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Unraveling the retroperitoneum

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Learning objectives

- Describe the anatomical landmarks of the retroperitoneal space and the clinical relevancy of this compartment;

- Explain the radiological signs that may help locate a mass in the retroperitoneal space.

Background

The retroperitoneum is an extraperitoneal space of complex anatomy in which many pathological processes may develop. On imaging methods, retroperitoneal masses are best illustrated with CT or MRI, making ultrasound less reliable due to the depth of this space.

Imaging techniques may also be used to guide biopsies.

Findings and procedure details

THE RETROPERITONEAL SPACE

The retroperitoneum is an anatomic space that deserves special attention because of its complexity and relevancy. It is a clinically hidden space where, due to its deep location and great compliance, many pathologic processes such as tumors or infections may grow enourmously with only subtle clinical signs. Therefore, imaging methods, particularly CT and MRI assume a great role in its evaluation.

A. Anatomy

The retroperitoneum is a extraperitoneal space that has the diaphragm as its superior boundary. At this level it is continuous with the retrocrural space and the posterior mediastinum. Inferiorly it communicates with the pelvis. Unlike its superior and inferior margins, the anterior and posterior limits are well established by bands of connective tissue - the posterior parietal peritoneum anteriorly and the transversalis fascia posteriorly (Figure 1).

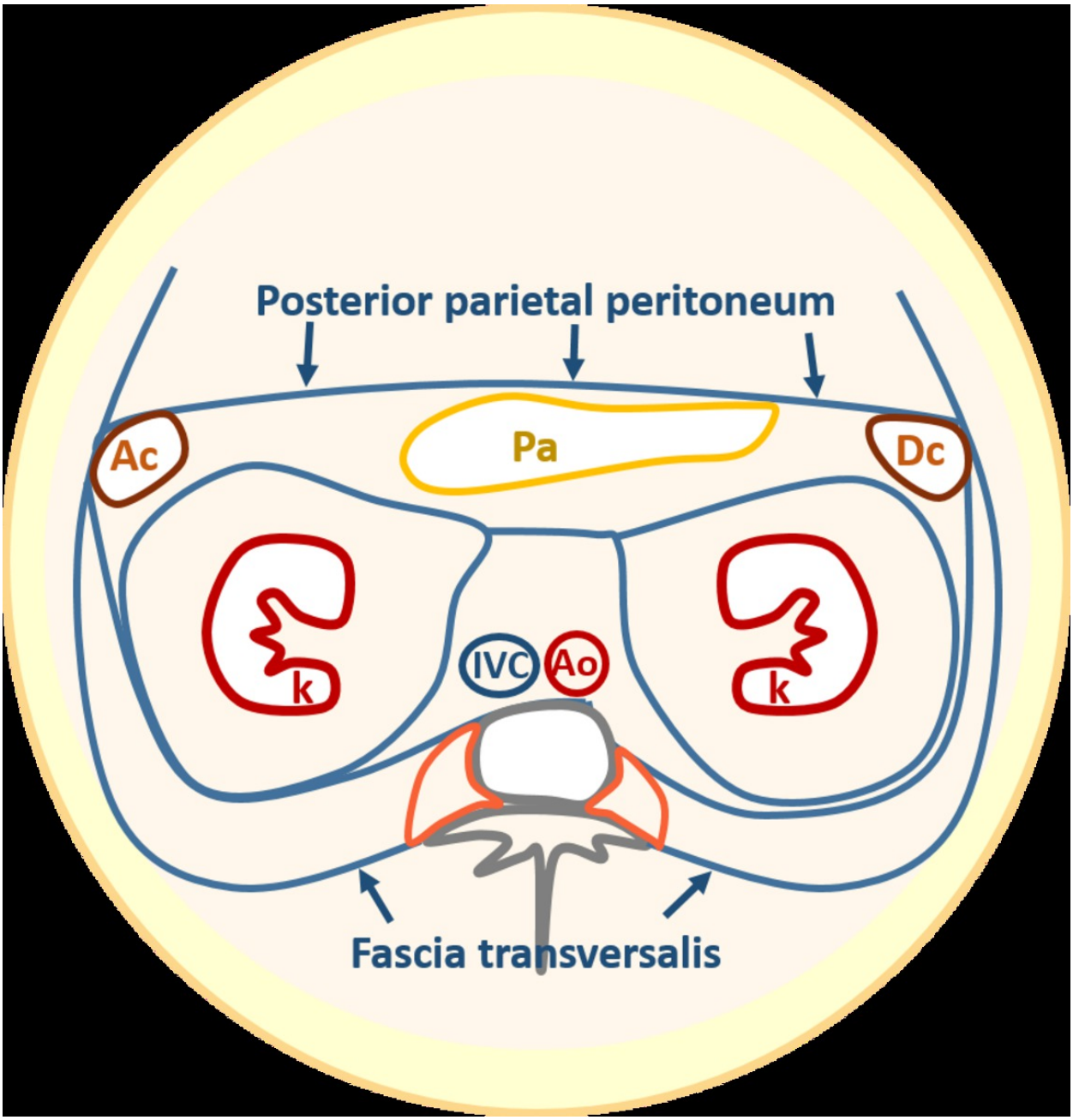


Fig. 1: The retroperitoneal space has well defined anterior and posterior limits. It is limited anteriorly by the posterior parietal peritoneum and posteriorly by the fascia transversalis. Pa = Pancreas; Ac = Ascending colon; Dc = Descending colon, k = Kidney; IVC = Inferior vena cava; Ao = Aorta.
References: Radiologia, Centro Hospitalar e Universitário de Coimbra - Guimarães/PT

Inside this space, three compartments are classically described. From anterior to posterior, these spaces are: the anterior pararenal space, the perirenal space and the posterior pararenal space.

A. I Anterior pararenal space

The most anterior compartment of the retroperitoneal space is the **anterior pararenal space**. It is limited anteriorly by the posterior parietal peritoneum which separates it from the peritoneal cavity.

Posteriorly it is separated from the perirenal space by the anterior renal fascia, also called Gerota's fascia. Laterally it goes until the lateroconal fascia, also named Sappey's fascia (Figure 2).

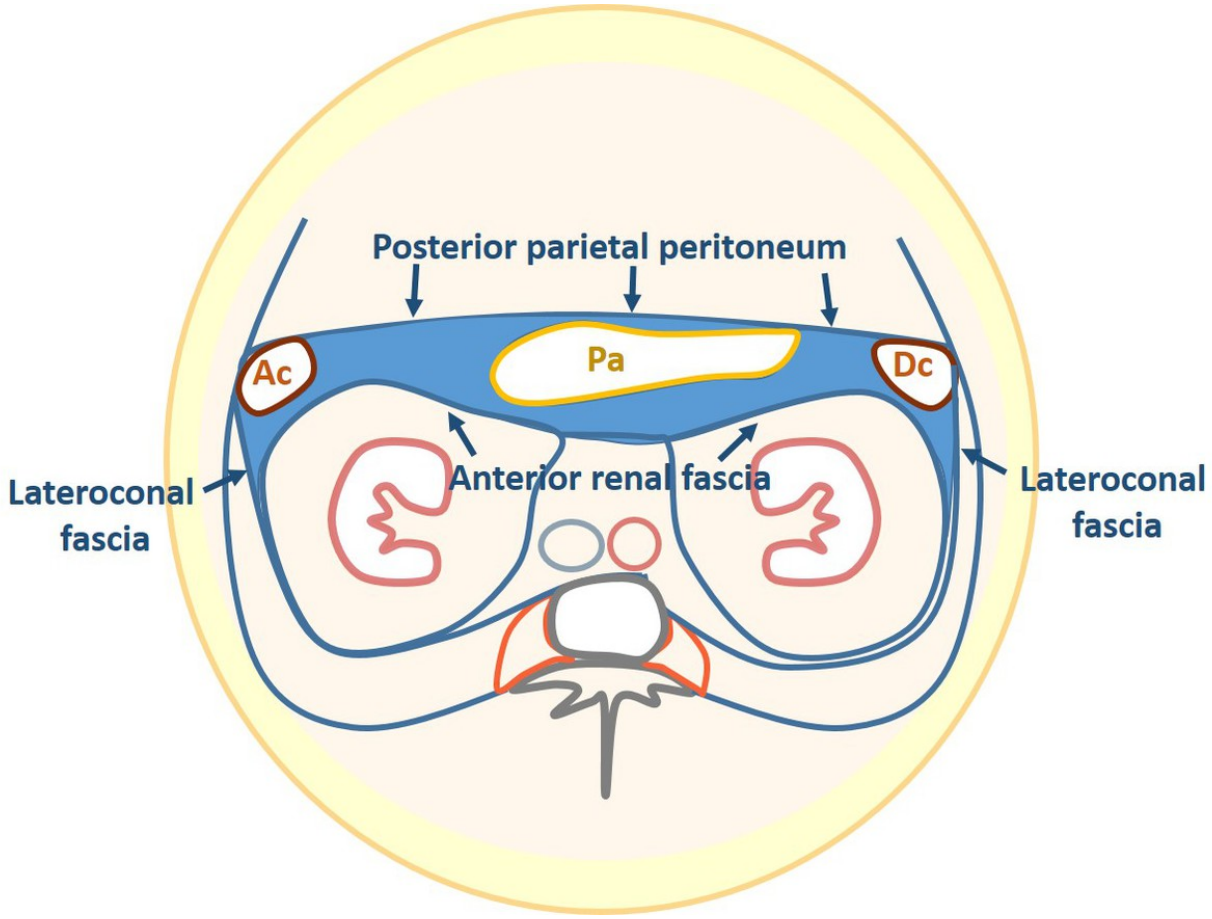


Fig. 2: Anterior pararenal space marked in blue. This compartment is limited anteriorly by the posterior parietal peritoneum and posteriorly by the anterior renal fascia or fascia of Gerota. Its lateral boundaries are the laterconal fascia. It contains the pancreas, the ascending and the descending colon, but also part of the duodenum. Pa = Pancreas; Ac = Ascending colon; Dc = Descending colon.
References: Radiologia, Centro Hospitalar e Universitário de Coimbra - Guimarães/PT

Two smaller spaces can be distinguished within the anterior pararenal space. Laterally, the **pericolic space** containing the ascending and descending colon. Medially, the **pacreatoduodenal space** contains part of the pancreas and the duodenum. It is important to remember that only the head and body of the pancreas are retroperitoneal, while the tail is intraperitoneal. The duodenum is mainly a retroperitoneal organ, having only the first segment intraperitoneal and the remaining three segments lined anteriorly by the posterior parietal peritoneum, making them retroperitoneal (Figure 3).

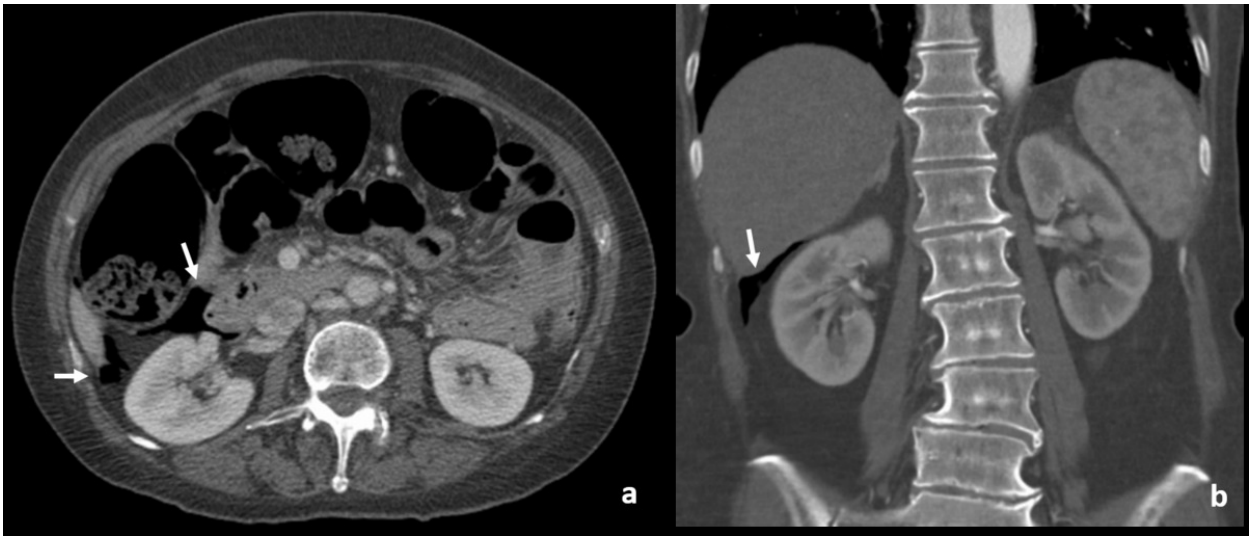


Fig. 3: Free air in the anterior pararenal space. CT of a patient who reported intesive pain after ERCP. Duodenal perforation was confirmed by the demonstration of extraluminal air. The air is seen to flow from the lateral wall of the second portion of the duodenum (which is retroperitoneal in this location), behind the colon and extending to the lateroconal fascia (arrows in a) and the anterior renal fascia. It does not enter the perirenal space (arrow in b).
References: Radiologia, Centro Hospitalar e Universitário de Coimbra - Guimarães/PT

Adipose tissue is also seen in this space. Despite being continuous in the middle, it is not common for fluids in this space to cross it (Figure 4). Pancreatic collections are the exceptions. They contain tripsin that will digest any thin fascia separating the two sides.

Fig. 4: The anterior pararenal space. Fluid is seen in the anterior pararenal space, circunscribed posteriorly by the anterior renal fascia (arrows). It envolves the third segment of the duodenum and does not cross the midline.
References: Radiologia, Centro Hospitalar e Universitário de Coimbra - Guimarães/PT

A. II Perirenal space

The **perirenal space** is separated from the anterior pararenal space by the anterior renal fascia or fascia of Gerota. This is a dense collagenous band of connective tissue that continues posteriorly with the posterior renal fascia or fascia of Zuckerkandl. Internally, the posterior fascia fuses with the psoas and quadratus lumbar fasciae but also with the fasciae that involve the great vessels. Laterally, the posterior renal fascia continues by one band with the anterior renal fascia and by another with the lateroconal fascia (Figure 5).

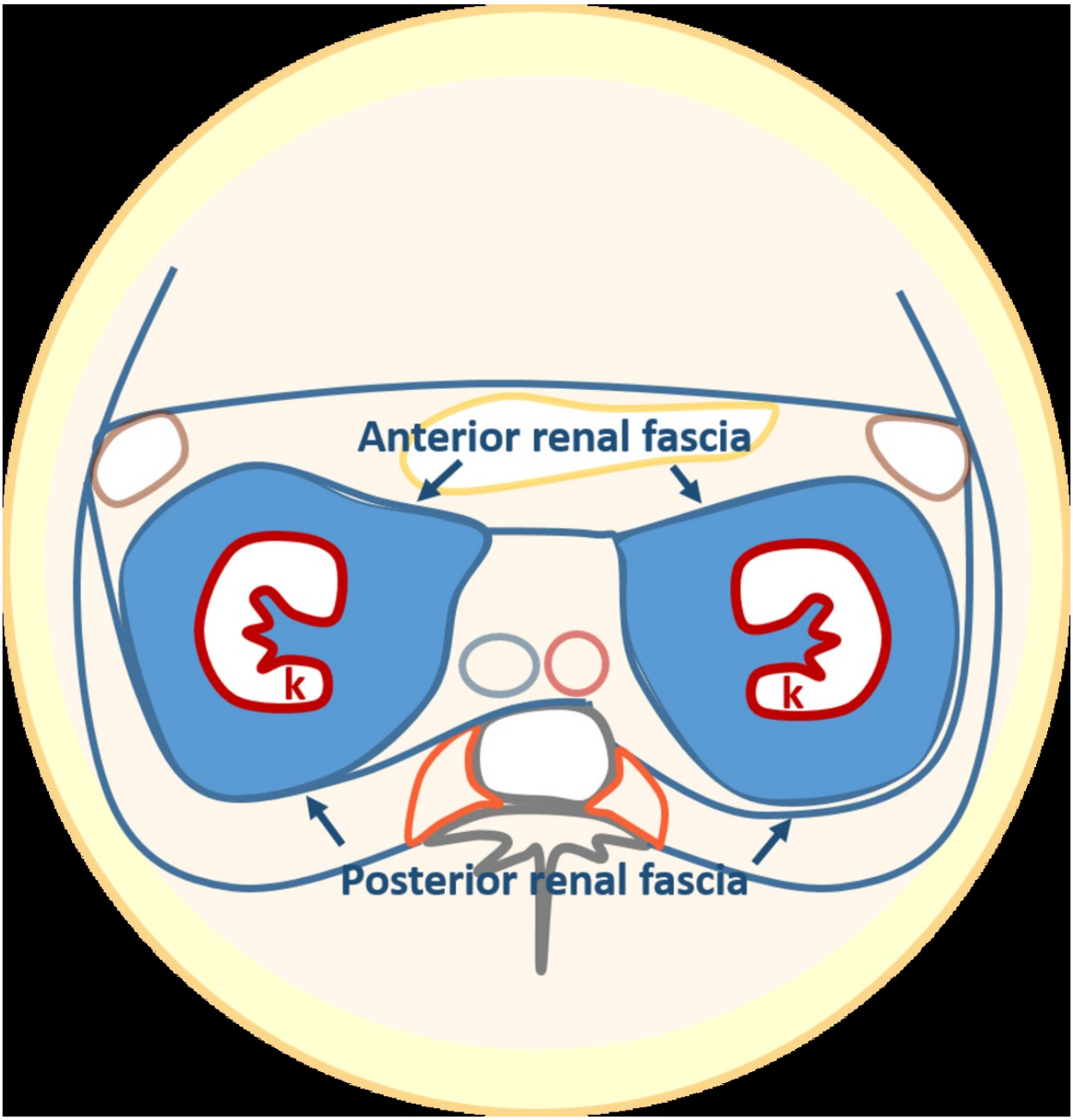


Fig. 5: Perirenal space marked in blue. This space is limited by the anterior and posterior renal fasciae. It contains the kidney, adrenals and adipose tissue. K = Kidneys.
References: Radiologia, Centro Hospitalar e Universitário de Coimbra - Guimarães/PT

The kidneys, calyx, adrenals and hilar vessels are contained in this compartment, also with adipose tissue. There is no midline communication in this space, as proved by numerous post-mortem experiments with fluid injections.

On a sagittal section, the perirenal space has a shape of an inverted cone, with a superior base. At the level of the iliac crest, the anterior and posterior renal fasciae fuse, corresponding to the vertex of this cone (Figure 6). Inferiorly to this level the anterior and posterior pararenal spaces communicate freely, allowing fluids originating in the anterior pararenal space to flow to the posterior pararenal space without entering the perirenal compartment (Figure 7).

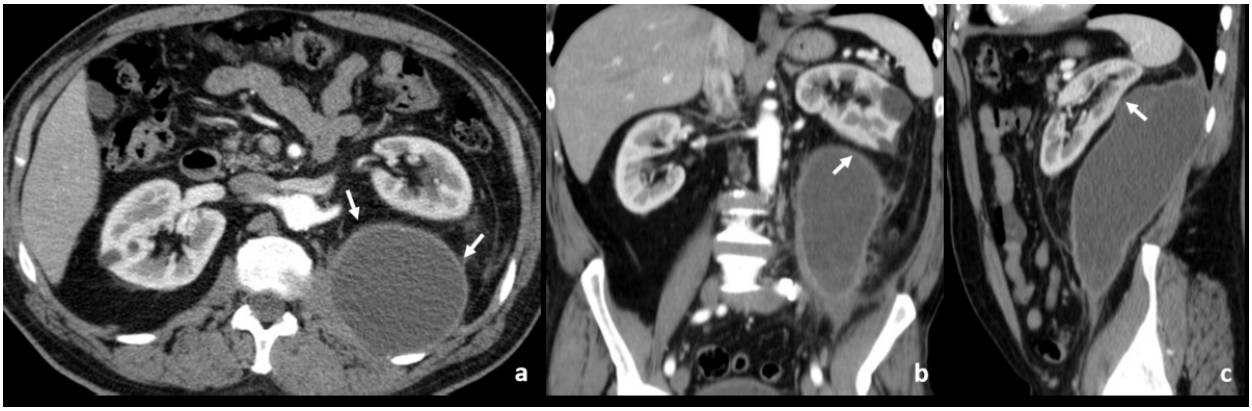


Fig. 6: Collection in the perirenal space. Contrast-enhanced CT demonstrates an homogenous collection with water density and a well defined enhancing wall (arrows in a). This collection is seen to push superior and anteriorly the left kidney (arrows in b and c, respectively). It is longitudinally orientated, respecting the limits of the perirenal space and ending inferiorly at the vertex of the inverted cone. This was a patient with trauma and a retroperitoneal hematoma who recently had increased inflammatory markers, consistent with inflamed hematoma.
References: Radiologia, Centro Hospitalar e Universitário de Coimbra - Guimarães/PT

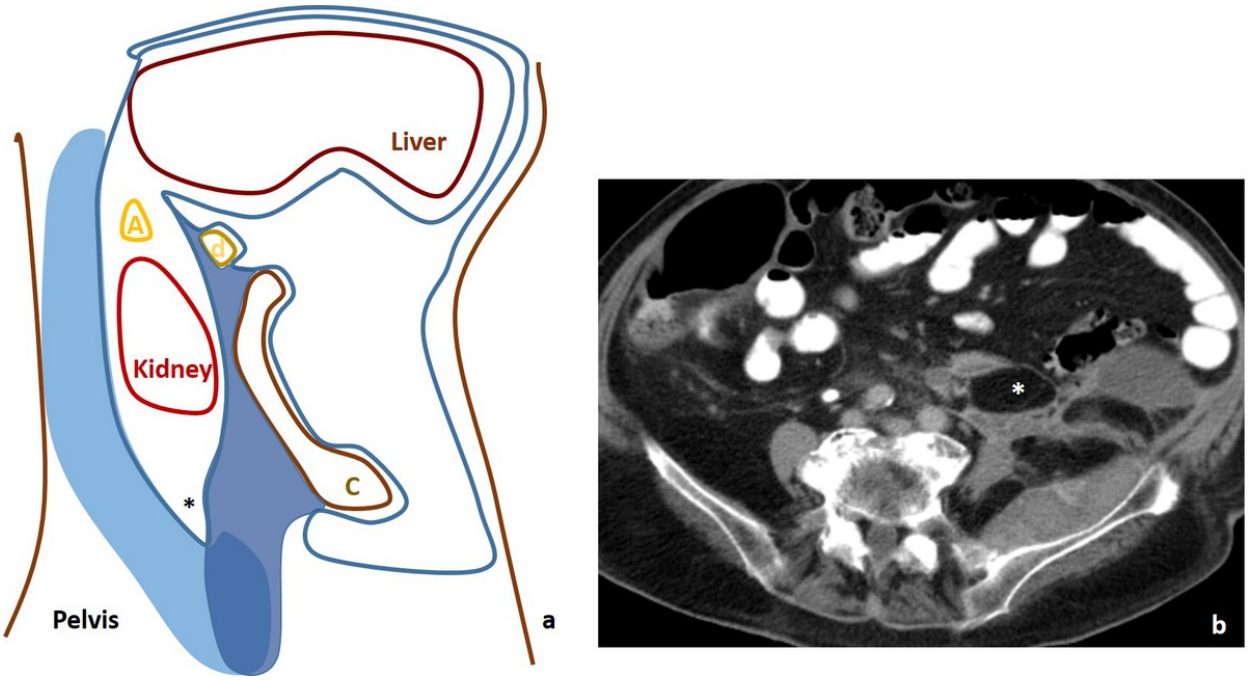


Fig. 7: The perirenal space on a sagittal section has an inverted cone shape. Little bellow the iliac crest level, the anterior and posterior renal fascia fuse (asterisk in a and b), alowing the anterior and posterior pararenal spaces to communicate (light blue space and dark blue space, respectively, showed in a). As seen on the CT (Figure b), fluids can extend between the anterior and posterior pararenal spaces, sparing the perirenal compartment.
References: Radiologia, Centro Hospitalar e Universitário de Coimbra - Guimarães/PT

Two defects are considered to exist in this space, which will allow localized and unexpected communications of spaces.

The first defect may allow bilateral contact of right and left perirenal spaces. This defect is inferior, at the level of the third/fifth lumbar vertebra, inferior to the origin of the superior mesenteric artery. Here, fluids may cross the midline through small communicating branches, anterior to the aorta and inferior vena cava.

The second defect is well documented and is frequently evidenced. It is a flaw in the right anterior renal fascia where the liver, in a surfaced called the bare area, is juxtaposed with the right kidney. At this location, the anterior renal fascia and the posterior parietal peritoneum fuse allowing these two organs to contact (Figure 7). Importantly, this may allow an hepatic laceration to cause a retroperitoneal hematoma without intraperitoneal fluid being detected.

A. III The Posterior pararenal space

This division of the retroperitoneum is well limited anteriorly and posteriorly by the posterior renal fascia and the fascia transversalis, respectively. Laterally, the **posterior pararenal space** extends to the lateroconal fascia. Inferiorly it opens into the pelvis. Unlike the other spaces, this one does not contain organs, but only adipose tissue (Figures 8 and 9).

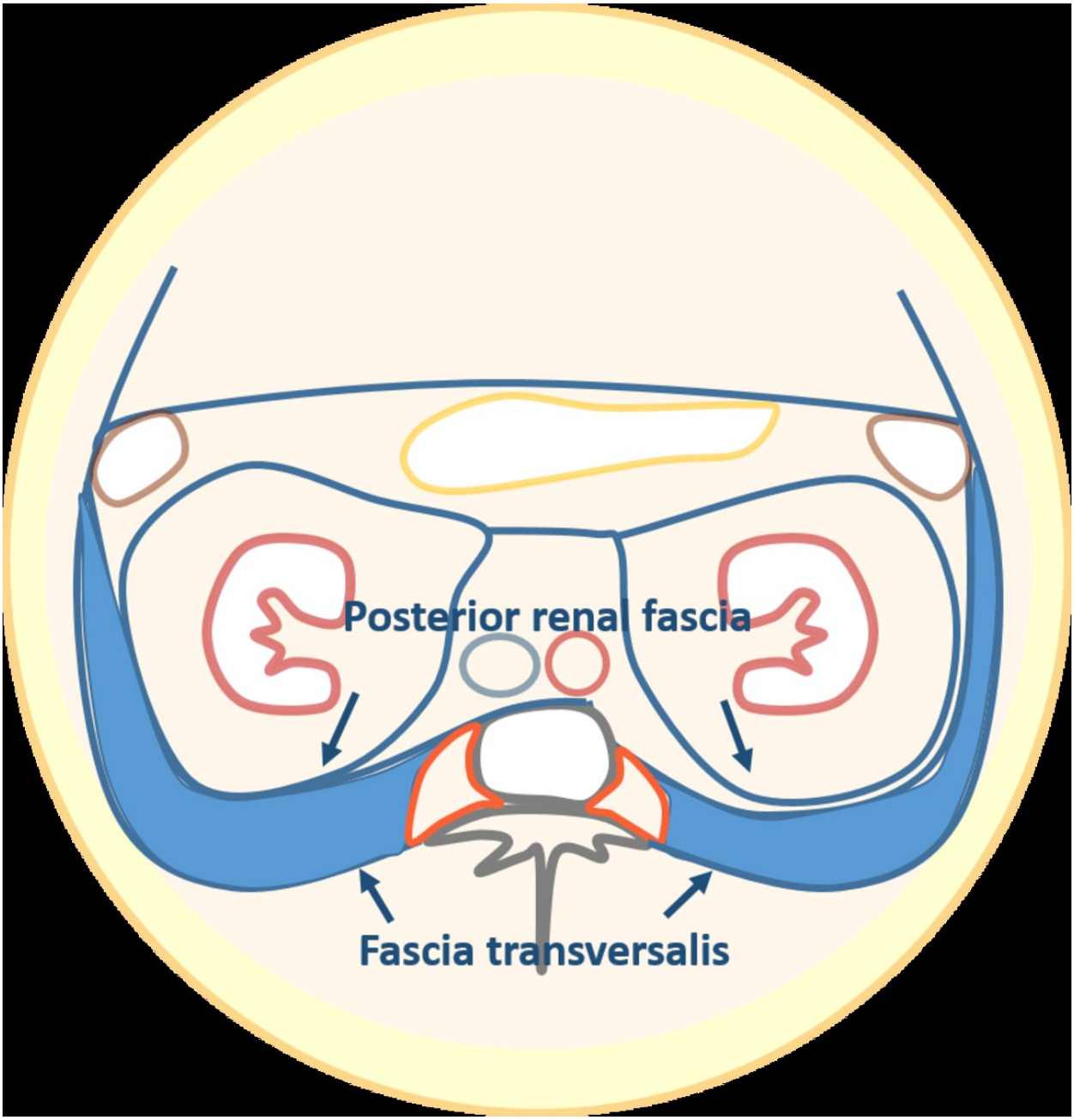


Fig. 8: The posterior pararenal space is marked in blue. The posterior renal fascia represents its anterior limit while the fascia transversalis is the posterior limit.

References: Radiologia, Centro Hospitalar e Universitário de Coimbra - Guimarães/ PT

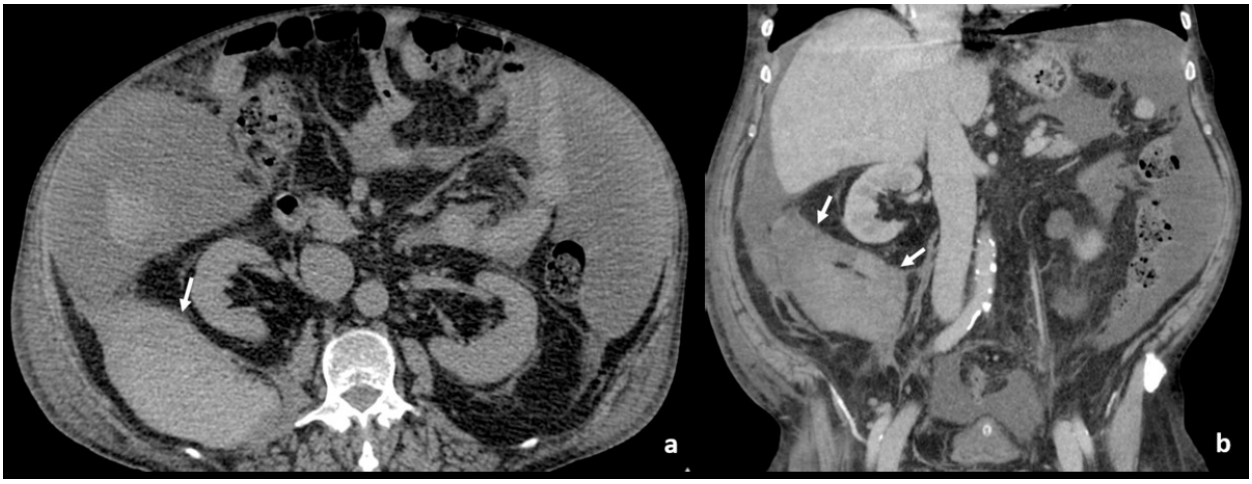


Fig. 9: Posterior pararenal space collection. A patient with chronic hepatopathy and ascitis who had a recent trauma in the right flank. CT aquisition before contrast reveals the presence of an homogenous hyperattenuating collection the the posterior pararenal space, limited anteriorly by the posterior renal fascia (arrows in a and b). This collection does not show contrast-enhancement (coronal reformatation in b) and is consistent with a retroperitoneal hematoma.
References: Radiologia, Centro Hospitalar e Universitário de Coimbra - Guimarães/PT

A. IV The great vessels space

Some authors have described the existence of another space in the retroperitoneum - the **great vessels space**. Anteriorly and laterally, it is limited by the fusion of the anterior and posterior renal fasciae. The vertebra and the psoas muscle establish the posterior limit. Superiorly it is continuous with the retrocrural space. It contains not only the great vessels, the aorta and the inferior vena cava, but also lymphatic structures, so it is an important location to search for enlarged lymph nodes (Figure 10).

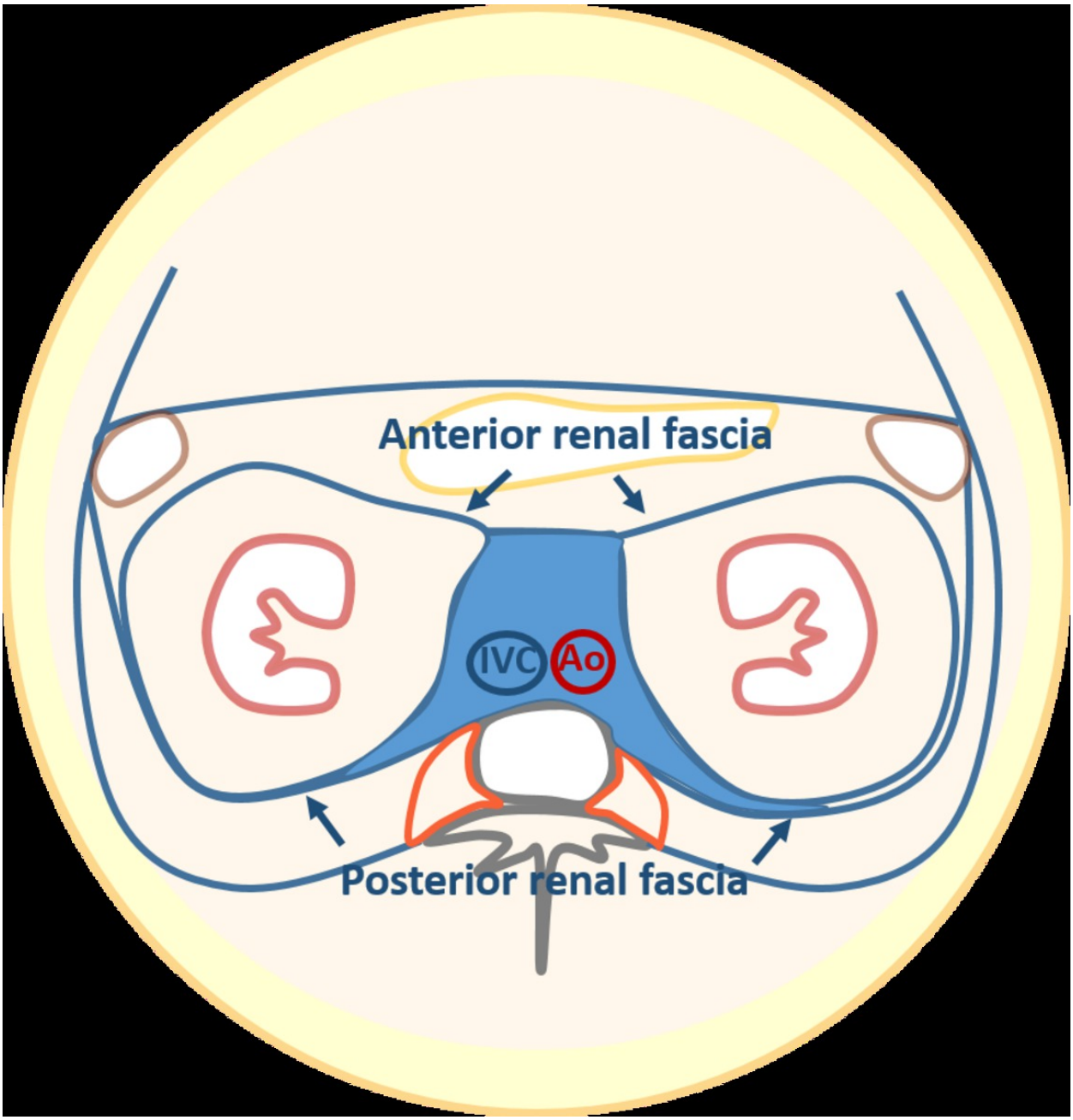


Fig. 10: The great vessels space is marked in blue. It is limited anterior and laterally by the anterior and posterior renal fasciae. Posteriorly it has the body of the vertebra as the limit. Contains the great vessels and lymphatic structures. IVC = Inferior vena cava; Ao = Aorta.
References: Radiologia, Centro Hospitalar e Universitário de Coimbra - Guimarães/PT

Unlike the previous, this compartment is not adequately separated by the others spaces by well defined fascia. Truly, it can be easily affected by pathologic processes developing in a nearby space (Figure 11).

Fig. 11: The great vessels space. Contrast-enhanced CT displaying an homogeneous, soft-tissue density mass surrounding the aorta and extending to the left renal hilum (arrows in a and b).Unlike the other three retroperitoneal spaces, this is not well circunscribed and can easily be affected by pathologic processes extending through the other spaces. The vessels involved by this mass show normal size and permeability. These abnormalities are typical of Lymphoma.
References: Radiologia, Centro Hospitalar e Universitário de Coimbra - Guimarães/PT

B. Interfascial spread of disease

Recent works have focused on the retropertioneal fasciae. They have proved that these fasciae are not unilaminated, but multilaminated structures with potential, expandable spaces within them. These potential spaces are represented by retromesenteric plane, retrorenal plane, lateroconal plane and combined fascial plane (Figures 12, 13, 14 and 15).

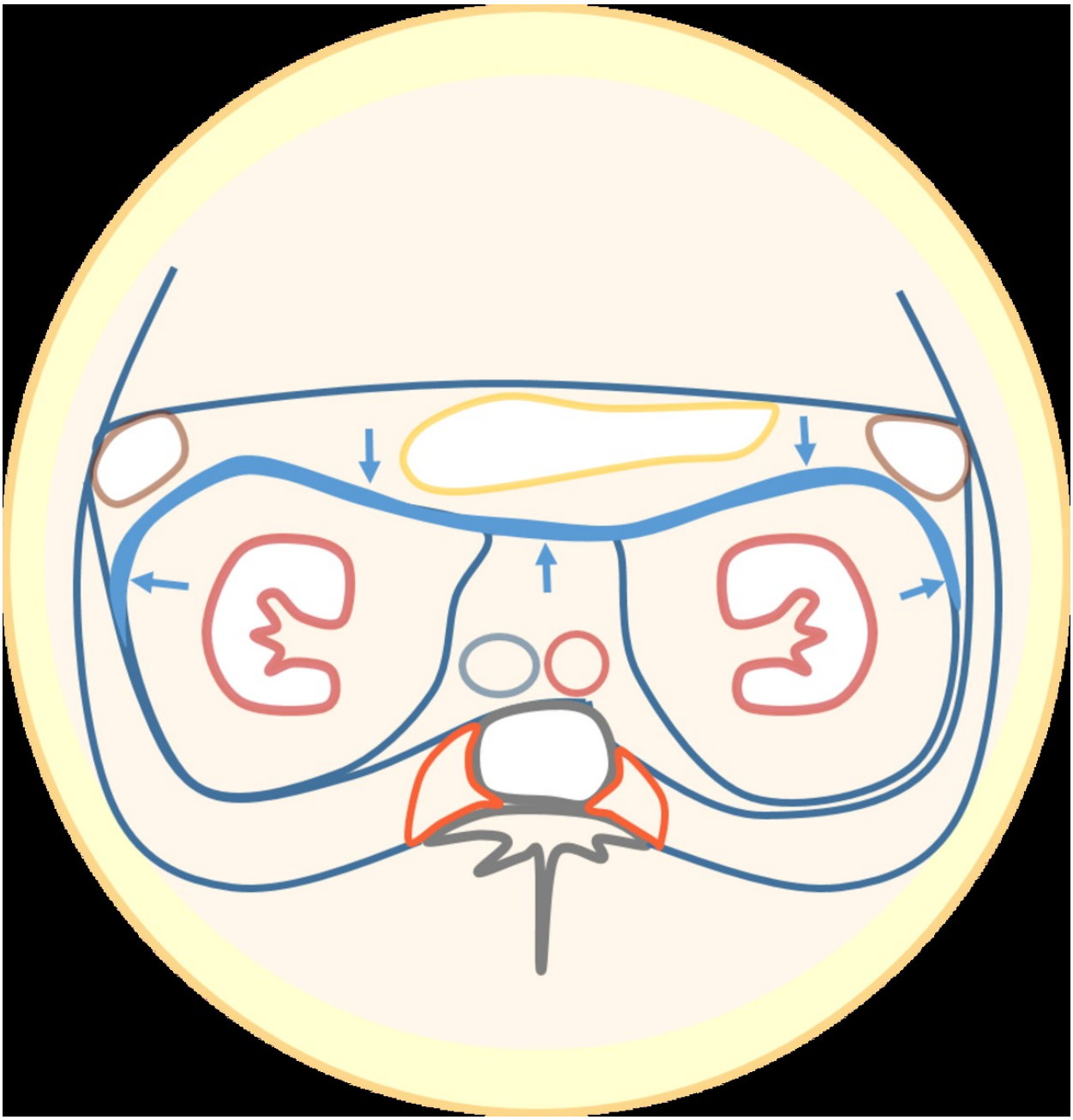


Fig. 12: Arrows showing the retromesenteric plane, a potencial space between the anterior pararenal space and the perirenal space.
References: Radiologia, Centro Hospitalar e Universitário de Coimbra - Guimarães/ PT

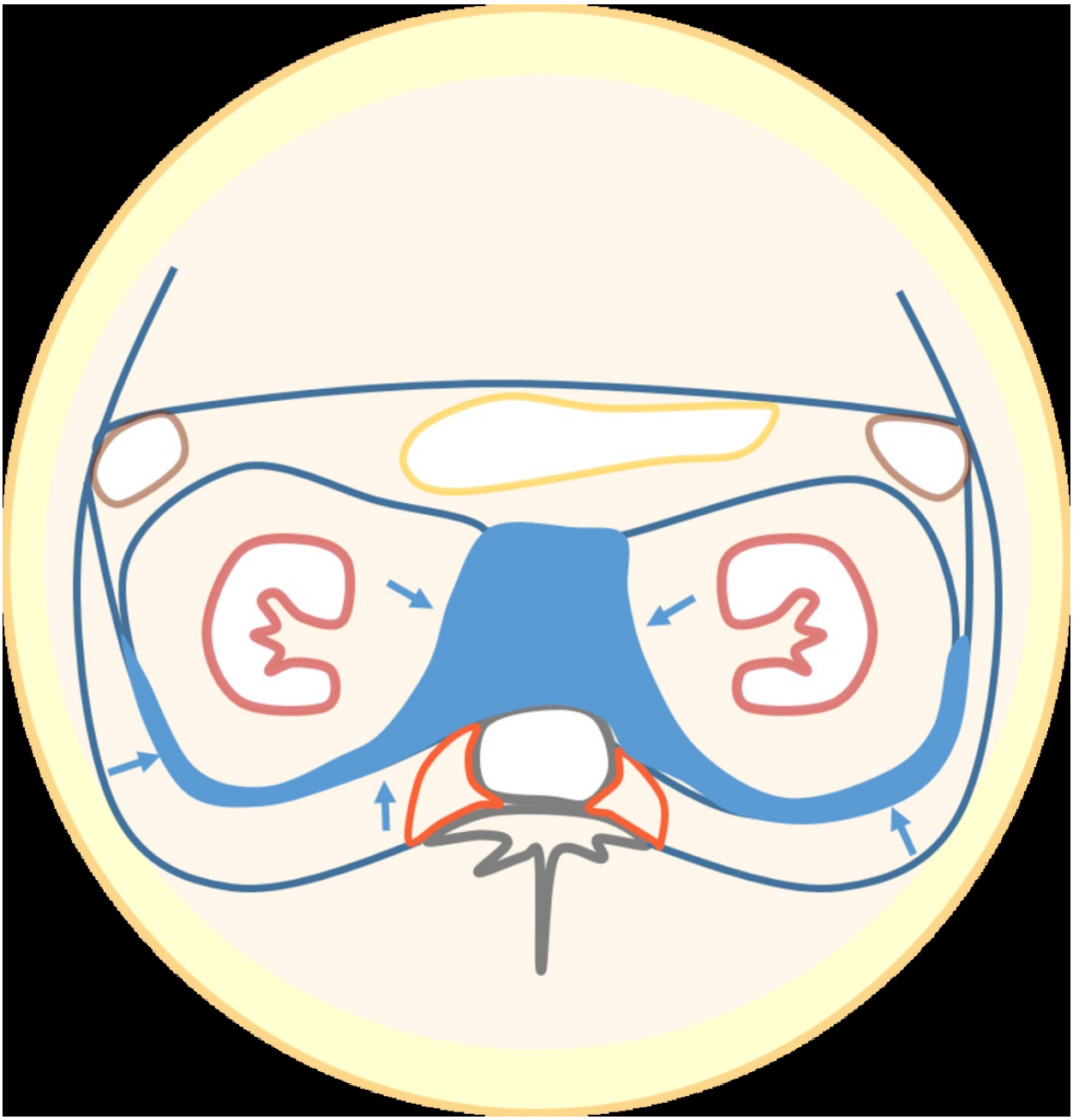


Fig. 13: Arrows showing the retrorenal plane, an expandable space between the perirenal space and the posterior pararenal space.
References: Radiologia, Centro Hospitalar e Universitário de Coimbra - Guimarães/ PT

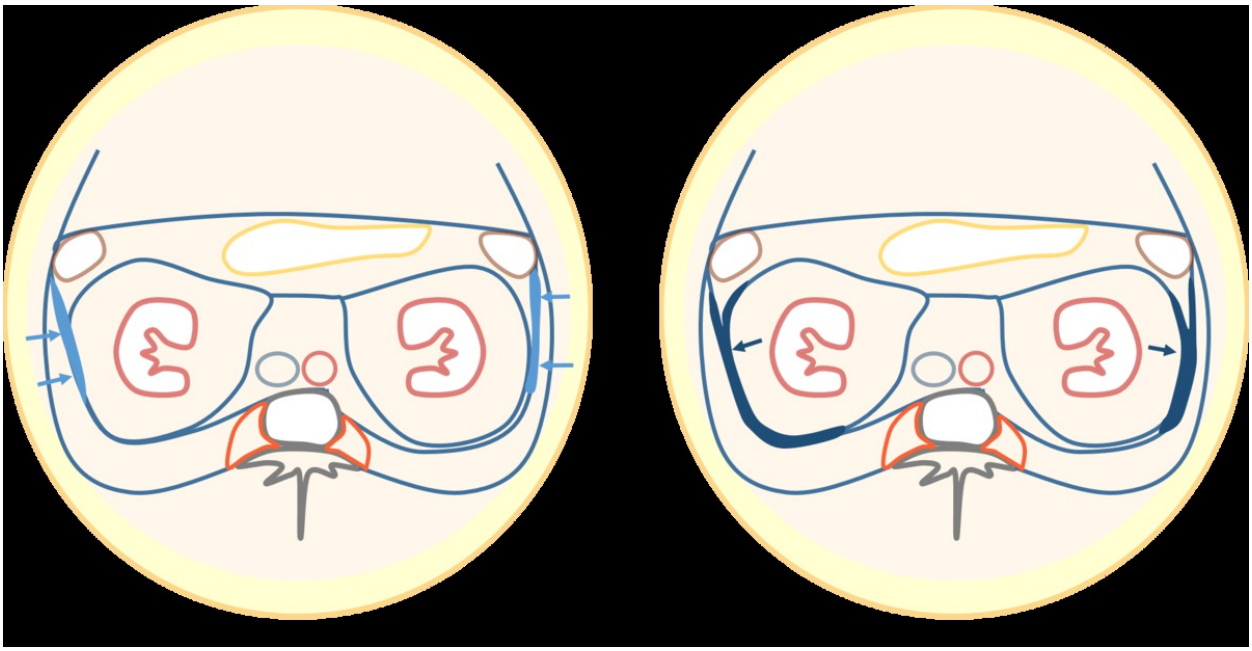


Fig. 14: The lateroconal interfascial plane is seen (blue arrows in a). It is formed by the dissection of the layers of the lateroconal fascia. The retromesenteric, retrorenal and lateroconal planes comunicate at a point called the fascial trifurcation (dark blue in b).
References: Radiologia, Centro Hospitalar e Universitário de Coimbra - Guimarães/PT

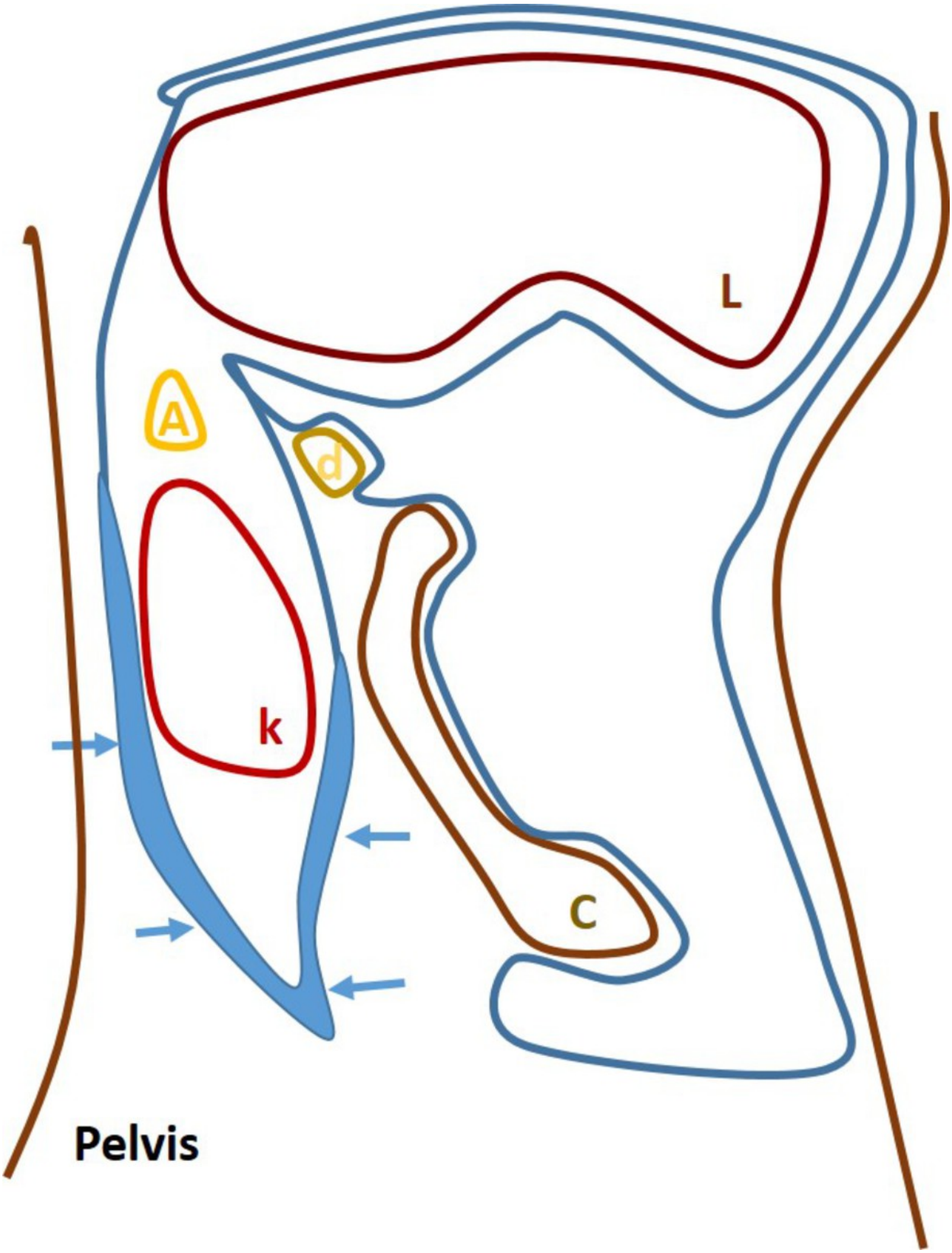

L
A
d
k
C
Pelvis

Fig. 15: The combined interfascial plane is formed inferiorly to the kidney, where the retromesenteric and retrorenal planes fuse (arrows). L = liver; A = adrenal, k = Kidney, d = duodenum; C = Colon.
References: Radiologia, Centro Hospitalar e Universitário de Coimbra - Guimarães/PT

C. Psoas muscle

The psoas muscle deserves a special mention because of its importance in the diagnosis of retroperitoneal pathologies. It originates in the transverse processes of the first four lumbar vertebrae and attaches distally with the iliac muscle to the lesser trochanter of the femur. Along its proximal path, it is juxtaposed with the kidney and the perirenal space. Inferiorly to the lower pole of the kidney it is in contact with the posterior pararenal space (Figure 16).

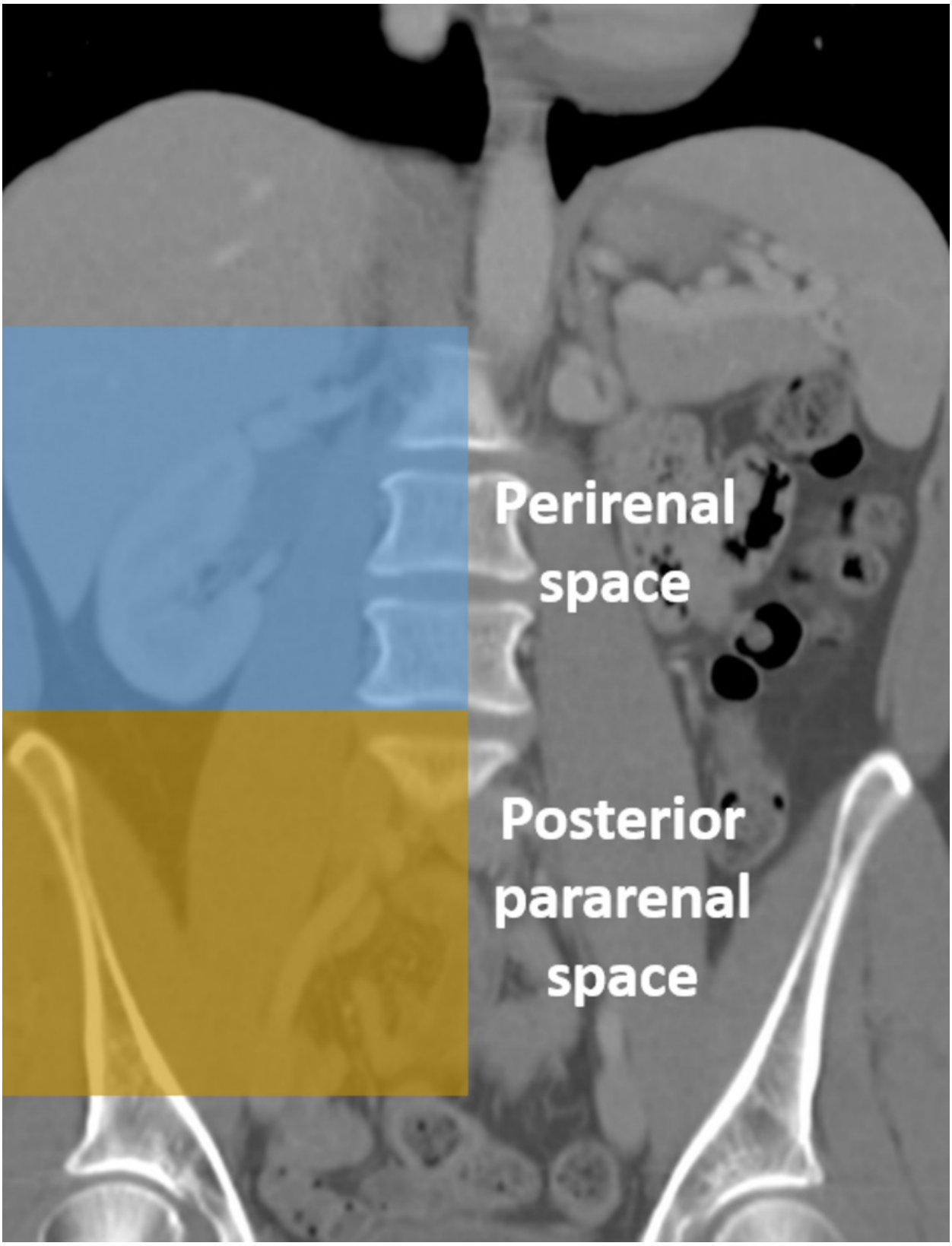


Fig. 16: The psoas sign. Along its path, the psoas muscle contacts superiorly with the kidney and the perirenal space and with the posterior pararenal space inferiorly.

Therefore, if the superior part of the psoas muscle is not seen on na abdominal radiography, a perirenal pathology should be expected while absence of its lower segment suggest a posterior pararenal pathology.
References: Radiologia, Centro Hospitalar e Universitário de Coimbra - Guimarães/PT

In the abdominal radiography the psoas sign represents no more than the interface of this muscle with the surrounding adipose tissue. Therefore, segmental absence of the psoas should be valued. If the superior part of the psoas muscle is not seen, a perirenal pathology should be expected, while absence of its lower segment suggest a posterior pararenal pathology (Figure 17).

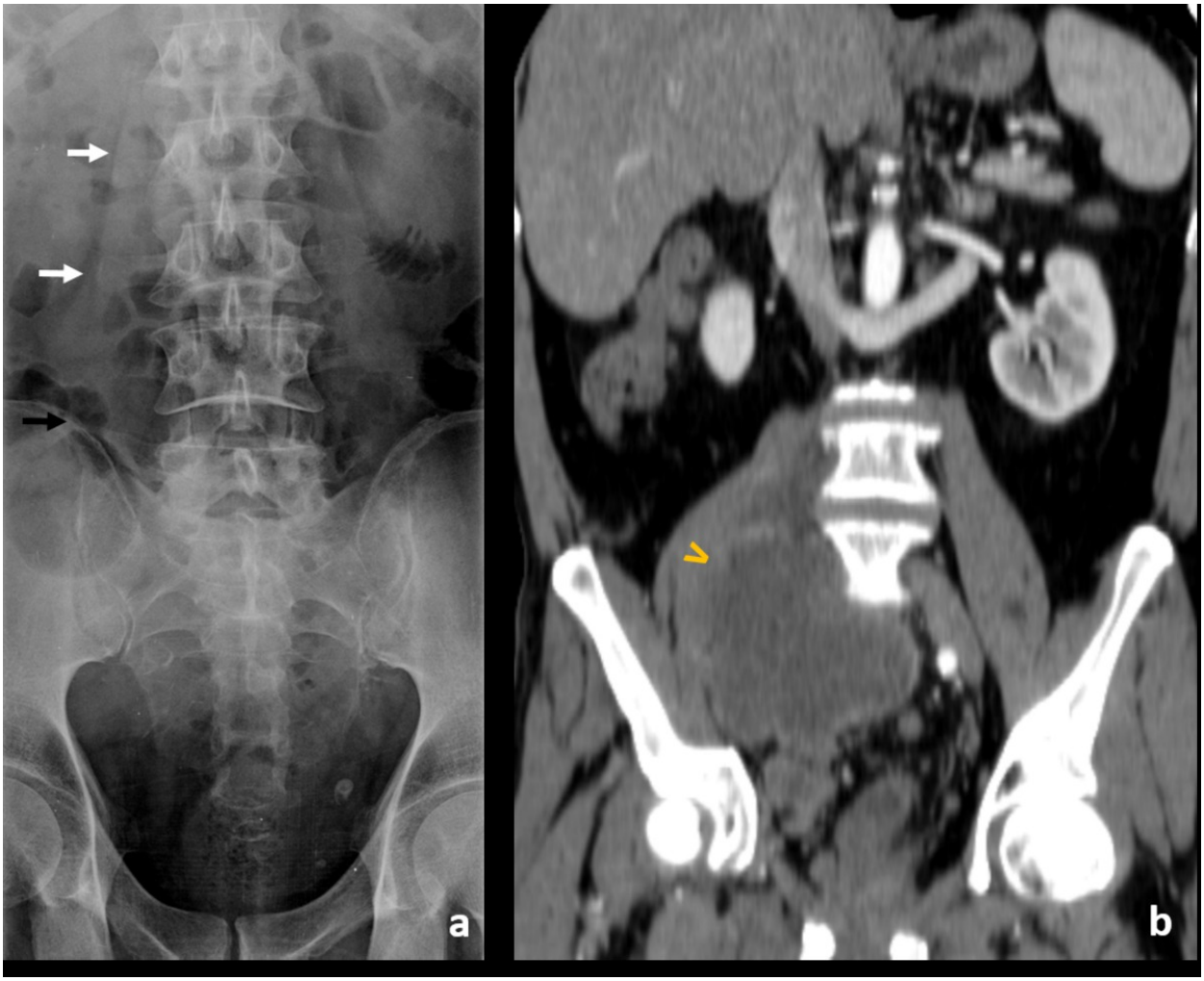


Fig. 17: Segmental absence of the psoas sign. The right psoas interface interface can be visualized superiorly at the level of the perirenal space (white arrows in a). Below, at the level of the iliac creast, the psoas is not distinguished (black arrow in a), suggesting a posterior pararenal pathology. This finding is confirmed on the contrast-enhanced CT, where an abscess can be seen (arrowhead in b).

References: Radiologia, Centro Hospitalar e Universitário de Coimbra - Guimarães/PT

On the other hand, failure to visualize the entire psoas muscle, even if the contralateral is seen, is a nonspecific sign. This can happen in patients who lost weight, scoliosis or just due to rotation.

D. Radiological signs of a retroperitoneal masses

To locate a mass to the retropertioneal space, deviation of its normal structures should be seen. In fact, anterior deviation of the head or tail of the pancreas, kidneys, adrenals, ureters, colon or the duodenum by a mass suggests its retroperitoneal origin. Also, a mass pushing the great vessels will have the same retroperitoneal origin (Figures 18 and 19).

Fig. 18: Locating a mass to the retroperitoneal space. A solid heterogenous volumous mass is seen occupying the the right qudrants of the abdomen. This mass deviates anteriorly the right kidney (arrows in a and b) so it can assumed to have a retroperitoneal origin. It also deviates medially the aorta (arrowheads in a and c).
References: Radiologia, Centro Hospitalar e Universitário de Coimbra - Guimarães/PT

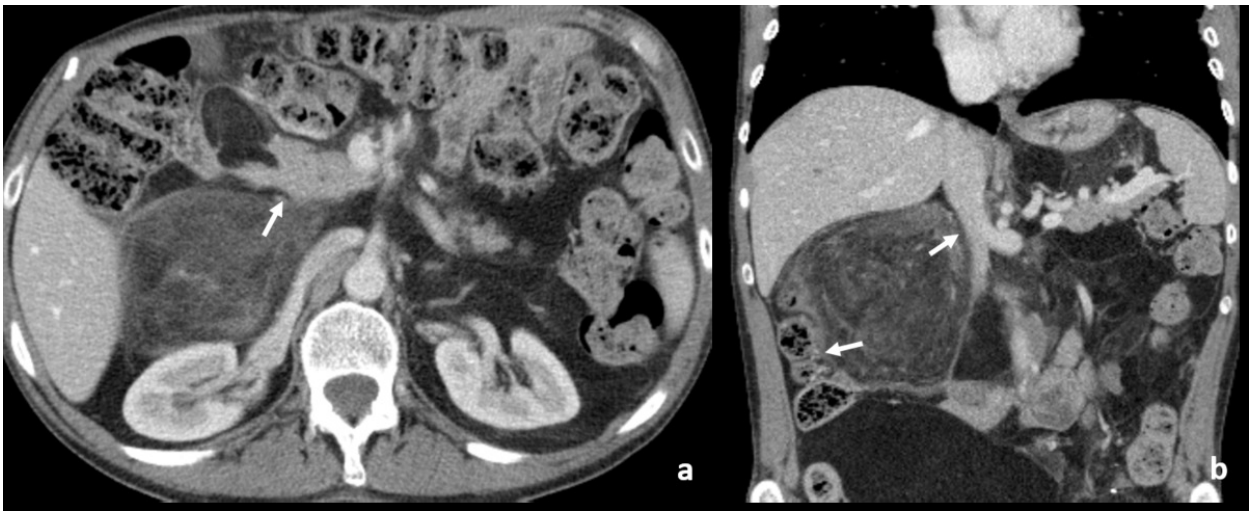


Fig. 19: Locating a mass to the retroperitoneal space. An heterogenous mass with rounded contours, showing fat density. This mass is seen to deviate anteriorly the pancreatic head (arrow in a). In the coronal reformatation, this mass shows medial deviation of the inferior vena cava and lateral deviation of the ascending colon (arrows in b), both retroperitoneal structures. This mass correspondend to a liposarcoma, the most common masses to be seen in the retroperitoneal space.
References: Radiologia, Centro Hospitalar e Universitário de Coimbra - Guimarães/PT

The following step after stating a retroperitoneal origin of a mass is to determine the organ of origin. Several signs could be used for this purpose.

The first of these signs is the **beak sign**. When a mass deforms an organ causing its margins to be beak shaped, the mass is probably originated in it(Figures 20 and 21).

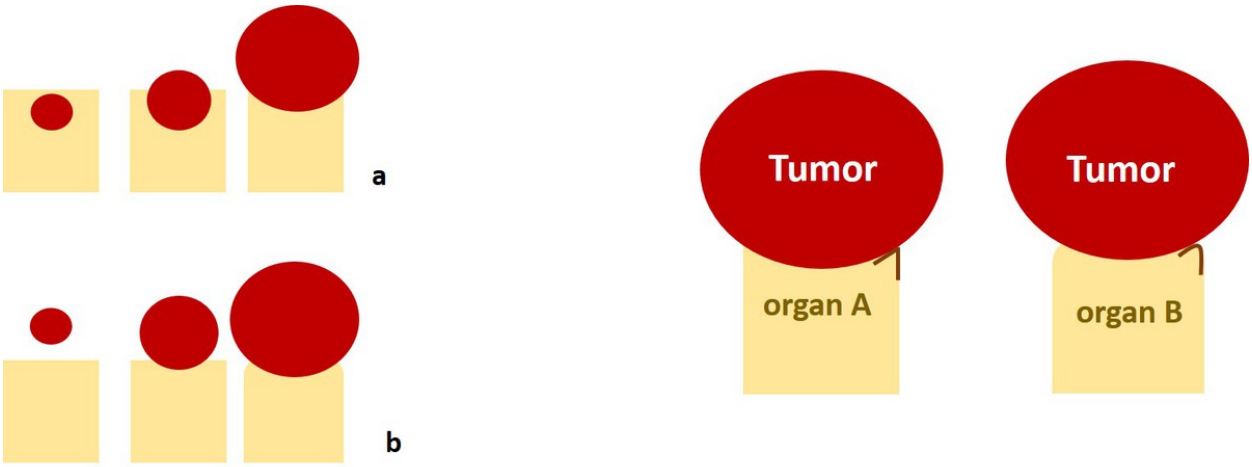


Fig. 20: The beak sign. When a mass deforms an organ causing its margins to be beak shaped (organ A), its likely its origin in this organ (example a). On the other

hand, the tumor grows outside an organ, it is likely to compress this organ, causing its margins to become convex (exemple b).
References: Radiologia, Centro Hospitalar e Universitário de Coimbra - Guimarães/PT

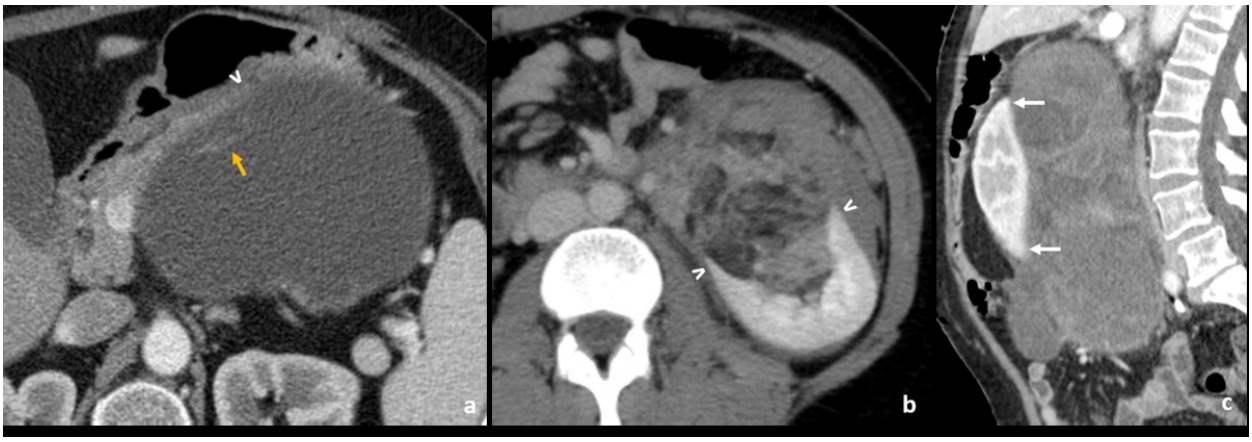


Fig. 21: The use of the beak sign in the determination of the organ of origin. On the image of the left, a cystic mass with septa (yellow arrow) can be seen in the region of the tail of the pancreas, deforming this organ and causing the body of the pancreas to have a beak margin (arrowhead) - pancreas would be the organ of origin. This mass was confirmed to be a mucinous cystadenoma of the pancreas. An heterogenous mass with areas of fat density can be seen at the level of the left renal hilum (arrowheads in b). The beak sign is prominent, suggesting the left kidney as the organ of origin. This was confirmed to be an angiomyolipoma of the left kidney. Finally, on the right one can see and heterogenous mass in the retroperitoneum. This mass is deforming the right kidney, but its margins are convex (arrows in C), indicating that this mass is extrinsic to the kidney. The pathology exam revealed to be a retroperitoneal sarcoma.
References: Radiologia, Centro Hospitalar e Universitário de Coimbra - Guimarães/PT

The **phantom organ sign** states that when a big mass originates in a small organ, this organ may not be visualized. This is especially helpful in detecting adrenal masses (Figure 22).

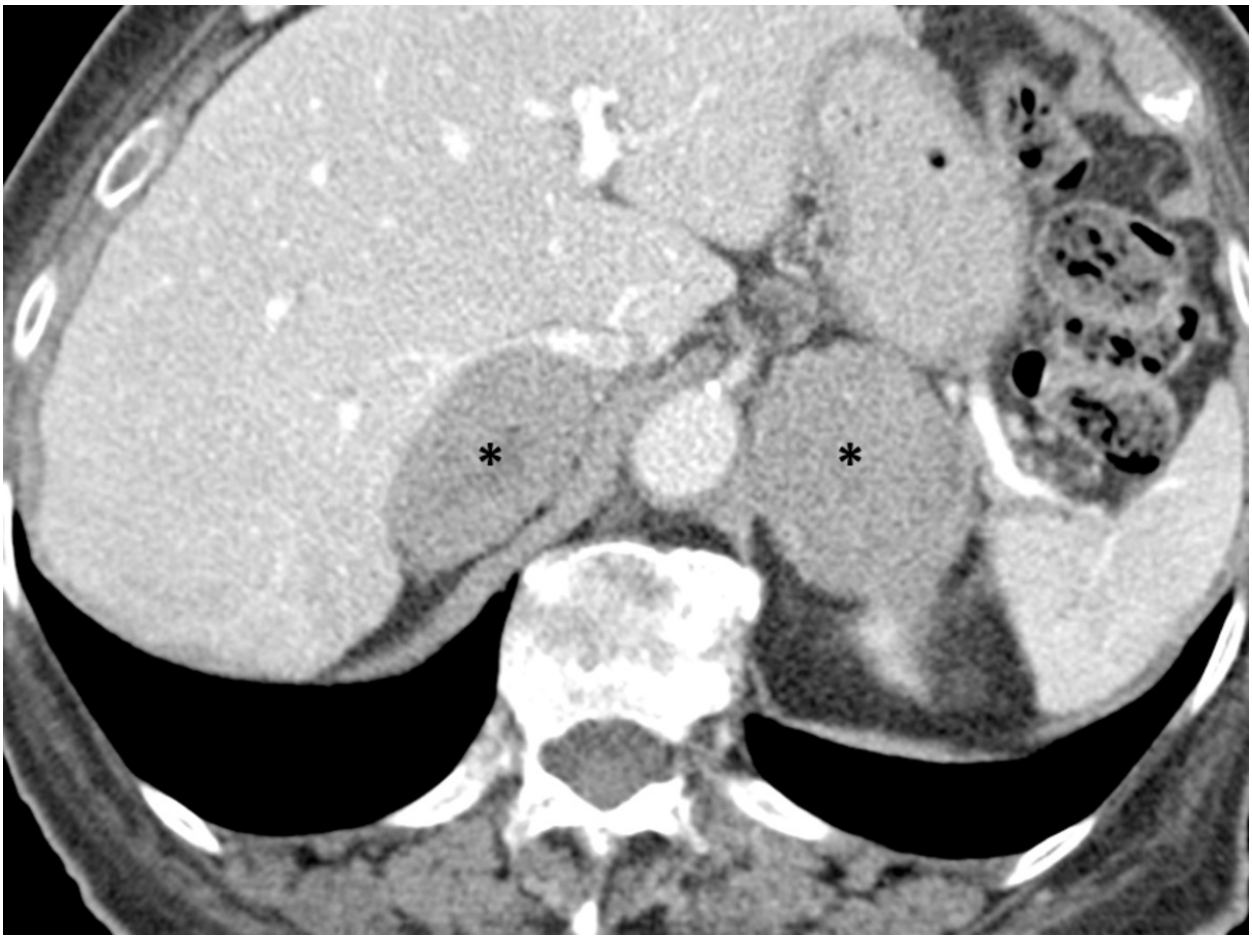
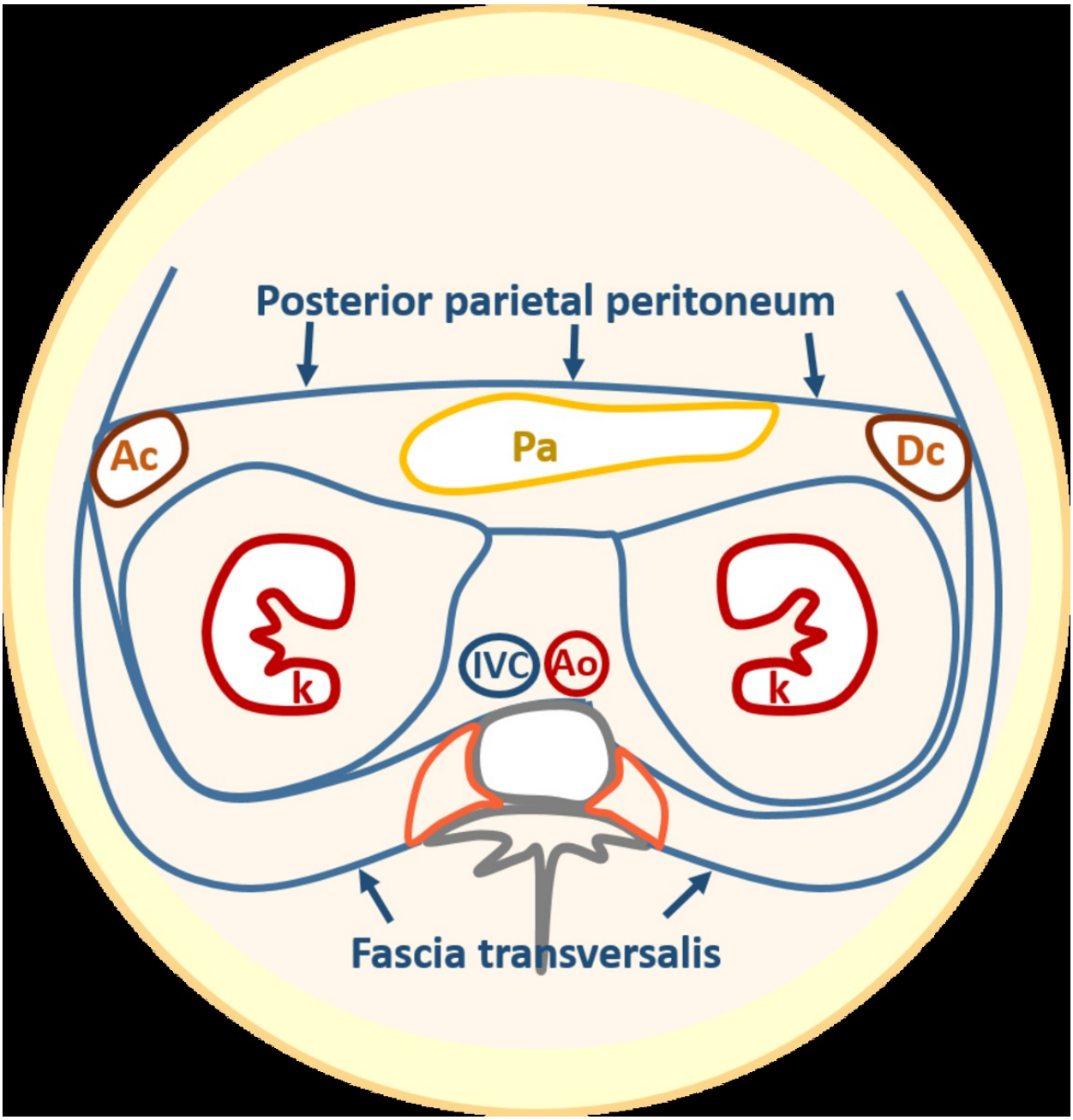


Fig. 22: The phantom organ sign. When a mass originates in a small organ, this organ may not be visualized. Contrast-enhanced CT depicts bilateral solid masses with lobulated contours in the location of the adrenals glands (asterisks), that could not be identificed. The patient had a known lung cancer and these proved to be adrenal metastasis of the lung cancer.
References: Radiologia, Centro Hospitalar e Universitário de Coimbra - Guimarães/PT

The last of these signs is the **nutritive artery sign**. By identifying the supplying artery of a mass, one can determine the likely organ of origin.

Images for this section:



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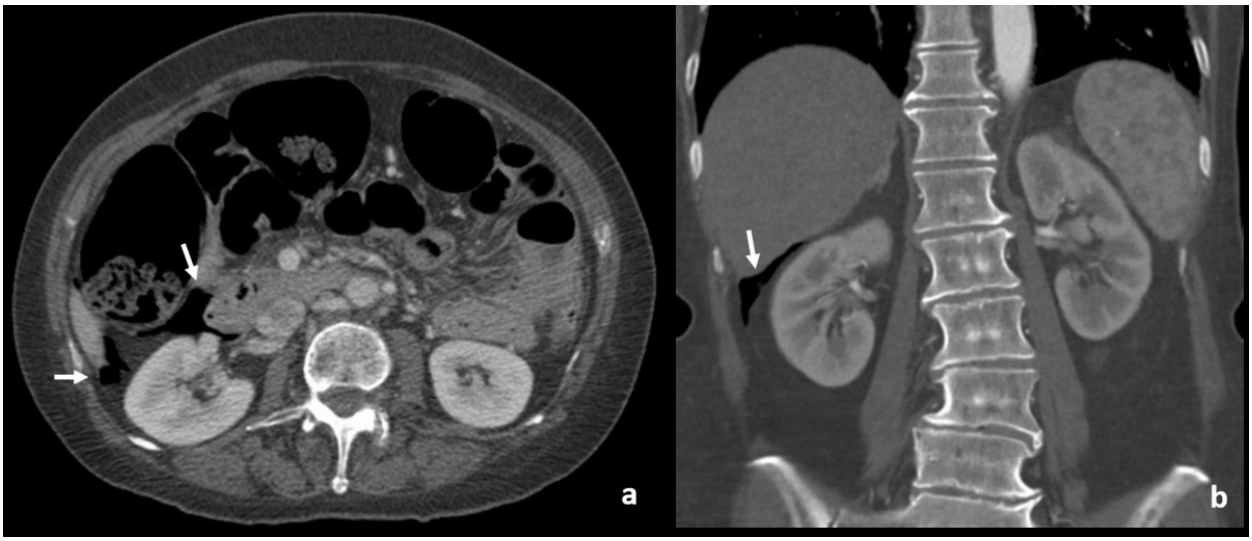

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Fig. 4: The anterior pararenal space. Fluid is seen in the anterior pararenal space, circunscribed posteriorly by the anterior renal fascia (arrows). It envolves the third segment of the duodenum and does not cross the midline.

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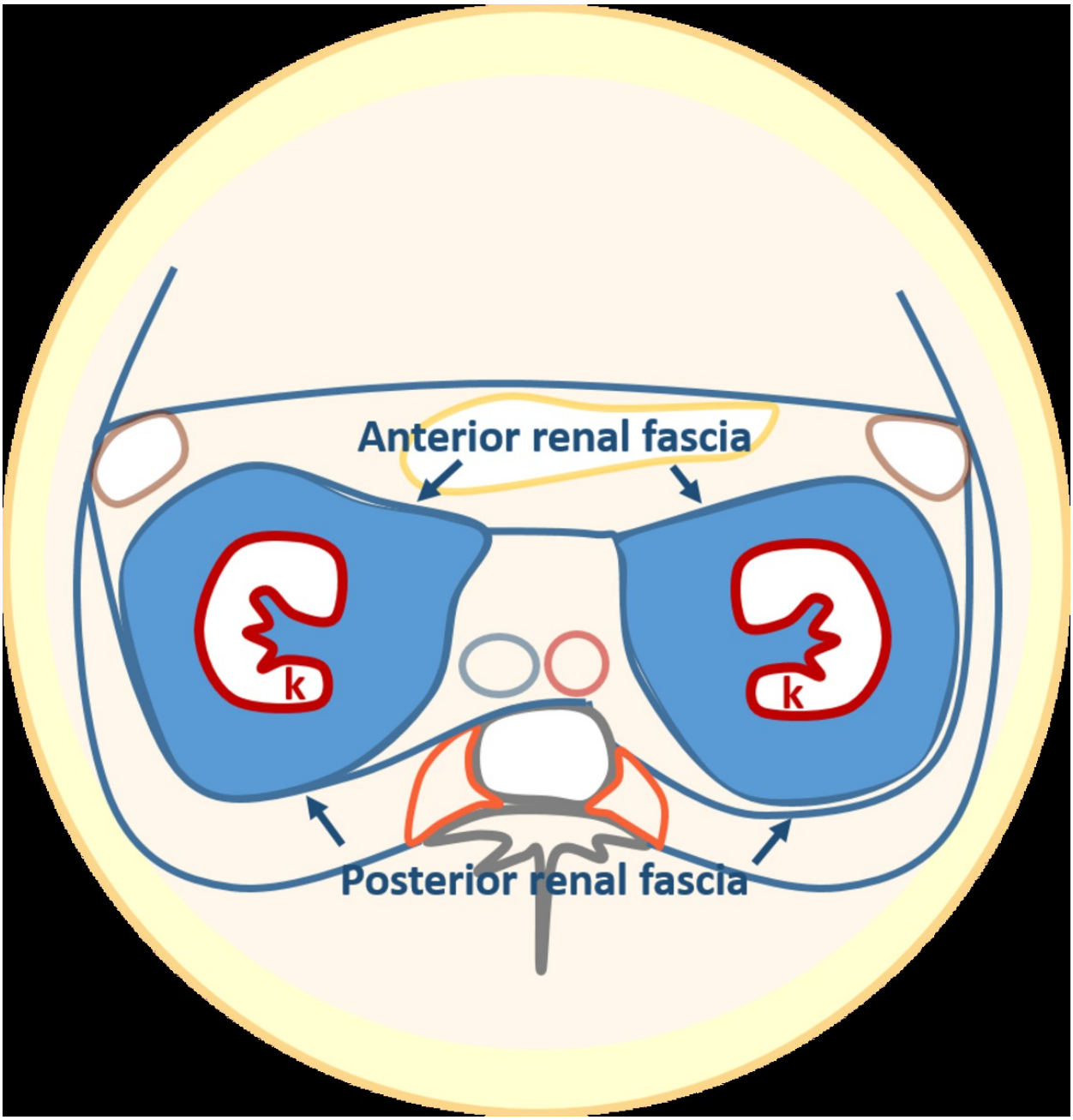

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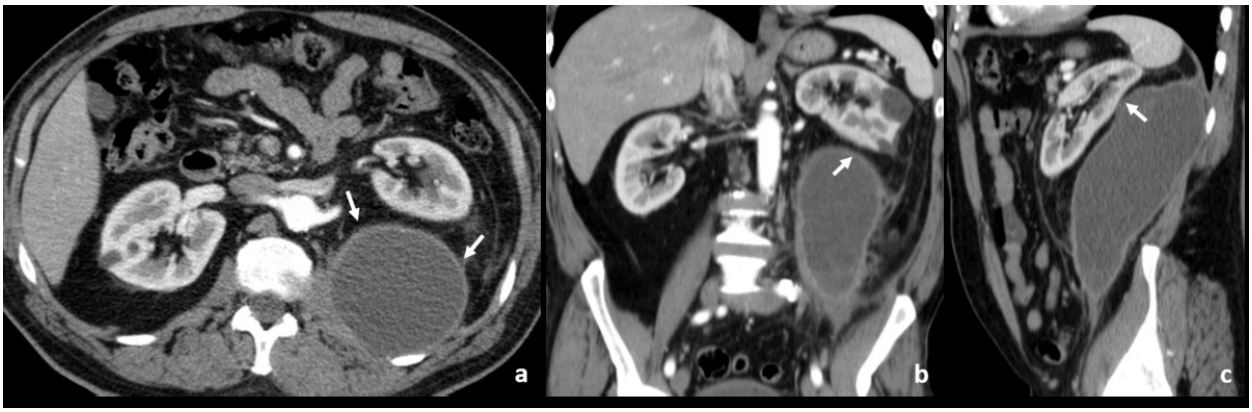

Fig. 6: Collection in the perirenal space. Contrast-enhanced CT demonstrates an homogenous collection with water density and a well defined enhancing wall (arrows in a). This collection is seen to push superior and anteriorly the left kidney (arrows in b and c, respectively). It is longitudinally orientated, respecting the limits of the perirenal space and ending inferiorly at the vertex of the inverted cone. This was a patient with trauma and a retroperitoneal hematoma who recently had increased inflammatory markers, consistent with inflamed hematoma.

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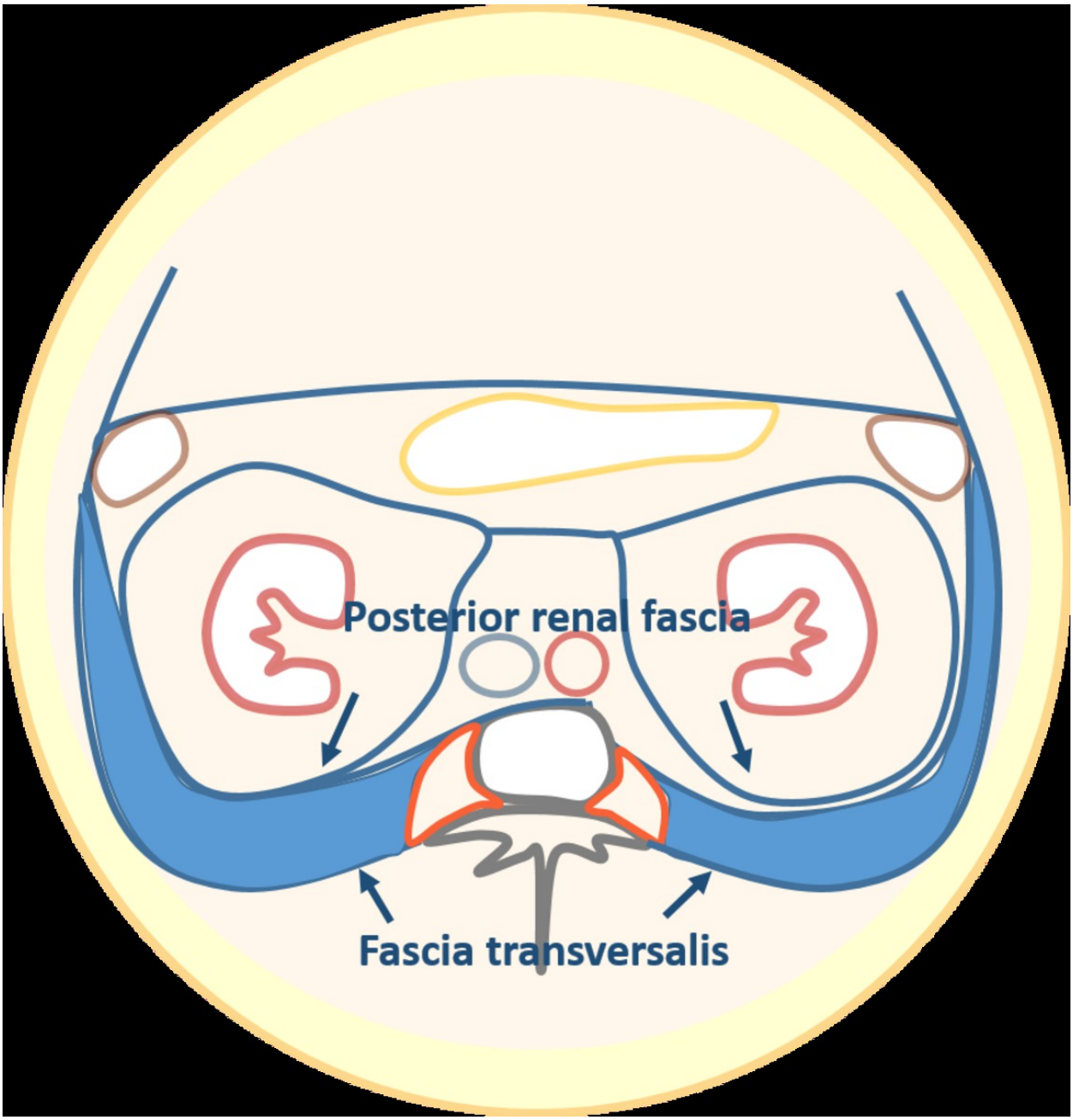

Fig. 8: The posterior pararenal space is marked in blue. The posterior renal fascia represents its anterior limit while the fascia transversalis is the posterior limit.

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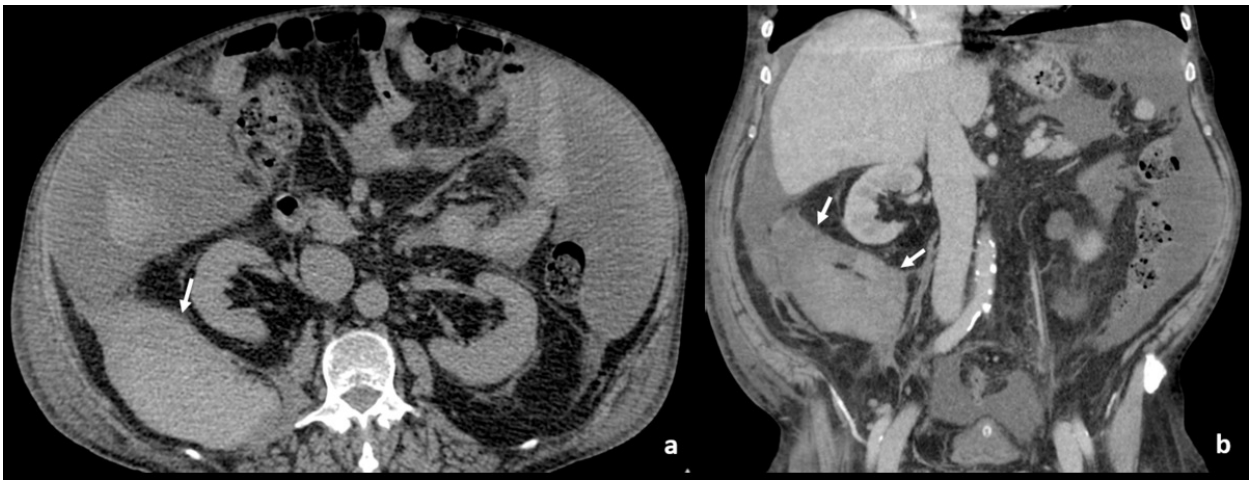

Fig. 9: Posterior pararenal space collection. A patient with chronic hepatopathy and ascitis who had a recent trauma in the right flank. CT aquisition before contrast reveals the presence of an homogenous hyperattenuating collection the the posterior pararenal space, limited anteriorly by the posterior renal fascia (arrows in a and b). This collection does not show contrast-enhancement (coronal reformatation in b) and is consistent with a retroperitoneal hematoma.

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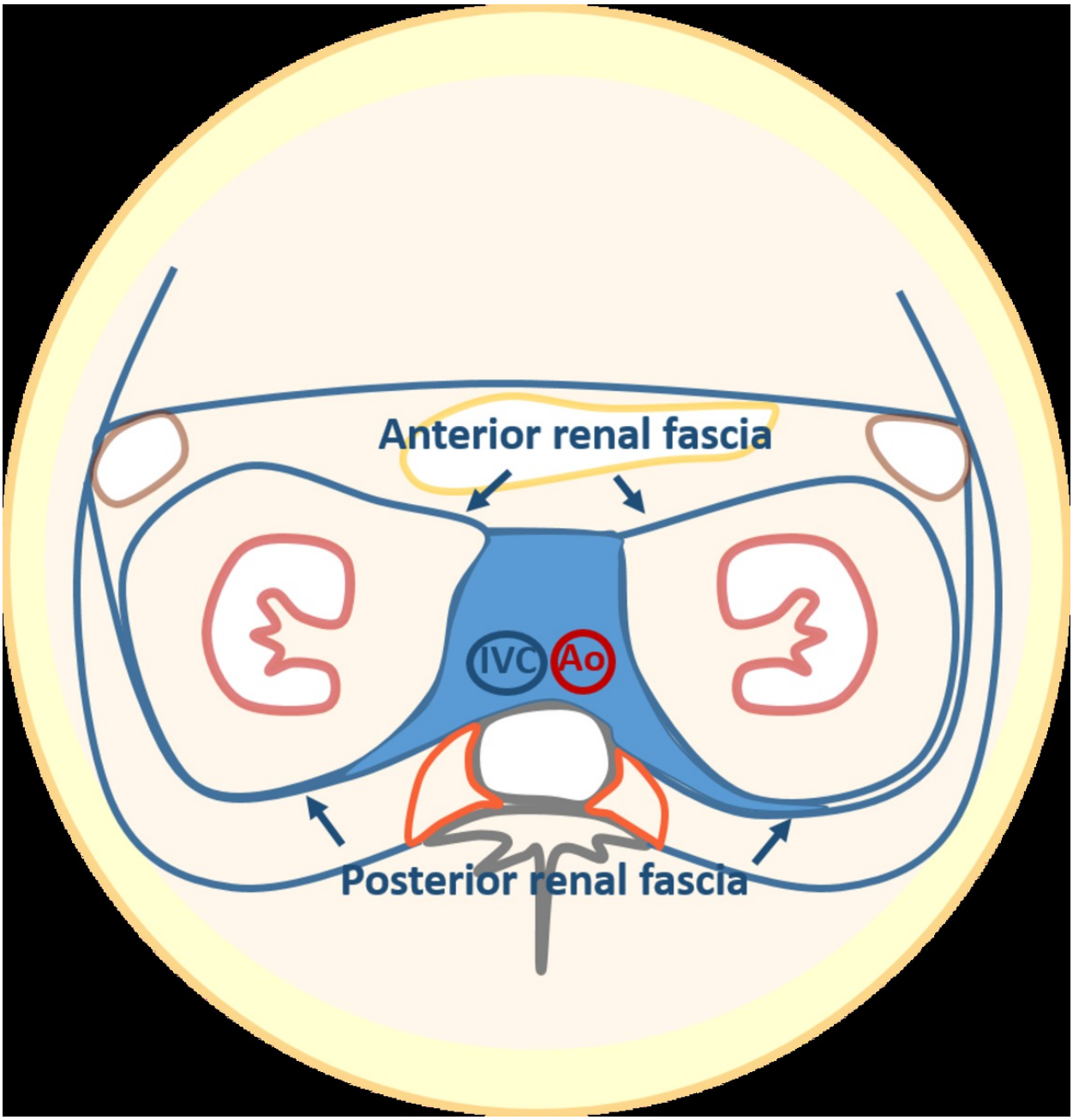

Fig. 10: The great vessels space is marked in blue. It is limited anterior and laterally by the anterior and posterior renal fasciae. Posteriorly it has the body of the vertebra as the limit. Contains the great vessels and lymphatic structures. IVC = Inferior vena cava; Ao = Aorta.

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Fig. 11: The great vessels space. Contrast-enhanced CT displaying an homogeneous, soft-tissue density mass surrounding the aorta and extending to the left renal hilum (arrows in a and b).Unlike the other three retroperitoneal spaces, this is not well circunscribed and can easily be affected by pathologic processes extending through the other spaces. The vessels involved by this mass show normal size and permeability. These abnormalities are typical of Lymphoma.

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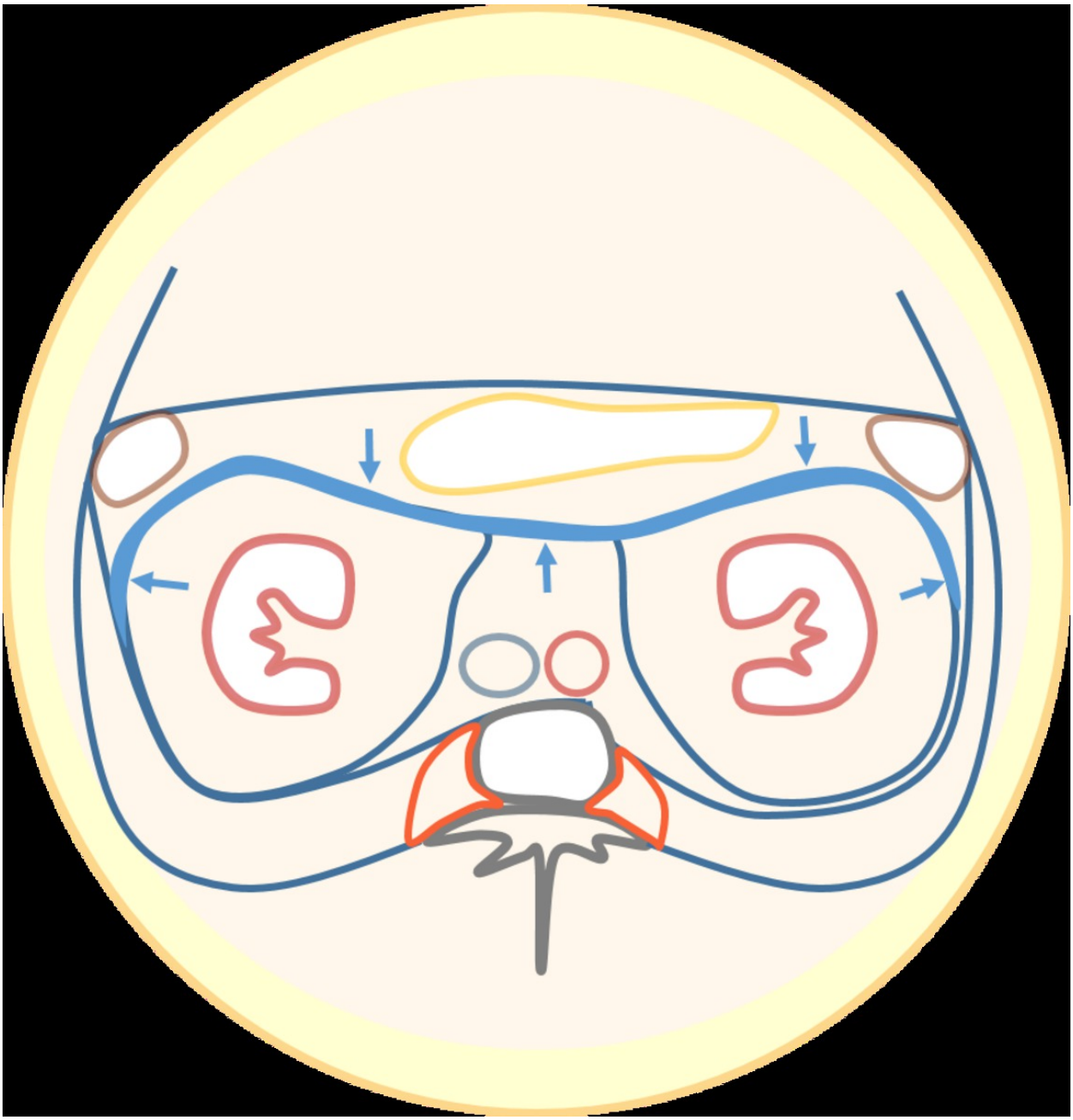

Fig. 12: Arrows showing the retromesenteric plane, a potencial space between the anterior pararenal space and the perirenal space.

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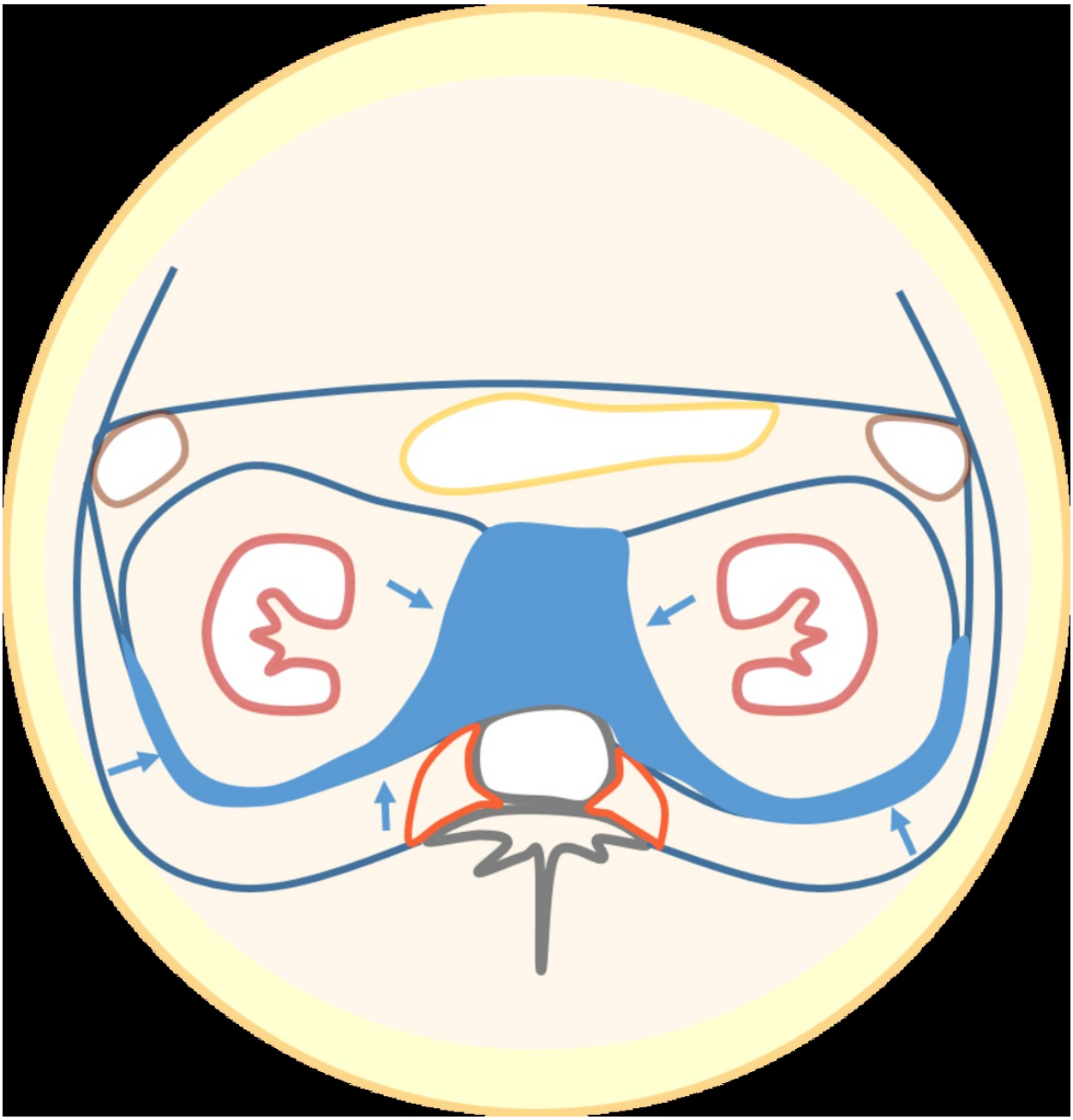

Fig. 13: Arrows showing the retrorenal plane, an expandable space between the perirenal space and the posterior pararenal space.

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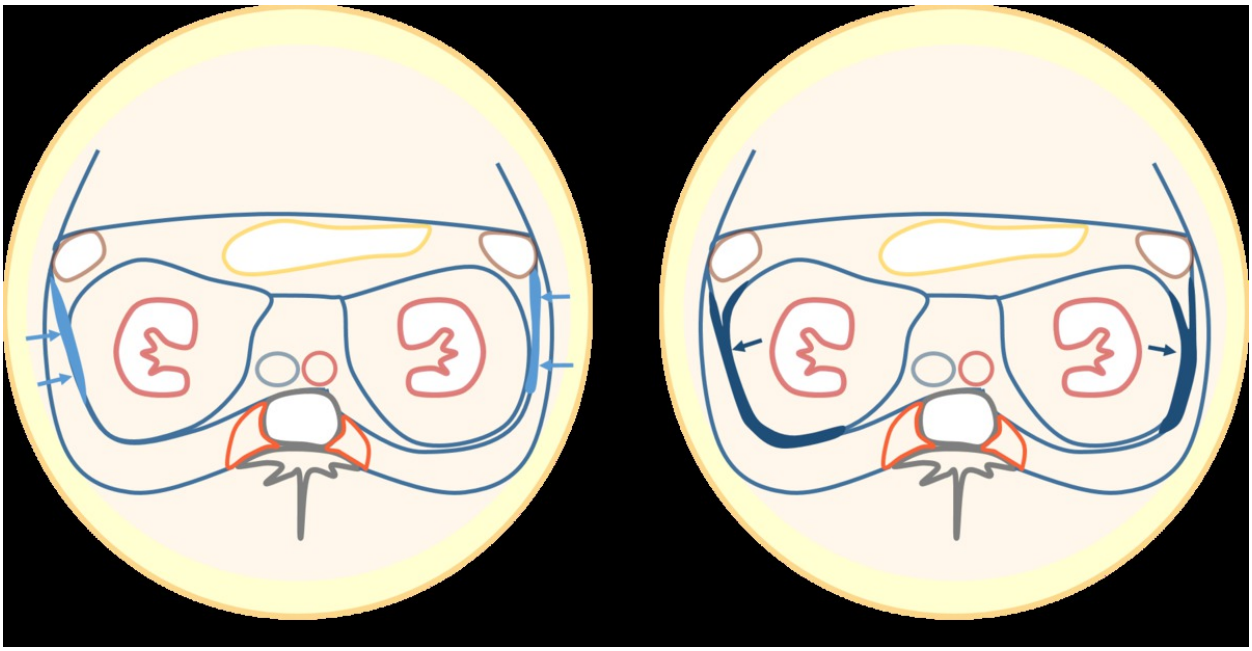

Fig. 14: The lateroconal interfascial plane is seen (blue arrows in a). It is formed by the dissection of the layers of the lateroconal fascia. The retromesenteric, retrorenal and lateroconal planes comunicate at a point called the fascial trifurcation (dark blue in b).

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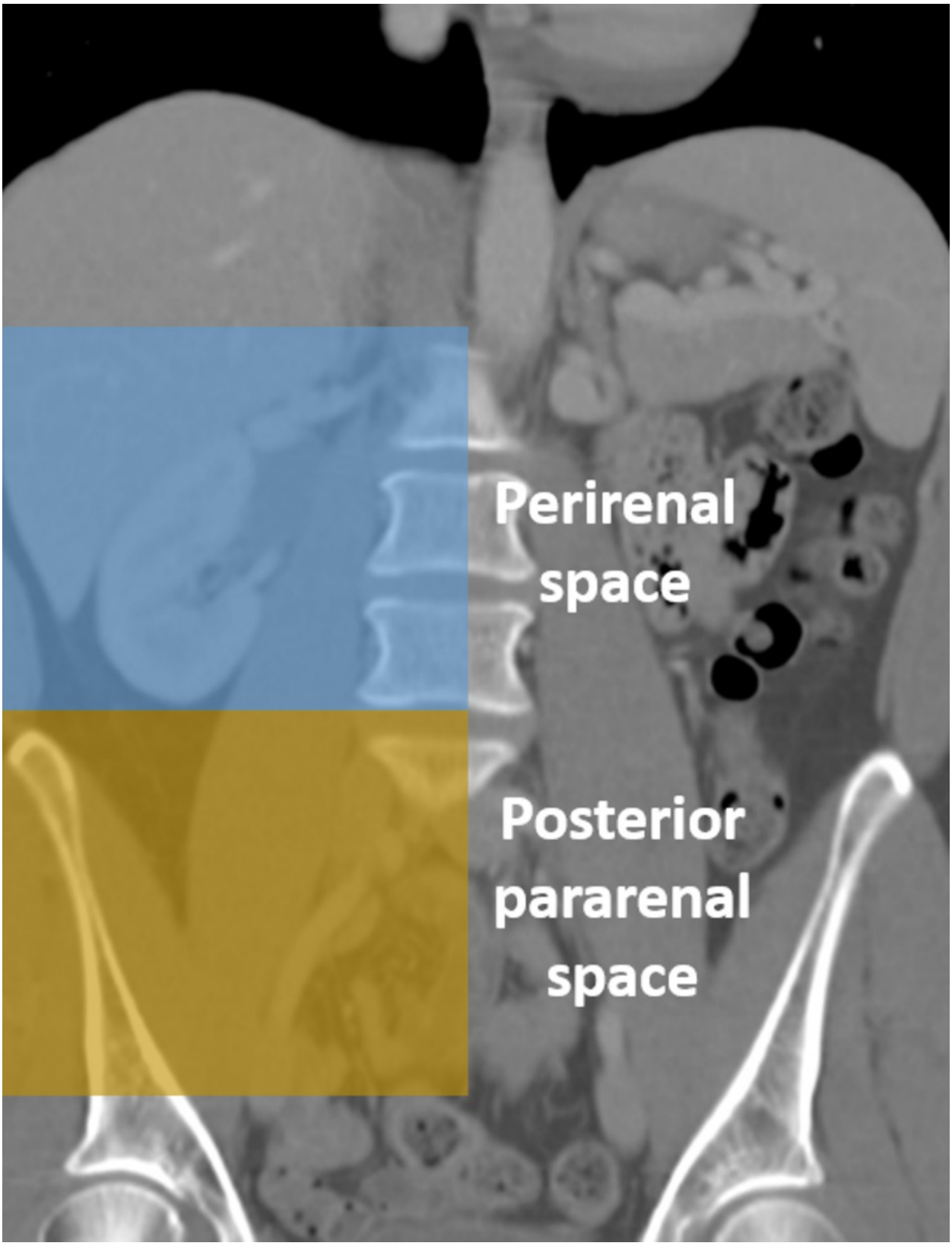

Fig. 16: The psoas sign. Along its path, the psoas muscle contacts superiorly with the kidney and the perirenal space and with the posterior pararenal space inferiorly.

Therefore, if the superior part of the psoas muscle is not seen on na abdominal radiography, a perirenal pathology should be expected while absence of its lower segment suggest a posterior pararenal pathology.

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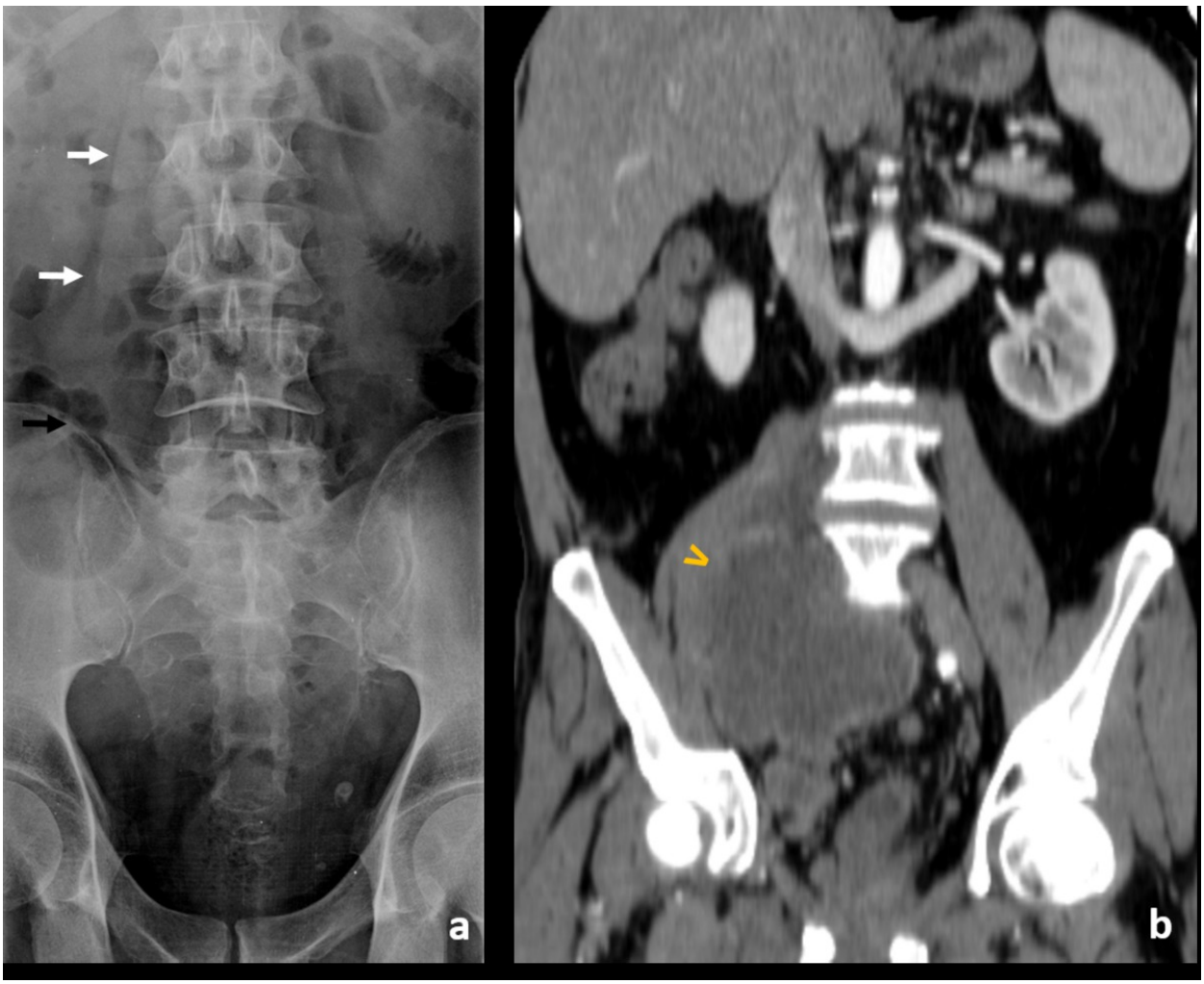

Fig. 17: Segmental absence of the psoas sign. The right psoas interface interface can be visualized superiorly at the level of the perirenal space (white arrows in a). Below, at the level of the iliac creast, the psoas is not distinguished (black arrow in a), suggesting a posterior pararenal pathology. This finding is confirmed on the contrast-enhanced CT, where an abscess can be seen (arrowhead in b).

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Fig. 18: Locating a mass to the retroperitoneal space. A solid heterogenous volumous mass is seen occupying the the right qudrants of the abdomen. This mass deviates anteriorly the right kidney (arrows in a and b) so it can assumed to have a retroperitoneal origin. It also deviates medially the aorta (arrowheads in a and c).

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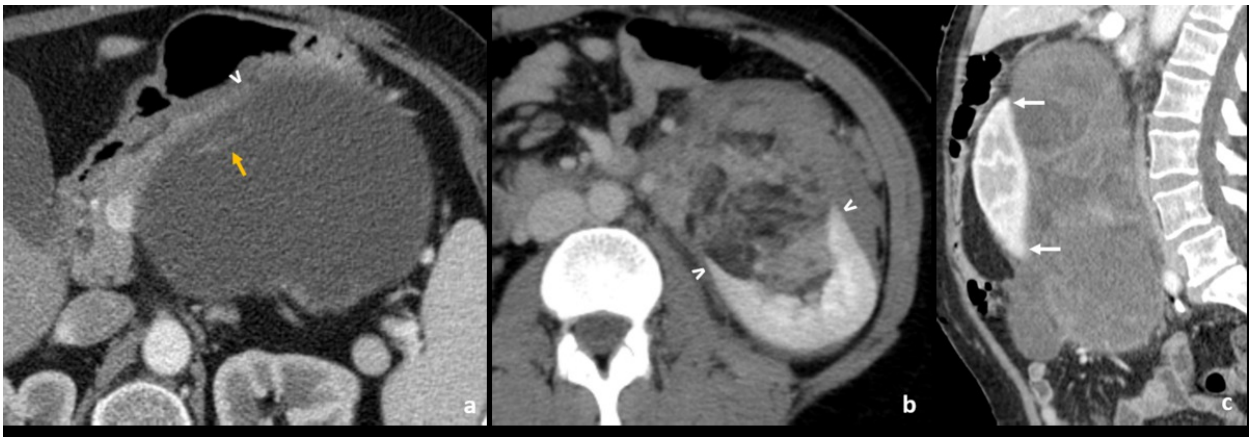

Fig. 21: The use of the beak sign in the determination of the organ of origin. On the image of the left, a cystic mass with septa (yellow arrow) can be seen in the region of the tail of the pancreas, deforming this organ and causing the body of the pancreas to have a beak margin (arrowhead) - pancreas would be the organ of origin. This mass was confirmed to be a mucinous cystadenoma of the pancreas. An heterogenous mass with areas of fat density can be seen at the level of the left renal hilum (arrowheads in b). The beak sign is prominent, suggesting the left kidney as the organ of origin. This was confirmed to be an angiomyolipoma of the left kidney. Finally, on the right one can see and heterogenous mass in the retroperitoneum. This mass is deforming the right kidney, but its margins are convex (arrows in C), indicating that this mass is extrinsic to the kidney. The pathology exam revealed to be a retroperitoneal sarcoma.

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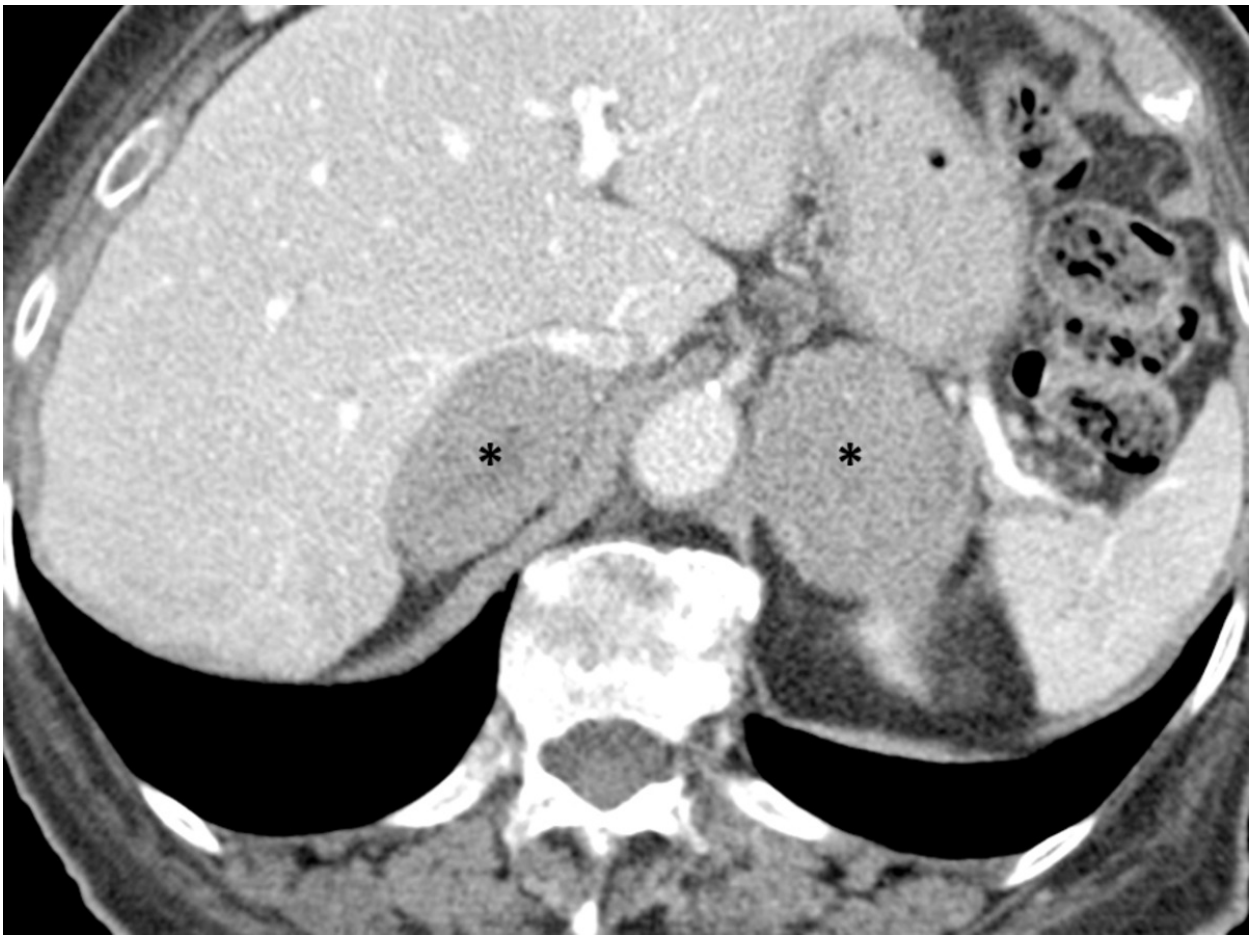

Fig. 22: The phantom organ sign. When a mass originates in a small organ, this organ may not be visualized. Contrast-enhanced CT depicts bilateral solid masses with lobulated contours in the location of the adrenals glands (asterisks), that could not be identificed. The patient had a known lung cancer and these proved to be adrenal metastasis of the lung cancer.

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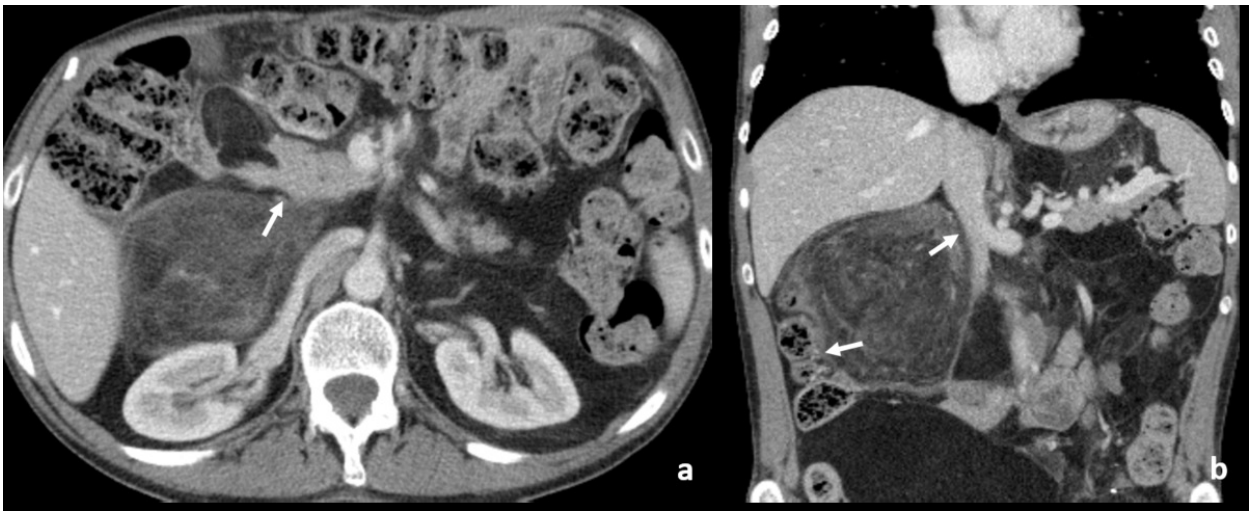

Fig. 19: Locating a mass to the retroperitoneal space. An heterogenous mass with rounded contours, showing fat density. This mass is seen to deviate anteriorly the pancreatic head (arrow in a). In the coronal reformatation, this mass shows medial deviation of the inferior vena cava and lateral deviation of the ascending colon (arrows in b), both retroperitoneal structures. This mass correspondend to a liposarcoma, the most common masses to be seen in the retroperitoneal space.

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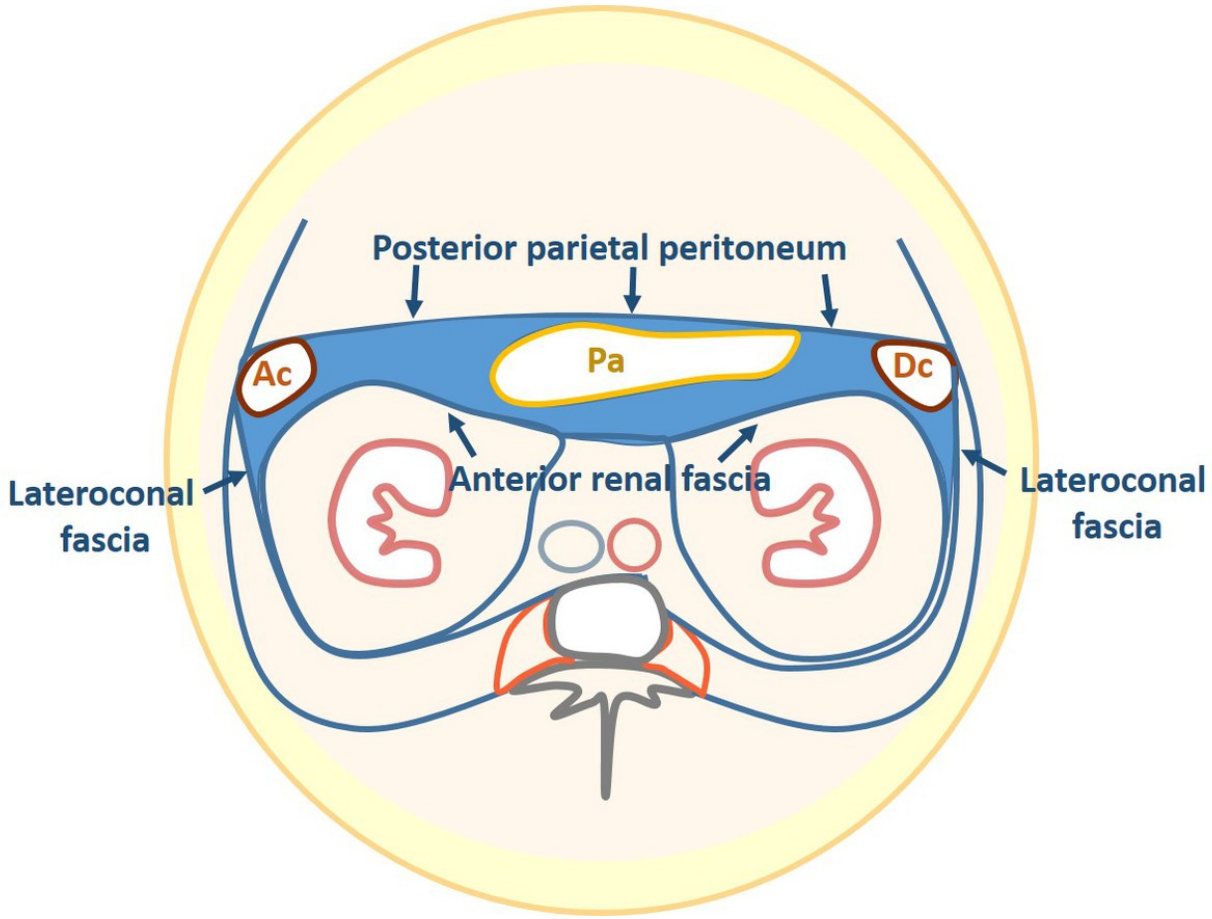

Fig. 2: Anterior pararenal space marked in blue. This compartment is limited anteriorly by the posterior parietal peritoneum and posteriorly by the anterior renal fascia or fascia of Gerota. Its lateral boundaries are the laterconal fascia. It contains the pancreas, the ascending and the descending colon, but also part of the duodenum. Pa = Pancreas; Ac = Ascending colon; Dc = Descending colon.

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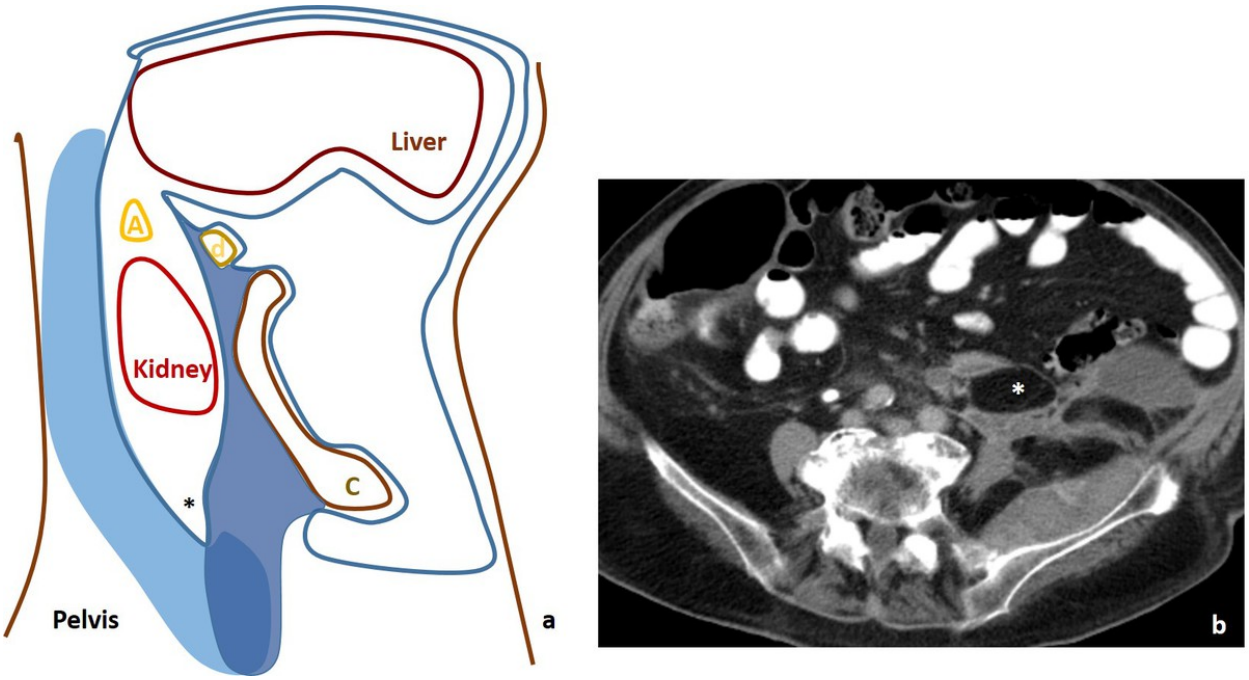

Fig. 7: The perirenal space on a sagittal section has an inverted cone shape. Little bellow the iliac crest level, the anterior and posterior renal fascia fuse (asterisk in a and b), alowing the anterior and posterior pararenal spaces to communicate (light blue space and dark blue space, respectively, showed in a). As seen on the CT (Figure b), fluids can extend between the anterior and posterior pararenal spaces, sparing the perirenal compartment.

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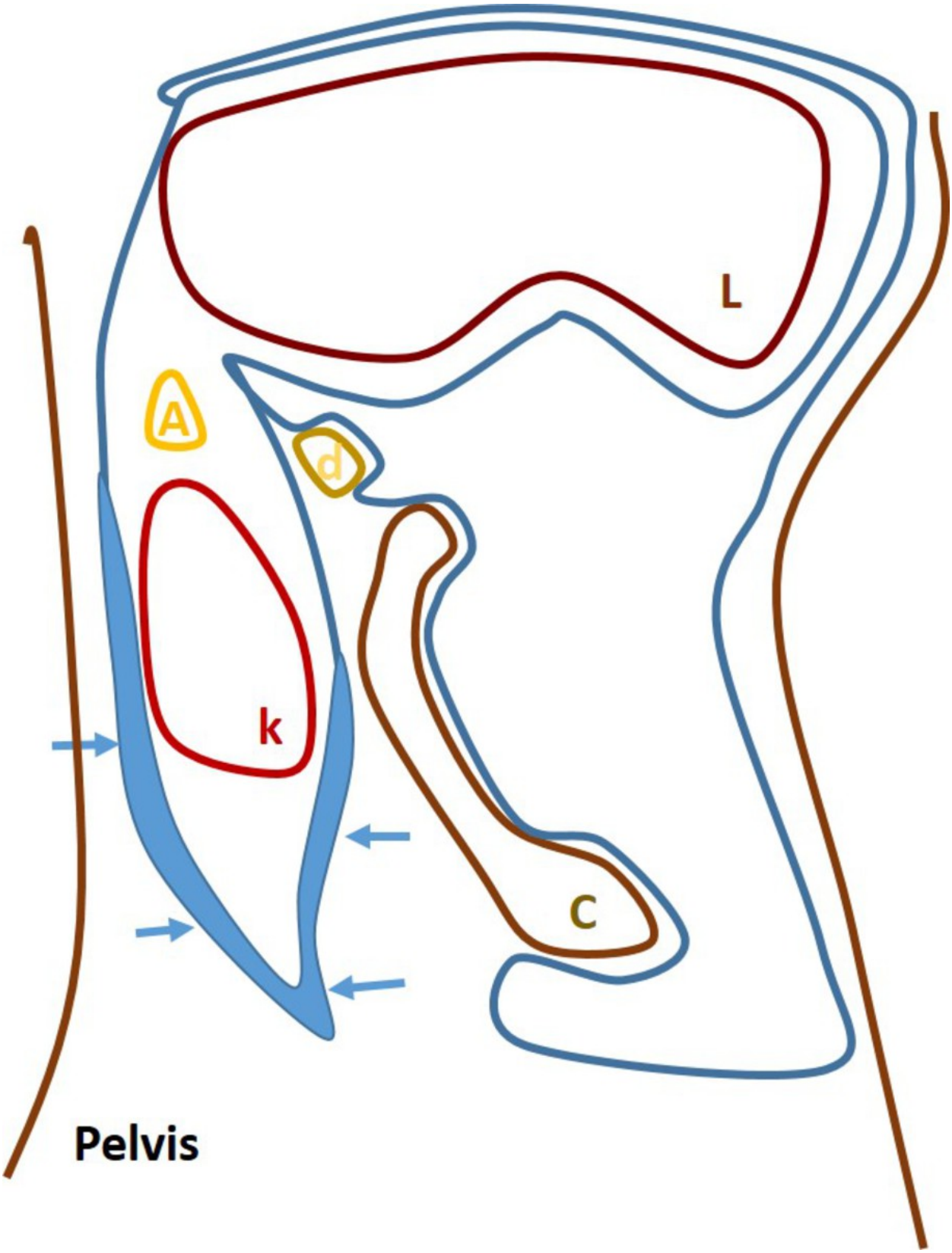
L
A
d
k
C
Pelvis

Fig. 15: The combined interfascial plane is formed inferiorly to the kidney, where the retromesenteric and retrorenal planes fuse (arrows). L = liver; A = adrenal, k = Kidney, d = duodenum; C = Colon.

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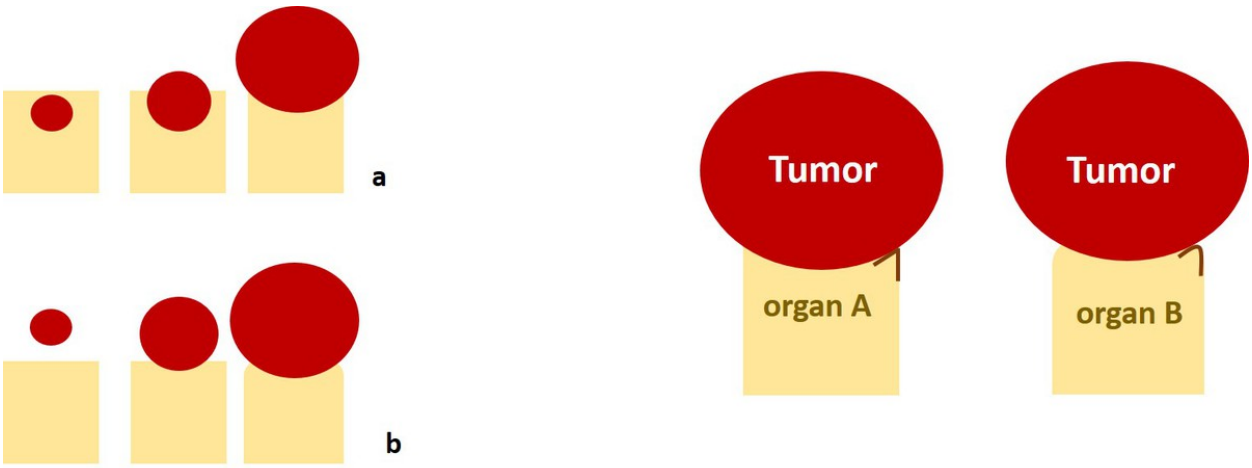

Fig. 20: The beak sign. When a mass deforms an organ causing its margins to be beak shaped (organ A), its likely its origin in this organ (example a). On the other hand, the tumor grows outside an organ, it is likely to compress this organ, causing its margins to become convex (exemple b).

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Conclusion

The retroperitoneum is a complex anatomical space in which imaging methods, particularly CT and MRI, are of great importance due to the clinical subtleness of its pathologies.

Knowledge of the precise anatomy of the retroperitoneal space is crucial for the radiologist to locate masses within this anatomical compartment. Identifying specific signs, such as the beak sign, the phantom organ sign or the nutritive artery sign may help in the determination of the organ in which the mass originates.

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