Peritoneum: anatomy and pathology. What a radiologist need to know.

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Learning objectives

• To define a brief description of the peritoneal spaces and recesses that help us understand the spread of some abdominal pathologies.

• To summarize a review of the main diseases that affect the peritoneum and its reflections.

• To show their most characteristic radiological signs.

• To discuss the differential diagnosis among these processes.
Background

1. INTRODUCTION

Continual advancements in computed tomography (CT) have effectively improved diagnostic capabilities, particularly in the localization of abdominal lesions and their ramifications within the abdominal cavity. The knowledge of the relevant anatomical spaces becomes therefore fundamental to the successful evaluation of abdominal pathologies.

In most of these pathologies, the peritoneum and its reflections (mesenteries and ligaments) are affected only secondarily. In such cases, their examination may allow establishing the differential diagnosis, as well as assist in the design of a percutaneous or surgical drainage for the collection of intra-abdominal fluids. Consequently, a more accurate diagnosis and treatment of the lesions and their extension may be achieved.

Although more infrequent, and occasionally unknown to the less-experienced radiologist, primary peritoneal and mesenteric pathologies may also occur. In the present text, a review of the primary pathologies most relevant to the practice of the radiologist has been compiled, together with a brief anatomical description of their localization.

2. EMBRYOLOGY and ANATOMY

The peritoneum is a membrane formed by mesothelial cells on a thin layer of connective tissue, which forms the lining of both the intraperitoneal organs and the peritoneal cavity. These two sections or layers are typically designated as visceral peritoneum and parietal peritoneum, respectively, and between them there is a virtual cavity.

The peritoneal reflections, which include ligaments, omenta and mesenteries, are named according to the organs they contribute to support: ligaments are formed by a double layer of peritoneum and support a structure to the peritoneal cavity; omenta are specialized ligaments that connect the gastric cavity to other structures; and mesenteries consist of two layers of peritoneum that link a section of the intestine to the retroperitoneum.

Most abdominal ligaments and mesenteries develop from remnants of the ventral and dorsal mesenteries of the embryo, which are suspended from the primitive intestine. These mesenteries divide the celomic cavity in right and left sections, from which
peritoneal spaces will subsequently originate. As the different organs develop, they migrate clockwise creating additional spaces, such as the perihepatic and the lesser sac.

Six ligaments in the superior abdomen originate from the dorsal mesentery: the gastrophrenic, gastropancreatic, gastroplenic, splenorenal and phrenicocolic, as well as the gastrocolic ligaments that constitute the greater omentum. Below the transverse colon, the transverse mesocolon, sigmoid mesocolon and the mesentery of the small intestine (or mesentery proper) are formed. Unlike abdominal ligaments, pelvic ligaments are formed by peritoneal reflections on pelvic structures, such as those around the uterus and the umbilical folds.

**PERITONEAL LIGAMENTS**

**LIVER SUSPENSORY LIGAMENTS**

- **TRIANGULAR LIGAMENTS**

The right and left triangular ligaments are formed by the apposition of the coronary ligaments. Unlike the left triangular ligament, the right one has a longer length and separates the right subphrenic space from the right subhepatic space. Both ligaments conform the bare area of the liver, devoid of peritoneal lining.

- **FALCIFORM LIGAMENT**

The falciform ligament contains the obliterated umbilical vein and separates the left and right subphrenic spaces. In the dissemination of tumours through the peritoneum, it is important to distinguish an affection of the ligament from hepatic metastases.

**STOMACH PERITONEAL LIGAMENTS**

- **LESSER OMENTUM**

It is formed by the gastrohepatic and hepatoduodenal ligaments:

- The gastrohepatic ligament is attached to the lesser curvature of the stomach and to the liver, and contains the coronary vein and the left gastric artery.

- The hepatoduodenal ligament extends from the duodenum to the liver, and contains the portal vein, the hepatic artery, the common hepatic duct and part of the cystic duct.

- **GASTROSPLENIC LIGAMENT**
It spans from the greater curvature of the stomach to the spleen, and contains the short gastric vessels.

- **GREATER OMENTUM**

It is constituted by the gastrocolic ligament. It connects the greater curvature of the stomach and the spleen to the transverse colon, and contains the gastroepiploic vessels.

**OTHER LIGAMENTS**

- **SPLENORENAL LIGAMENT**

It contains the tail of pancreas.

**PERITONEAL MESENTERIES**

**TRANSVERSE MESOCOLON**

It is a peritoneal fold connecting the transverse colon to the retroperitoneum, which contains the middle colic vessels. This mesentery is an important dissemination path in patients with tumour affectation in the head of pancreas.

**MESENTERY OF THE SMALL INTESTINE**

It extends from the ligament of Treitz to the ileocecal valve, linking the small intestine to the retroperitoneum. It contains the upper mesenteric vessels and their branches.

**SIGMOID MESOCOLON**

It connects the sigmoid colon to the posterior pelvic wall, and contains haemorrhoidal and sigmoid vessels. Its most common affectation is by diverticulitis.

**PERITONEAL SPACES**

The peritoneal cavity is divided into several spaces, all of them interconnected. The two main compartments, separated by the transverse mesocolon, are:
SUPRAMESOCOLIC: formed by the left and right subphrenic spaces, left and right perihepatic spaces, subhepatic and perisplenic spaces, and the lesser sac.

INFRAMESOCOLIC: formed by the left and right parietocolic spaces, pelvic space and a central section of the abdomen.

LEFT SUPRAMESOCOLIC SPACE

It is formed by the perihepatic space, the periesplenic spaces and the left subphrenic space. The right subphrenic space is separated from the left one by the falciform ligament.

RIGHT SUPRAMESOCOLIC SPACE

It incorporates the right subphrenic space, the subhepatic space (or Morison space) and the lesser sac. The lesser sac forms an upper recess, located above the peritoneal reflection of the left gastric artery, and a lower recess, larger in size, between the stomach and the pancreatic body. The lower recess is connected on the right-hand side with the subhepatic space via the foramen of Winslow.

RIGHT AND LEFT INFRAMESOCOLIC SPACES

These are separated from the supramesocolic spaces by the transverse mesocolon, and from the paracolic gutters by the descending and ascending colon. The right inframesocolic space is bound by the mesentery of the small intestine and is not connected to the pelvis, unlike the left space.

PARACOLIC SPACES

The main paracolic gutters lie laterally to the colon on each side. While the right paracolic gutter is in direct contact with the subphrenic space, the left paracolic gutter connects with it through the prenicocolic ligament. Both are connected to the pelvic spaces.

PELVIC SPACES

These are the recto-vesical pouch, in men, and the recto-uterine and vesico-uterine pouches, in women; as well as anterior vesical spaces delimited by umbilical folds.
RETROPERITONEAL SPACES

The retroperitoneum is constituted by three distinct compartments: the anterior pararenal space, delimited by the transversalis fascia; the posterior pararenal space, delimited by the posterior parietal peritoneum; and the perirenal space, which contains the kidneys and adrenal glands, and is delimited by the perirenal fascia (formed by two layers, the anterior Gerota’s fascia and the posterior Zuckerkandl’s fascia).

There is a fourth space surrounding the aorta and the inferior vena cava, which is bound laterally by the perirenal spaces and the ureters, and extends upwards through to the posterior mediastinum.

RETROMESENTERIC PLANE

It is an expansile plane located between the anterior pararenal space and the perirenal space. In cases of pancreatitis, it crosses the middle line and allows the expansion of fluid towards the laterals, which can be erroneously attributed to the anterior pararenal space.

RETRORENAL PLANE

It connects with the anterior pararenal space and, although it does not cross the middle line, it has the potential to expand similarly to the retromesenteric plane.
Fig. 1: Axial CT imaging with oral administration of contrast. Left anterior perihepatic space (green) and falciform ligament (red).

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Fig. 2: Axial CT imaging with oral administration of contrast. Left posterior perihepatic space or gastrohepatic recess (green), and venous ligament (blue)

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**Fig. 3:** Coronal CT imaging with oral administration of contrast. Left posterior perihepatic space or gastrohepatic recess (green).

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Fig. 4: Axial CT imaging with oral administration of contrast. Left subfrenic space and gastrosplenic space (green).

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Fig. 5: Sagital CT imaging with oral administration of contrast. Gastrocolic ligament (red) and gastroplenic ligament (blue).

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Fig. 6: Coronal CT imaging with oral administration of contrast. Phrenicocolic ligament (orange).

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Fig. 7: Axial CT imaging with oral administration of contrast. Right anterior perihepatic space or subfrenic space. Falciform ligament.

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Fig. 8: Coronal CT imaging with oral administration of contrast. Right anterior perihepatic space or subfrenic space (green) and bare area of the liver.

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**Fig. 9:** Sagital CT imaging with oral administration of contrast. Right anterior perihepatic space or subfrenic space (green).

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Fig. 10: Coronal CT imaging with oral administration of contrast. Right posterior perihepatic space or subhepatic space (green). (Morrison space).

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**Fig. 11:** Sagital CT imaging with oral administration of contrast. Right posterior perihepatic space or subhepatic space (green). (Morrison space).

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**Fig. 12:** Axial CT imaging with oral administration of contrast. Right posterior perihepatic space or subhepatic space (green). (Morrison space).

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**Fig. 13:** Axial CT imaging with oral administration of contrast. Lesser sac is limited by: Anteriorly: stomach and gastrohepatic and gastrocolic ligaments. Laterally: Caudate lobe and gastrosplenic, gastrocolic and splenorenal ligaments. Posteriorly: pancreas, diaphragm and left superior renal pole.

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Fig. 14: Coronal CT imaging with oral administration of contrast. Mesenteric root. Inferiorly: cecum. Laterally: ascending colon.

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Fig. 15: Axial CT imaging with oral administration of contrast. Sigmoid mesocolon (green).

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Fig. 16: Axial CT imaging with oral administration of contrast. Rectovesical space (orange)

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Fig. 17: Coronal CT imaging with oral administration of contrast. Paracolics gutters (green and orange). Left Subfrenic space (yellow). Right subhepatic space (red). Phrenicocolic ligament (blue).

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**Fig. 18:** Axial CT imaging with oral administration of contrast. Greater omentum.

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Fig. 19: Axial CT imaging with oral administration of contrast. Lesser omentum.

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Findings and procedure details

3. IMAGE MODALITIES

Radiologists need to be aware of the limitations of image techniques. Coronal and sagittal reformation improves the resolution of omental anatomy and the detection of omental pathologic conditions.

MDCT

Images obtained by multiple-detector computed tomography (MDCT) exhibit 90% sensitivity in the detection of peritoneal lesions greater than 5mm in diameter. This technique, combined with the application of multiplanar reformatted images and the usage of oral and IV contrast, is a versatile imaging tool very well suited for the assessment of peritoneal diseases. Below 5mm, however, the sensitivity decreases substantially, particularly with slim patients.

PET

Positron emission tomography with 2-deoxy-2-[fluorine-18]fluoro-D-glucose integrated with computed tomography (18F-FDG PET/CT) offers a similar sensitivity to MDCT, but superior results in the assessment of therapeutic responses and recurrence of the disease. However, false positive findings in benign diseases have been reported, due to infectious or inflammatory diseases capturing high amounts of FDG and simulating a malign process.

MRI

Diffusion-weighted magnetic resonance imaging (DW-MRI) also allows for the detection of peritoneal neoplasms. Generally, tissues with high cellularity or exhibiting cellular swelling result in lower apparent diffusion coefficients (ADCs), which is particularly useful in the characterisation of neoplastic lesions. However, fibrotic lesions or with low cellularity, like mucinous adenocarcinomas, may be difficult to assess. Additionally, benign lesions such as abscesses or proteins within the peritoneal fluid may give rise to diagnostic errors. The diffusion sequence may also be used to evaluate the response to a treatment.
4. PERITONEAL PATHOLOGY

Pathological processes involving the peritoneum, mesentery and omenta present considerable variability. Still, secondary neoplasms are the most frequent affectation. They typically display similar appearances, and a biopsy or analysis of the fluid is required to establish the diagnosis. Depending on their presentation, these pathologies can be classified as solid, cystic or infiltrative.

A. PERITONEUM

Neoplastic processes can spread throughout the peritoneal cavity with relative ease, due to the pressure gradients in the abdominal cavity. Among the most frequent localizations are the hepatic dome, anterior abdominal wall, pelvic area and peritoneal reflections. The affectation of the periumbilical region is typically observed in cases of gastric metastasis, but also ovarian or pancreatic.

• SOLID MASSES

Primary Neoplasms:

Mesothelioma

Malignant mesothelioma is a rare cancer, often associated to asbestos exposure, which affects the peritoneum in 30-40% of cases. The mesothelioma grows from mesothelial cells in the peritoneal cavity, although it may also originate in the pulmonary pleurae, the pericardium or the tunica vaginalis, and affect abdominal organs, including the liver, pancreas, vesicle and intestine. Mesothelioma preferentially affects middle-aged men and has a poor prognosis.

Radiological findings include peritoneal nodularity and omental caking, while calcified peritoneal plates are rarely observed. CT observations may help differentiate between the two clinical types of peritoneal mesothelioma, termed "wet" (when it appears in association with ascites) or "dry" (which typically exhibits dominant localized masses and may produce an infiltrative pattern extending to fat and soft tissues, affecting the mesentery).

Other subtypes of mesothelioma include the well-differentiated papillary mesothelioma (which is not related to asbestos, affects exclusively women and has a better prognosis) and a cystic form, which will be discussed in the pertinent section.
Secondary Neoplasms:

Peritoneal Carcinomatosis

This type of cancer is a secondary affection of the peritoneum due to tumorous dissemination. The most frequent primary sources are ovaries, colon and stomach, followed by pancreas, uterus or vesicle.

Radiologically, CT images typically reveal nodular regions with soft-tissue attenuation, which may also appear as bulky masses. Other common observations are ascites, as well as the thickening and enhancement of peritoneal reflections. Although the latter have been linked to carcinomatosis, they are unspecific and can be associated to various diseases such as mesothelioma or tuberculosis. Calcified metastatic implants may be observed in cases of ovarian cystadenocarcinoma, particularly in the right hemidiaphragm and perihepatic.

• CYSTIC MASSES

Primary Neoplasms:

Cystic mesothelioma

It is an extremely rare, benign tumour originated from mesothelial cells in the peritoneum, and is not associated with asbestos exposure. Most cases develop in the pelvic peritoneum and it commonly affects middle-aged women. Despite its low metastatic potential, it has a high recurrence rate (30-50%). It may adopt either a unilocular or a multicystic configuration (with individual cysts ranging from 1mm to 6cm), and reaches sizes of up to 10cm.

This type of cyst may occasionally mimic a lymphangioma or a carcinoma / ovarian cystadenoma. However, its mesothelial origin can be revealed by anatomopathological examination, and MRI may be used to characterize the lesion and its relation to the ovaries or other gynecological organs. More infrequent lesions such as peritoneal or duplication cysts should also be considered.

Secondary Neoplasms:
Pseudomixoma peritonei and other cystic metastases

The term pseudomyxoma peritonei describes the intraperitoneal rupture of a cystadenoma or mucinous cystadenocarcinoma with dissemination through the peritoneum. Its most frequent sources are the ovary and appendix, in women and men respectively.

The presence of septa or the detection of distinctive peritoneal scalloping of the liver margin are useful in distinguishing this condition from simple ascites. In some cases it may present high attenuation. An alternative diagnosis that needs to be considered would be the presence of mucinous peritoneal metastases, which can calcify, especially after chemotherapy or radiation therapy.

• OTHER TUMOURS

Desmoplastic small-round-cell tumour

It is a rare, malignant and aggressive tumour, similar to Wilms’s tumour or Ewing’s sarcoma. It is typical of young patients and usually manifests in the diffuse soft tissue of the peritoneum, although it may also appear as a single mass.

Peritoneal serous carcinoma

It grows from extraovarian mesothelium in postmenopausal women and is related to the BRCA 1 mutation.

• INFLAMMATORY / INFECTIOUS PROCESSES

These include conditions caused by bacteria and mycobacteria, which may result in loculated ascites and fluid collections.

Abdominal tuberculosis is not uncommon, and it may affect the peritoneum, mesenteries and omenta. It has been observed in up to 38% of patients with primary pulmonary tuberculosis, especially in cases with high risk of immunosuppression, cirrhotic patients, alcoholics, or intravenous drug users. Its origin can also be secondary to a primary silent pulmonary tuberculosis, an ileocecal tuberculosis or a miliary tuberculosis. Another possible source is the lymphatic or haematogenous dissemination of a primary tuberculous salpingitis.
The CT observations may be similar to those of a secondary neoplastic process, such as omental caking or masses. Other possible findings include: enlarged lymph nodes, ring enhancement, necrotic centre, calcified ganglia, thickening of the terminal ileum, hepatic and splenic microabscesses, or diffuse peritoneal affectation. Ascites is a frequent finding in 90% of patients, although the 10% it is not manifested is characterized by greater fibrosis and adhesions.

Other relevant pathogens are histoplasma or pneumocysti, especially in immunocompromised patients.

Peritonitis can be a source of inflammation in cases of biliary peritonitis or in patients with renal or hepatic failure combined with spontaneous bacterial peritonitis. Cocoon syndrome is a rare and severe form of sclerosing peritonitis in patients undergoing chronic outpatient lavage.

**B. OMENTUM**

Omentum affectations are varied and frequently originated by extension from adjacent structures. The most relevant cases are presented below:

- **SOLID MASSES**

**Primary Neoplasms:**

Omentum primary tumours are very unfrequent and include both benign conditions, such as leiomyomas, lipomas and neurofibromas, and malignant tumours, such as leiomyosarcomas, liposarcomas, fibrosarcomas, mesothelioma and hemangiopericytoma. The incidence of malignant conditions is approximately 33% of all omentum primary tumours.

The imaging findings are non-specific. Generally, benign tumours appear well delimited. In contrast, malignant neoplasms often present worse delimitation with invasion and infiltration of adjacent structures. However, the image findings are not entirely conclusive.

Several lesions may affect the greater omentum, such as cystic lymphangioma, enteric duplication cyst, or pancreatic pseudocyst.
Both benign and malignant manifestations may be heterogeneous, with both cystic and solid areas.

**Secondary Neoplasms:**

These are considerably more frequent than primary neoplasms and, as with secondary peritoneal neoplasms, the ovary is the most common metastatic origin.

- **CYSTIC MASSES**

Fluid collections (both walled and walled-off) may form in the lesser omentum due to a variety of sources: loculated ascites, inflammatory exudate, bile or blood (during the subacute phase, a hematoma may appear as a cystic mass and residual areas of greater attenuation may be useful in diagnosis).

For the most part, the cause of fluid collections will be a renal or hepatic failure. However, isolated ascites in the lesser sac are rare. In those cases, other sources must be considered, principally a post-surgical origin (from gastric or hepatobiliary surgery), or an inflammatory origin (from pancreatitis, cholecystitis or gastric perforation).

- **INFLAMMATORY / INFECTIOUS PROCESSES**

In addition to tuberculosis, which has been discussed in a previous section, other infectious process that typically affect the omentum are paragonimiasis and actinomycosis.

Abdominal actinomycosis manifests as a solid mass with areas of less attenuation or even cystic.

Paragonimiasis usually courses as a lung infection, although it can affect other organs, and presents multiple small nodules that appear densely calcified.

- **MISCELLANY**

Internal hernias
They can be classified depending on their localization and cause of herniation in: epigastric, umbilical, subumbilical, spigelian, incisional or parastomal.

**Epiploic appendagitis**

This is an unfrequent, benign, non-surgical, inflammatory process of the epiploic appendices. It is more frequent in men and typically affects patients in their 4th or 5th decade. Its clinical course involves pain in the lower left quadrant, and therefore it is often mistaken for diverticulitis or appendicitis, even though these usually have a more marked clinical picture.

In such cases, a misdiagnosis could likely lead to an inappropriate surgical intervention. This condition is typically resolved in about two weeks, although radiological data can be gathered for up to six months.

Radiological observations will show an oval lesion under 5 cm in diameter, with attenuation equivalent to that of fat and surrounded by inflammatory changes. The identification of a hyperdense point at the centre of the lesion is an indication of venous thrombosis (which might still occur in its absence). Thickening of the parietal peritoneum can be secondary to the dissemination of inflammation.

The wall of the colon may also thicken, but intestinal obstruction or abscess formation are rare.

**Omental infarction**

It is an acute vascular disorder that mimics appendicitis, and therefore its correct diagnosis is important to avoid surgical intervention.

This condition occurs because of focal torsion or lack of blood flow to a portion of the omentum, usually due to a vascular affectation of its vessels by twisting, trauma or thrombosis. Although it is more common among older patients, it may also affect young people.

Other factors such as obesity, congestive cardiac failure or recent surgery have been found to predispose towards omental infarction.
Radiological findings consist of a large omental mass, without enhancement, presenting heterogeneous attenuation and located in the lower right-hand quadrant, deep within the rectus abdominis. It can lead to abscesses produced by infection.

It may be distinguished from epipolytic appendangitis by the larger mass observed, its localization in the ascending colon and the lack of hiper-attenuating ring. It differs from the findings characteristic of diverticulitis in the absence of mural inflammation of the colon, although it could appear affected by the inflammatory changes in its vicinity.

- **INFILTRANT INJURIES**

Infiltrating lesions may affect the peritoneum, the omenta or the mesenteries. The origin of these entities is varied and their radiological findings non-specific and difficult to analyse.

**Hepatic cirrhosis** with portal hypertension is one of the most frequent causes of diffuse affection of the omentum, mesentery and retroperitoneum. The evidence of edema within the findings ranges from a simple, ill-defined increase in attenuation to the formation of a masslike configuration.

**Secondary metastasic involvement** often originates from the ovary, but can also develop from the stomach, pancreas, or colon. The findings typically reveal ascites, peritoneal thickening, nodules and omental infiltration. However, these manifestations can also be present in cases of mesothelioma, tuberculosis or lymphomatosis.

**Tuberculous peritonitis** is caused by either haematogenous dissemination or the rupture of a mesenteric lymph node. Findings in support of this diagnosis are a smooth thickening combined with substantial enhancement after the administration of IV contrast.

**C. MESENTERY**

- **SOLID MASSES**

**Primary Neoplasms:**

Solid masses are less frequent than cystic ones. Among the benign lesions, which are more frequent than malignant tumours, are desmoids, lipomas, schwannomas or smooth muscle cell tumours.
The same types of malignants tumours described for the omenta are pertinent in this case.

Radiological findings are not specific. While malignant tumours tend to originate at the root of the mesentery, benign tumours are more likely to form near the periphery.

**Desmoid Tumour**

It is a rare tumour, locally aggressive, that arises due to the abnormal growth of fibrous tissue and may develop anywhere in the abdomen, including on the abdominal musculature, the retroperitoneum or the pelvis.

Typically, a single tumour is formed, although some people have multiple tumours. They are frequent in young multiparous women, and in 20% of the cases have been associated to Gardner's syndrome.

75% of the patients affected had previously undergone surgery. The recurrence rate for desmoid tumours can be as high as 50%, and more than one surgery is usually required. The tumour tends to become more aggressive when they recur after resection.

Mesenteric desmoid tumours (about 40% of the cases) may either exhibit well-defined margins or be associated with the affectation of the soft tissue adjacent to fat, in which case they present radial extension and ill-defined margins.

Radiologically, they are isodense with the musculature, but can be heterogeneous due to areas presenting lower attenuation secondary to necrosis.

Organ affectation is infrequent, but factors such a large size (> 10cm), multiplicity, extensive infiltration or the obstruction of bowel loops or ureters can be the cause of life-threatening complications.

**Carcinoid Tumour**

These tumours usually originate in the digestive tract, so strictly speaking they should be classified as secondary affectations.
However, the primary lesion in the distal ileum is usually hard to identify, and oftentimes the only detectable finding is the mesenteric tumour.

These tumours originate from neuroendocrine cells in the mucosa or submucosa, and so they can secrete vasoactive substances.

They spread into the mesentery by direct or lymphatic extension.

Radiologically, the most common manifestation is a hypervascular and well-defined soft tissue mass, which presents radial lines in the mesenteric fat. This indicates a neurovascular involvement, although it is occasionally due to the desmoplastic reaction produced by an intense fibrosis.

The ileal loop may appear thickened or enhanced and calcifications are present in 70% of the lesions.

**Sclerosing mesenteritis**

This inflammatory disease has an unknown origin, is fibrotic, slowly progressive, and affects the mesentery. Despite its benign behaviour, local infiltration may lead to complications. It can be associated with retroperitoneal fibrosis, Gardner's syndrome or lymphoma.

This condition manifests as a lineal and radial attenuation area of soft tissue, which mimics those characteristic of desmoid and carcinoid tumours, and peritoneal mesothelioma. In magnetic resonance imaging, low signal intensities are obtained using T1 and T2 sequences. The mesenteric fat is affected by inflammatory tissue, fat necrosis and fibrosis.

Inflammatory findings predominate in mesenterica paniculitis, where a pseudocapsule surrounds a focal area of fat exhibiting greater attenuation. Conversely, fibrosis predominates in the chronic form, also known as retractile mesenteritis. In this case, the disease is manifested as masses of soft parts with calcifications, which may occasionally appear ill-defined and affect adjacent fat and even organs.

Retractile mesenteritis cannot be distinguished from a desmoid tumour, carcinoid or peritoneal mesothelioma without a biopsy.
Other inflammatory processes, such as diverticulitis, pancreatitis or Crohn's disease, can affect portions of the mesentery adjacent to the relevant organ. They often appear as an increase of soft areas radiating around the organ, and are secondary inflammatory affectations.

• **CYSTIC MASSES**

**Primary Neoplasms:**

*Cystic lymphangioma* is a true neoplasm of the lymphatic system, and is more common in the mesentery than in the omentum. They are typically multilocular, although unilocular cysts are possible, and have internal septa. They contain chylous or serous components that may present low attenuation or be assessed by MRI. While it is a benign condition, it may occasionally be a lymphangiosarcoma.

*Teratomas* are rare benign tumours in both mesentery and omentum. They may have fat or calcium.

**WAYS OF DISSEMINATION SECONDARY TO THE MESENTERY**

Metastatic tumours and lymphomas affect the mesentery, and more so than primary tumours. The main pathways of secondary affectation of the mesentery are:

**DIRECT SPREAD**

It is observed in carcinoid tumours and other malignant neoplasms, such as gastric, pancreatic, biliary or colorectal tumours, which spread through the mesenteric vessels. An example of this involvement is the pancreatic adenocarcinoma, whose extension along the mesenteric root is detected in 40% of the patients.

**SPREAD THROUGH LINFATICS CHANNELS**

It is characteristic of lymphomas. The non-*Hodgkin lymphoma* produces mesenteric adenopathies in 30-50% of patients, frequently associated with retroperitoneal disease.
The mesenteric lymph nodes can also be affected in patients with chronic lymphatic leukaemia.

Radiologically, multiple, rounded masses with medium enhancement intensity can be observed, often surrounding the mesenteric vessels in a sandwich sign.

They may also form a large mass and displace other structures. In patients treated successfully with chemotherapy, they may display an infiltrative pattern in the mesenteric fat, poorly defined and with an increase in fat attenuation.

The metastasis of the colon, ovary, breast, lung, or melanoma may also affect the mesenteric lymph nodes. However, the degree of enhancement is less pronounced than that observed in case of lymphoma, and the distribution more localized.

Mesenteric lymphadenopathy is a frequent occurrence in infectious processes caused by tuberculosis or other mycobacteria such as MAI (Mycobacterium avium-intracellulare), which commonly affects patients with immunodeficiency.

This may result in enhancement of the mesenteric lymph nodes, similarly to a lymphoma or metastasis. In these cases, however, the characteristic configuration is more discrete, as opposed to the typical conglomerated arrangements secondary to lymphoma.

Low attenuation or cystic appearance of lymph nodes can indicate an infection by MAI or TBC.

**Whipple's disease**, caused by the Gram-positive bacterium trophermyma whipplei, should be considered in the differential diagnosis of low-attenuation lymph nodes in the mesentery.

Other causes of non-infectious lymphadenopathy include celiac sprue or Crohn's disease, or systemic diseases such as mastocytosis or sarcoidosis.

In mesenteric castleman disease, adenopathies manifest with an intense enhancement.

**HEMATOGENIC SPREAD**
Haematogenous metastasis of melanoma, breast, or lung often involves the antimesenteric borders of small intestine loops, irrigated by mesenteric vessels. It may manifest as nodules protruding into the intestinal lumen or mural thickening of the loop, and can be a source of intussusception. The small intestine and its mesentery are the most favoured sites of metastatic melanoma.

**INTRAPERITONEAL SPREAD**

Due to the natural fluid flow throughout the peritoneal anatomy, the right lower quadrant, pelvis and paracolic gutters are the most frequent sites of this type of dissemination.

This is the case in **peritoneal carcinomatosis**, particularly when caused by breast, gastric, pancreatic or ovarian tumours.

**Peritoneal lymphomatosis** results from the peritoneal involvement by lymphoma of the digestive tract, and is indistinguishable from peritoneal carcinomatosis.
Fig. 20: Carcinoid tumor. A) Coronal CT post-contrast showing a mesenteric well defined mass near to the mesenteric root. B) Axial CT post-contrast, arterial phase. Calcified mass with infiltrated fat.

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Fig. 21: Carcinoid tumor. A) Axial CT post-contrast. Thickening of ileum. B) Axial CT post-contrast, arterial phase. Hipervascular liver metastasis.

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Fig. 22: Hepatic cirrhosis. Axial CT post-contrast. Patient with portal hypertension, ascites and omental edema.

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Fig. 23: Desmoid Tumor. A) Coronal CT post-contrast. Mesenteric desmoid tumor. B) Axial CT post-contrast. Mesenteric desmoid tumor.

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Fig. 24: Omental infarction secondary to ileocolic intussusception. A) Axial CT imaging. Omental mass located in lower right quadrant. B) Coronal CT imaging. Local inflammatory changes. C) Reformatted imaging. Ileocolic intussusception with target sign.

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**Fig. 25:** Tuberculous peritonitis in young patient. A) Axial CT imaging. Falciform ligament.

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**Fig. 26:** Tuberculous peritonitis in young patient. A) and B) Axial CT imaging. Large volume of ascites perihepatic, periesplenic, lesser sac and around small bowel.
**Fig. 27:** Lymphoma. A) and B) Coronal reformatted CT imaging post-contrast. Large and isodense abdominal mass, well-delimited.

**Fig. 28:** Lymphoma. A) and B) Axial CT image post-contrast. Sandwich sign with mesenteric and renal vessels through the mass.
**Fig. 29:** Liposarcoma. Ecography imaging. Large and homogeneous mass slightly echogenic.

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**Fig. 30:** Liposarcoma. B) and C) Axial CT imaging post-contrast. Large retroperitoneal mass predominantly fat with nodular áreas.

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**Fig. 31:** Mesothelioma pleural with abdominal extension. A) and B) Axial CT imaging post-contrast. Large mesenteric and retroperitoneal masses with peritoneal nodularity and ascites, especially located on paracolic gutters.

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Fig. 32: Mesothelioma pleural with abdominal extension. A) and B) Coronal and Axial CT post-contrast. Large mesenteric and retroperitoneal masses with peritoneal nodularity and ascites, especially located on paracolic gutters.

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**Fig. 33:** Mesothelioma (Abdominal mesothelioma). Axial CT post-contrast. Nodularity and Peritoneal thickening with ascites and tumoral implants on sigmoid mesocolon.

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**Fig. 34:** Mesothelioma. (Abdominal mesothelioma). Axial CT post-contrast. Nodularity and Peritoneal thickening with ascites and tumoral implants on sigmoid mesocolon.

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**Fig. 35:** Cystic mesothelioma. A) Sagital MRI imaging. T2 sequence. B) and C) Axial oblique MRI imaging. T2 sequence. Multiple cysts in recto-uterine space (douglas pouch). Uterine myoma

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**Fig. 36:** Pseudomixoma peritonei. Ecography imaging. Complex Cyst lesion.

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**Fig. 37:** Pseudomixoma peritonei. A) and B) Axial CT post-contrast. "Scalloped margin" can be useful to distinguish from simple ascites. Umbilical extension.

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Conclusion

Imaging plays a vital role to evaluate patients with suspected primary or secondary peritoneal diseases. The knowledge of the relevant anatomical spaces becomes therefore fundamental to the successful evaluation of abdominal pathologies.

MDCT is an excellent imaging modality for detecting and characterizing peritoneal involvement from these unusual diseases and remains the most versatile imaging tool and the first indication.

There is a wide range of pathologic conditions that affect the peritoneum, mesentery, and omentum. Usually, imaging findings are non-specific. However, differential diagnostic considerations can often be significantly narrowed if we categorizes the findings by location and imaging patterns.
References


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