two PPR spaces can communicate with each other [3]. Another communication route is towards the pelvis, following the ureter in the same way as in the APR space.

MRI clearly demonstrates the pathway from the fatty PPR space along the length of the ureter between the fascia of the iliac perivascular spaces and the sigmoid mesocolon, then allowing spread into the perivesical space medially, towards the sigmoid mesocolon behind and along the perivascular spaces laterally.

Communication routes

APR space

The various midline communication routes of the APR space with the mesenteries and the pelvis are summarized in Fig. 21. Fig. 22 illustrates the communication of a pancreatic pseudocyst with the descending colon. The ureter runs towards the pelvis passing under the parietal peritoneum, crossing in front of the iliac vessels, and then once again meeting the bladder at the perivesical space. On the left the ureter runs under the primary root of the sigmoid mesocolon, in front of the iliac vessels (Fig. 23). In the pelvic cavity, the ureter with its surrounding renal fasciae passes between the sigmoid mesocolon, the rectal mesentery, and the fasciae surrounding the neurovascular bundles as shown in Fig. 24a, allowing for interfascial passage to the presacral space. Finally, it is possible that anterior spread may occur along the umbilical prevesical fascia as described in Fig. 24b. All of these fasciae are easily visible on MRI. Fig. 25 illustrates spread from the perivesical space to the retroperitoneum during a traumatic bladder lavage in a 54-year-old patient.

Perirenal space

There is a midline passage between the two perirenal spaces in the form of the Kneeland channel [4].

Mindell describes in his study one case in which a contrast medium was blocked from spreading between the perirenal spaces through this channel by a voluminous abdominal aortic aneurysm, and it was displaced in front of the bifurcation of the iliac vessels [4]. There is also the possibility of upward spread: towards the bare area of the liver, but also the mediastinum and the sub-pleural space, via the lesser apertures of the crura of the diaphragm, and multiple lymphatics [1,3]. The perirenal space communicates with the pelvis [4] along the combined interfascial plane (seen in 100% or 5 cases in Mindell’s study [4]).

Posterior pararenal (PPR) space

This space communicates with the preperitoneal fat by running along the lateroconal fascia, which, in fusing with the parietal peritoneum, leaves a space for communication between the lateroconal fascia medially and the transversalis fascia laterally. From here, the two PPR spaces can communicate with each other [3]. Another communication route is towards the pelvis, following the ureter in the same way as in the APR space.

MRI clearly demonstrates the pathway from the fatty PPR space along the length of the ureter between the fascia of the iliac perivascular spaces and the sigmoid mesocolon, then allowing spread into the perivesical space medially, towards the sigmoid mesocolon behind and along the perivascular spaces laterally.

Communication routes

APR space

The various midline communication routes of the APR space with the mesenteries and the pelvis are summarized in Fig. 21. Fig. 22 illustrates the communication of a pancreatic pseudocyst with the descending colon. The ureter runs towards the pelvis passing under the parietal peritoneum, crossing in front of the iliac vessels, and then once again meeting the bladder at the perivesical space. On the left the ureter runs under the primary root of the sigmoid mesocolon, in front of the iliac vessels (Fig. 23). In the pelvic cavity, the ureter with its surrounding renal fasciae passes between the sigmoid mesocolon, the rectal mesentery, and the fasciae surrounding the neurovascular bundles as shown in Fig. 24a, allowing for interfascial passage to the presacral space. Finally, it is possible that anterior spread may occur along the umbilical prevesical fascia as described in Fig. 24b. All of these fasciae are easily visible on MRI. Fig. 25 illustrates spread from the perivesical space to the retroperitoneum during a traumatic bladder lavage in a 54-year-old patient.

Perirenal space

There is a midline passage between the two perirenal spaces in the form of the Kneeland channel [4].

Mindell describes in his study one case in which a contrast medium was blocked from spreading between the perirenal spaces through this channel by a voluminous abdominal aortic aneurysm, and it was displaced in front of the bifurcation of the iliac vessels [4]. There is also the possibility of upward spread: towards the bare area of the liver, but also the mediastinum and the sub-pleural space, via the lesser apertures of the crura of the diaphragm, and multiple lymphatics [1,3]. The perirenal space communicates with the pelvis [4] along the combined interfascial plane (seen in 100% or 5 cases in Mindell’s study [4]).

Posterior pararenal (PPR) space

This space communicates with the preperitoneal fat by running along the lateroconal fascia, which, in fusing with the parietal peritoneum, leaves a space for communication between the lateroconal fascia medially and the transversalis fascia laterally. From here, the two PPR spaces can communicate with each other [3]. Another communication route is towards the pelvis, following the ureter in the same way as in the APR space.

MRI clearly demonstrates the pathway from the fatty PPR space along the length of the ureter between the fascia of the iliac perivascular spaces and the sigmoid mesocolon, then allowing spread into the perivesical space medially, towards the sigmoid mesocolon behind and along the perivascular spaces laterally.
Figure 10. Medial border of the fasciae. a: axial CT view through the left renal hilum. The fusion of the PRf (in pink) to the quadratus lumborum muscle continues downwards to become increasingly medial, as far as the transversalis fascia (in light green) next to the psoas muscle. Parietal peritoneum (in green), ARf (in blue). Lateroconal fascia (in light pink), continuous with the PRf. b: a lower axial CT view through the inferior pole of the kidney. The PRf joins with the transversalis fascia increasingly medially. c: axial view lower still, the PRf is at the midline.

Figure 11. Medial extension of the ARf. a: diagram of an axial cross-section through the inferior pole of the kidneys. ARf (in blue). Perivascular connective tissue (in light blue). b: the theory of the Kneeland channel (light blue) is based on the spread of a fluid collection between the two perirenal spaces (star) through the perivascular connective tissue fibres.
Figure 12. Inferior extension of the perirenal fasciae. a: diagram of an axial cross-section through the inferior part of the renal cone. In front: a lamina of parietal peritoneum (dark green), covering a strip of ARf (in blue) flattened against the ureter (in yellow), and continuous with the PRf (in purple) at the posterior part of the ureter. Behind: a layer of fatty tissue: the PPR space (in brown), and finally the transversalis fascia (light green) which then covers the psoas muscle (shaded area). b: diagram of an oblique cross-section showing how the various laminae of the retroperitoneum are superimposed and attach to each other above at the diaphragm (D) with from front to back: the parietal peritoneum (dark green), the ARf in blue, the kidney and ureter (in yellow), the PRf (in pink), the PPR space in orange, the transversalis fascia (light green) and finally the psoas muscle (P) in front of the iliac wing.

Figure 13. Bridging septa of the perirenal space. Axial CT view through the left kidney: from a) to c), ARf and PRf in beige. a) The type I septa (in yellow) extend from the perirenal fascia to the renal capsule. b) Type II (in red) run from capsule to capsule, forming a curved arch, of which one is constant: the posterior renorenal septum, where a perirenal haematoma bordered by this septum can mimic a subcapsular haematoma. c) Type III septa (in green) connect the ARf to the PRf. d) Network created by the bridging septa that support the kidney.
Figure 14. APR space. Simplified axial CT view through the kidneys and duodenum. Parietal peritoneum (in green) delineating the peritoneal cavity. The ARf (in blue) borders the posterior surface of the APR space. The lateroconal fascia (in purple) borders the APR space laterally. Ascending colon (brown, asterisk) on the right, and descending colon (brown, white circle); duodenum and pancreas (in purple).

Figure 15. Diagram of retropancreatic and peritoneal fusion. a) Axial cross-section at the embryonic stage with the primordia of various organs surrounded by peritoneum (in green). Primordium of liver (in orange), primitive gut (in yellow), primordium of spleen (in red), and primordium of pancreas (in purple). The folds of peritoneum form the various ligaments marked on the diagram. b) and c) Peritoneal and retropancreatic folds: the primordium of pancreas (in purple) is at first surrounded by peritoneum like the rest of the visceral primordia. The development of the spleen causes the pancreas to move to the left in a clockwise direction. This means that the left lateral fold of visceral peritoneum that finds itself in contact with the lamina of parietal peritoneum fuses with it (cross-hatched area), which leads in particular to the formation of the Treitz fascia at its uppermost part. d) The fusion of these layers of peritoneum with the posterior connective tissue through mechanical change is accompanied by a change in their texture, and leaves the duodenum and pancreas in communication with the retroperitoneal space, thus making them into ‘retroperitoneal’ organs.
Radioanatomy of the retroperitoneal space

Figure 16. Formation of the omental bursa. Sagittal cross-sections through the lesser sac. a) Initially there is a vestigial yolk sac between the liver (L) above and in front, the stomach (S) below and in front, and the pancreas (P) below and behind, forming the omental bursa (in light green). The simplified laminae of peritoneum are shown (in dark green) around the organs represented in cross-section: the duodenum (D), transverse colon (C), and intestine (I). b) A small protuberance from the bursa will then infiltrate in front of the pancreas and behind the stomach, running downwards, accompanied by the peritoneum surrounding these viscera (four layers of peritoneal fascia). c) As it grows, this protuberance forms a true pocket, the walls of which, made up of peritoneum, will fuse together to form the greater omentum (corresponding to the four apposed layers of peritoneum, in blue) which fuses to its posterior part with the transverse colon. In parallel with the formation of the greater omentum, the pancreas and the duodenum behind become closer together until their peritoneal fasciae fuse (in pink), which explains how the duodenum, from around its second to fourth parts, is found in a retroperitoneal position.

Figure 17. Diagram of the borders of the APR space. a) Diagram of a sagittal cross-section through the kidney (K) and liver (L). The peritoneum (in green) forms the anterior border of the APR space. The ARF (in blue) is the posterior border. On the right, the superior border of the APR space is where the ARF behind and the peritoneum in front fuse (black arrow). The ARF fuses with the diaphragm on the left and at the inferior layer of the coronary ligament on the right. b) Inferior border of the APR space, diagram of an axial cross-section through the inferior point of the "renal cone" (shown by the white dotted line on figure a). The inferior borders are the fusion of the ARF (in blue) to the parietal peritoneum (asterisk) in front, and the fusion of the ARF to the periureteral connective tissue (yellow) behind. The PRF (in pink) is joined to the posterior surface of the ureter, in front of the PPR space (in orange) with its fatty content resting on the transversalis fascia (light green) that covers the psoas muscle (P).
Figure 18. Borders of the PPR space. Diagrams of axial cross-sections through the inferior pole of the left kidney (a); the inferior point of the renal cone (b), and the pelvis (c, d, e and f). a) The PPR space (in dark pink) is bordered by the PRF in continuity with the lateroconal fascia (in light pink) in front and the transversalis fascia (in orange) behind. b) PPR space (in dark pink), ureter (in yellow) at the medial part. c) In the pelvis, the fatty PPR space (in purple) follows the progression of the ureter (in yellow), which remains in a medial position. d) Same cross-section as c) showing the PPR space (in pink) and the preperitoneal space (in pink, white arrow). The ureter (in yellow) is located between the peritoneal cavity (in green) and the perivascular space (in orange). e) Simplified axial MRI view showing the peritoneal space (in green). The PPR space (in pink), in contact with the ureter (in yellow), is in contact with the perivascular spaces (in orange) along the iliac vessels, which bifurcate into the internal and external iliac vessels at the most lateral part of the pelvis. f) The PPR space (in pink) terminates with a potential space between the perivesical peritoneal folds running along the ureter to the bladder. These fasciae are clearly demonstrated on MRI. Ureter (in yellow), bladder (V), lateral perivascular spaces (in orange), and rectal mesentery (in green).

Figure 19. Retromesenteric interfascial plane. a) Diagram of an axial cross-section of an embryo through the pancreas (asterisk), showing the laminae of posterior peritoneum fused with the posterior fatty structures (black arrow). The peritoneal cavity (solid green), liver (L), primitive gut (G), spleen (S), kidneys (K), and vertebral primordium are shown (V). Perivascular connective tissue (Kneeland channel, in blue and white arrow). b) Diagram of the communications of the retromesenteric interfascial plane shown in a sagittal cross-section. Peritoneal cavity (in green), APR space (in blue) containing the pancreas (P) and colon (C). Perirenal space (in yellow), PPR space (in purple), and psoas muscle covered with transversalis fascia (in orange). The injection of a dye (in red) into the pancreas identifies spread: 1) The “retromesenteric interfascial plane” behind the pancreas, and between the APR space and perirenal space. 2) Laterally between the peritoneum and the APR space along the colon and its mesentery, along the interface between the posterior parietal peritoneum and the fatty tissue of the APR space. 3) Above, near to the diaphragm, the fluid spreads towards the esophageal hiatus, where the posterior parietal peritoneum fuses with the anterior renal fascia; the fluid diffusing through the mesh of connective tissue between the posterior parietal peritoneum and the APR space. 4) Posteriorly between the perirenal and PPR spaces. 5) Below, towards the pelvis, the fluid travels along the surface of the psoas muscle, in front of the transversalis fascia.
Figure 20. Posterior and lateroconal interfascial planes. a) Posterior interfascial plane (dark blue). A collection can spread from the APR space (light blue) between the two apposed laminae of connective tissue of the PRf (the deep lamina of the PRf continuous with the ARf, and the superficial lamina of the PRf continuous with the lateroconal fascia), i.e., between the perirenal space (in yellow) covered with the deep lamina of the PRf and the PPR space (in red) (bordered by the superficial lamina of the PRf). b) Lateroconal interfascial plane. Potential space (in red) within the laminae of lateroconal fascia (in orange). It is closely linked to the posterior interfascial plane at the fascial trifurcation (black arrow).

Figure 21. Communications of the APR space. Axial CT view: There is free communication between the two APR spaces (in blue) behind the duodenum and pancreas. b) Sagittal cross-section showing extension along the mesenteries. The APR space communicates with the spaces located along the mesenteries [3], remaining separated from the peritoneal cavity by the visceral peritoneum: transverse mesocolon (in pink), mesentery (in blue), and sigmoid mesocolon (in orange). This means that a fluid collection may run from the APR space to the transverse mesocolon, for example, and end up around an organ that is entirely covered with visceral peritoneum. Peritoneum (in green). c) Diagram of a ¾ axial cross-section through the ureter: there is communication from the APR space to the pelvis [4] through spread into the potential space between the parietal peritoneum in front (in dark green) and the ARf (in blue) behind, following the path of the ureter (in yellow). PRf (in purple), fat from the posterior part of the PPR space (asterisk), transversalis fascia (light green), psoas muscle (P).
Figure 22. Pseudocyst in the APR space. Contrast-enhanced CT in a 54-year-old female. Post-ERCP pancreatitis. a): Axial view: voluminous pseudocyst at the tail of the pancreas (white arrow). b): Axial view: communication between a pseudocyst in the APR space (white arrow) and the left colon at a point of contact, which the cyst can drain into (red arrow). c): Axial view: effusion of the APR space (white arrow), with a pseudocyst draining into the left colon (red arrow), pseudocyst in contact with the kidney in the APR space (black arrow). d): Sagittal view: pseudocyst coming into contact with the stomach (white arrow). Pseudocyst of the APR space at the inferior pole of the kidney (red arrow).

Figure 23. Pelvic position of the ureter. Diagram of a left lateral view of the abdominal cavity, showing the path of the ureter (in yellow) passing under the peritoneal cavity bordered by parietal peritoneum (light blue). On the left the ureter passes in front of the iliac vessels, under the primary root of the sigmoid mesocolon (black arrow). Sigmoid colon (S).
Figure 24. Communication from the retroperitoneum to the pelvis. a) Simplified axial MRI view through the superior part of the bladder (B). The ureters (in yellow) surrounded by fat from the PPR space, run alongside the point of contact with the rectal mesentery behind, the vascular spaces (vessels in red) with their surrounding fasciae laterally, and the peritoneal cavity in front. The peritoneum and the fasciae are shown in green, and they separate the different compartments. In front of the sacrum: the presacral space with its surrounding fasciae. b) Diagram of the umbilical prevesical fascia with a left lateral view of the pelvic cavity. Iliac wing drawn in to show the lateral border of the pelvis. From the perivesical space there is an anterior route for spread along the umbilical prevesical fascia (cross-hatched area), which then covers the medial umbilical ligament (in pink) and the median umbilical ligament (in blue), above the space of Retzius (asterisk) (located between the transversalis fascia in front (in orange), and the umbilical prevesical fascia behind). Bladder (B), pubovesical ligaments (thin black arrow), internal iliac arteries (large black arrows).

Figure 25. CT of a 54-year-old patient with a bladder rupture following traumatic lavage. a) Sagittal contrast-enhanced CT. Pneumatosi in the space of Retzius (white arrow), preperitoneal pneumatosi between the transversalis fascia and parietal peritoneum (red arrow). Effusion spreading from the perivesical space (black arrow) along the presacral fascia (curved white arrow). b) Sagittal CT view with pulmonary window: pneumatosi in the space of Retzius and along the umbilical prevesical fascia (white arrows), preperitoneal pneumatosi (red arrow) between the umbilical prevesical fascia and the parietal peritoneum. c) Axial CT view. Effusion in the presacral space (white arrow) that has spread into the perivesical space (black arrow) along the pelvic fasciae, especially the perivasculack fasciae, subcutaneous emphysema (red arrow). d) Axial CT view: the effusion has spread to the APR space causing distension (white arrow) and along the perivesical layers to the presacral space (red arrow). e) Axial CT view: effusion in the APR spaces (white arrows) with communication through the Kneeland channel (red arrow) in front of the vascular space. f) Axial CT view: effusion in the APR space (white arrow) that has spread into the posterior interfascial plane (black arrow). Preperitoneal pneumatosi (red arrow).

Conclusion

The lateral retroperitoneal space is split by its fasciae into three main spaces: the anterior pararenal space, the perirenal space, and the posterior pararenal space. Between these spaces there are numerous sliding decompression planes: this is where interfascial spread occurs. It is important to appreciate that the organs belonging to the anterior pararenal space are in fact situated in the retroperitoneum (ascending colon, descending colon, pancreas and duodenum). An analysis founded on anatomy leads to an understanding of pathological processes in these sites and how they spread locally or to sites further away.
Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

References


