Peritoneal Carcinomatosis: unravelling its main features and mimics

Rebelo, João; Sousa, Célia; Moreira, Adriana; Leitão, Patrícia; Preto, Ana Sofia

Learning Objectives

The purpose of this paper is to review the main imaging features of the peritoneal carcinomatosis and its main differential diagnosis on cross-sectional imaging.

Background

Peritoneal disease can be caused by a wide spectrum of pathologies.
While peritoneal disease is usually caused by primary or secondary malignancies, benign diseases can occur and mimic malignancies.

Common diseases include:

- peritoneal carcinomatosis
- pseudomyxoma peritonei
- lymphomatosis, sarcomatosis
- tuberculous peritonites

Uncommon diseases which cause peritoneal disease include desmoid fibromatosis, desmoplastic small round cell tumor, malignant mesothelioma, well-differentiated mesothelioma, multicystic mesothelioma, papillary serous carcinoma, leiomyomatosis, extramedullary hematopoiesis, inflammatory pseudotumor and amyloidosis.

Background

Peritoneal carcinomatosis is the intraperitoneal dissemination of any tumour that does not originate from the peritoneum itself.

It is the most common diffuse peritoneal disease.

For a long time, it has been considered to be the terminal stage of malignant disease, with a very poor prognosis if untreated.

Since the 1990s and the development of treatment combining cytoreduction surgery and hyperthermic intraperitoneal chemotherapy (HIPEC), the management of this disease has been totally changed.

These techniques are aggressive and they are associated with high morbidity, so patient selection is crucial for optimum efficacy.

Background - Anatomy

The peritoneum, the largest serous membrane of the body, is composed of a single layer of mesothelial cells supported by connective tissue, which lines the inner surface of the abdominal cavity (parietal peritoneum) and envelopes the majority of the abdominal organs (visceral peritoneum).

The peritoneal cavity refers to the potential space between these two layers.

The peritoneum's primary functions are to suspend the visceral organs and to act as a conduit for the network of blood vessels, lymphatics, and nerves that supply the abdominal and pelvic organs.
Unfortunately, malignant and benign diseases use these same conduits to spread throughout the abdomen and pelvis.

The compartmentalization of the peritoneum by its reflections and mesenteries commands the direction and flow of fluid within the abdominopelvic cavity.

The two main peritoneal compartments - supramesocolic and inframesocolic – are separated by the transverse mesocolon.

Background - Anatomy

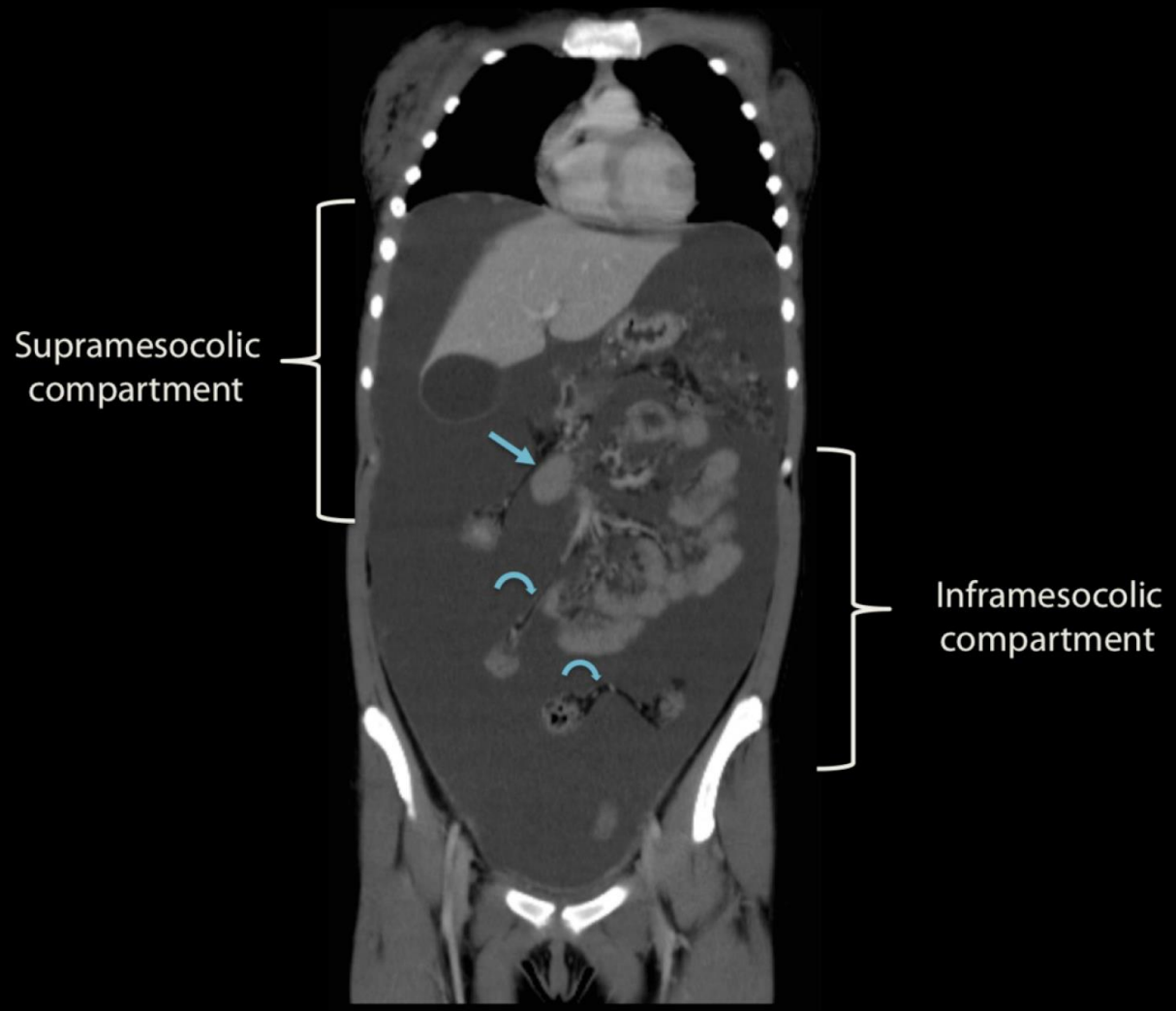


Fig. 1: Anatomy of the peritoneal cavity: Coronal CT image of a patient with large volum ascites depicts the division of the supramesocolic and inframesocolic compartments by the transverse mesocolon (arrow). Also seen are the small bowel mesentery and the sigmoid mesocolon (curved arrows).

References: Radiology Department, Centro Hospitalar São João, Faculdade de Medicina da Universidade do Porto – Porto/PT

Background - Anatomy

Supramesocolic compartment

Divided by the falciform ligament into the right and left supramesocolic spaces.

The right supramesocolic space is further divided into:

• Right subphrenic space: extending over the diaphragmatic surface of the right liver lobe to the right coronary ligament (posteroinferiorly) and the falciform ligament (medially).

• Right subhepatic space: bounded superiorly by the inferior surface of the liver and communicating freely either with the right subphrenic space and the right paracolic gutter. The posterior right subhepatic space (Morrison's pouch) extends posteriorly to the peritoneum overlying the right kidney and is the most dependent portion of the peritoneal cavity in the supine position.

• Lesser sac: located posterior to the lesser omentum, stomach, duodenum and gastrocolic ligament and anterior to the pancreas. Communicates with the rest of the peritoneal cavity through the epiploic foramen (of Winslow).

Background - Anatomy

Supramesocolic compartment

Divided by the falciform ligament into the right and left supramesocolic spaces.

The left supramesocolic space is divided into four compartments in communication:

• Left perihepatic space: further divided into the left anterior perihepatic space, bounded medially by the falciform ligament, posteriorly by the liver and anteriorly by the diaphragm; and the left posterior perihepatic space, bounded posteriorly by the lesser omentum, extending from the surface of the liver into the fissure for the ligamentum venosum. The left perihepatic space communicates superiorly and to the left with the left subphrenic space and inferiorly with the peritoneal cavity over the surface of the transverse mesocolon.

• Left subphrenic space: divided into the left anterior subphrenic space, which lies between the stomach and the left hemdiaphragm; and the left posterior subphrenic space, which covers the superior and inferolateral borders of the spleen and is bounded inferiorly by the phrenicocolic ligament and superiorly by the gastrosplenic ligament.

Background - Anatomy

Supramesocolic compartment

Fig. 2 and 3: The supramesocolic compartment. Axial and Coronal CT images illustrating (1) the right and (2) left supramesocolic spaces, divided by the falciform ligament (arrow).

On the right, note also the subphrenic (1) and subhepatic (3) spaces, communicating freely with each other and with the ipsilateral paracolic gutter (*).

References: Radiology Department, Centro Hospitalar São João, Faculdade de Medicina da Universidade do Porto – Porto/PT

Background - Anatomy

Supramesocolic compartment

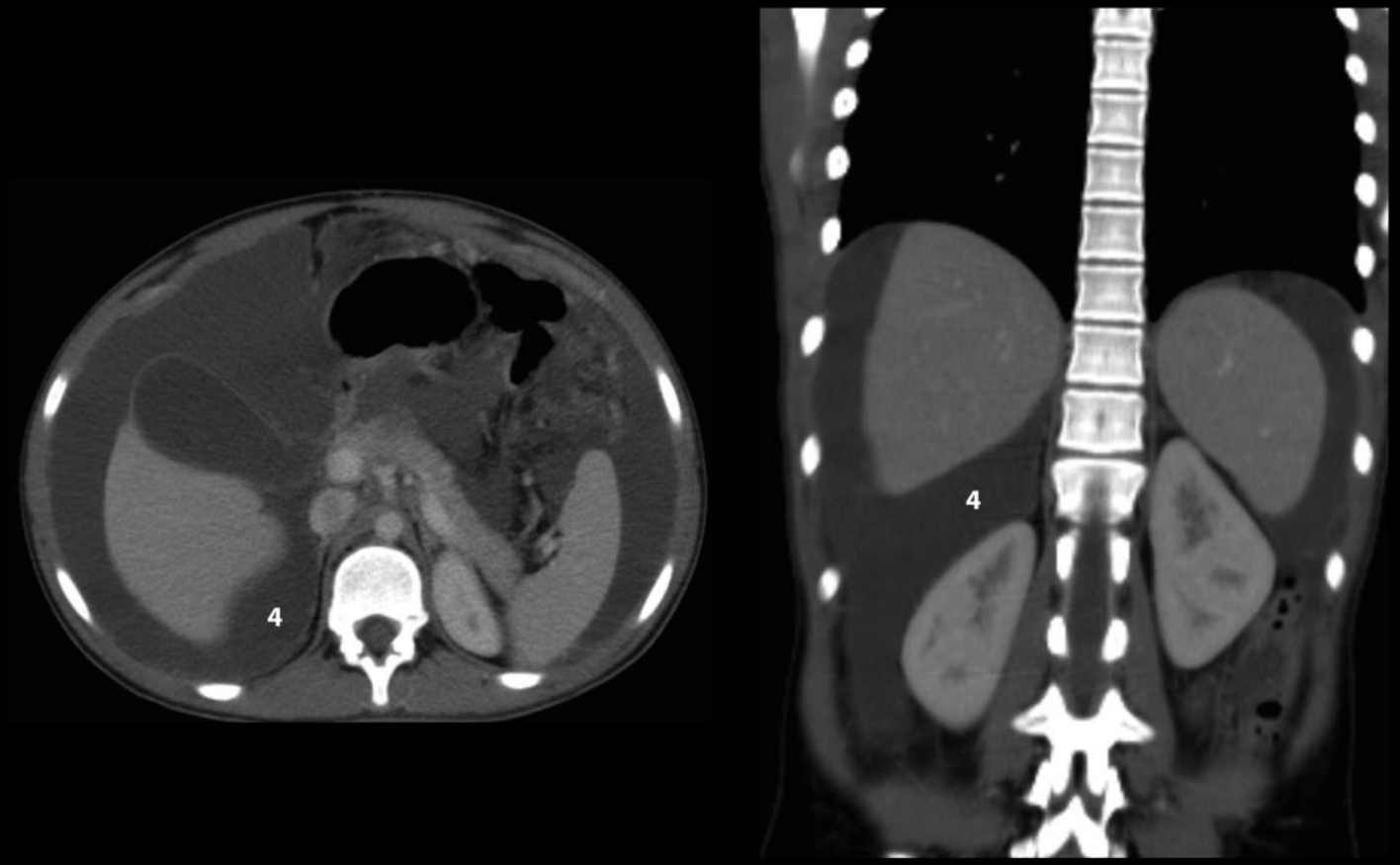


Fig. 4 and 5: Anatomy of the peritoneal cavity: Morrison's pouch (4), also known as right posterior subhepatic space, extends posteriorly over the right kidney and is the most dependent position of the abdominal cavity in the supine position.

References: Radiology Department, Centro Hospitalar São João, Faculdade de Medicina da Universidade do Porto – Porto/PT

Background - Anatomy

Supramesocolic compartment

Fig. 6: Anatomy of the peritoneal cavity: The lesser sac (5) is depicted in these axial and coronal images.

References: Radiology Department, Centro Hospitalar São João, Faculdade de Medicina da Universidade do Porto – Porto/PT

Background - Anatomy

Inframesocolic compartment

Divided by the root of the small bowel mesentery into:

• Right inframesocolic space: between the transverse mesocolon superiorly and to the right and the small bowel mesentery inferiorly and to the left.

• Left inframesocolic space: Larger than the contralateral right inframesocolic space, is in communication with the pelvic cavity to the right of the midline. The sigmoid mesocolon forms a barrier to the left of the midline.

• Paracolic gutters: peritoneal recesses situated between the posterior abdominal wall and the ascending and descending colon. The right paracolic gutter is larger than the left and communicates superiorly with the right subhepatic and subphrenic spaces (from the supramesocolic space). The left paracolic gutter is partially separated from the left subphrenic spaces by the phrenicocolic ligament.
Both communicate inferiorly with the pelvic peritoneal spaces.

Background - Anatomy

Inframesocolic compartment

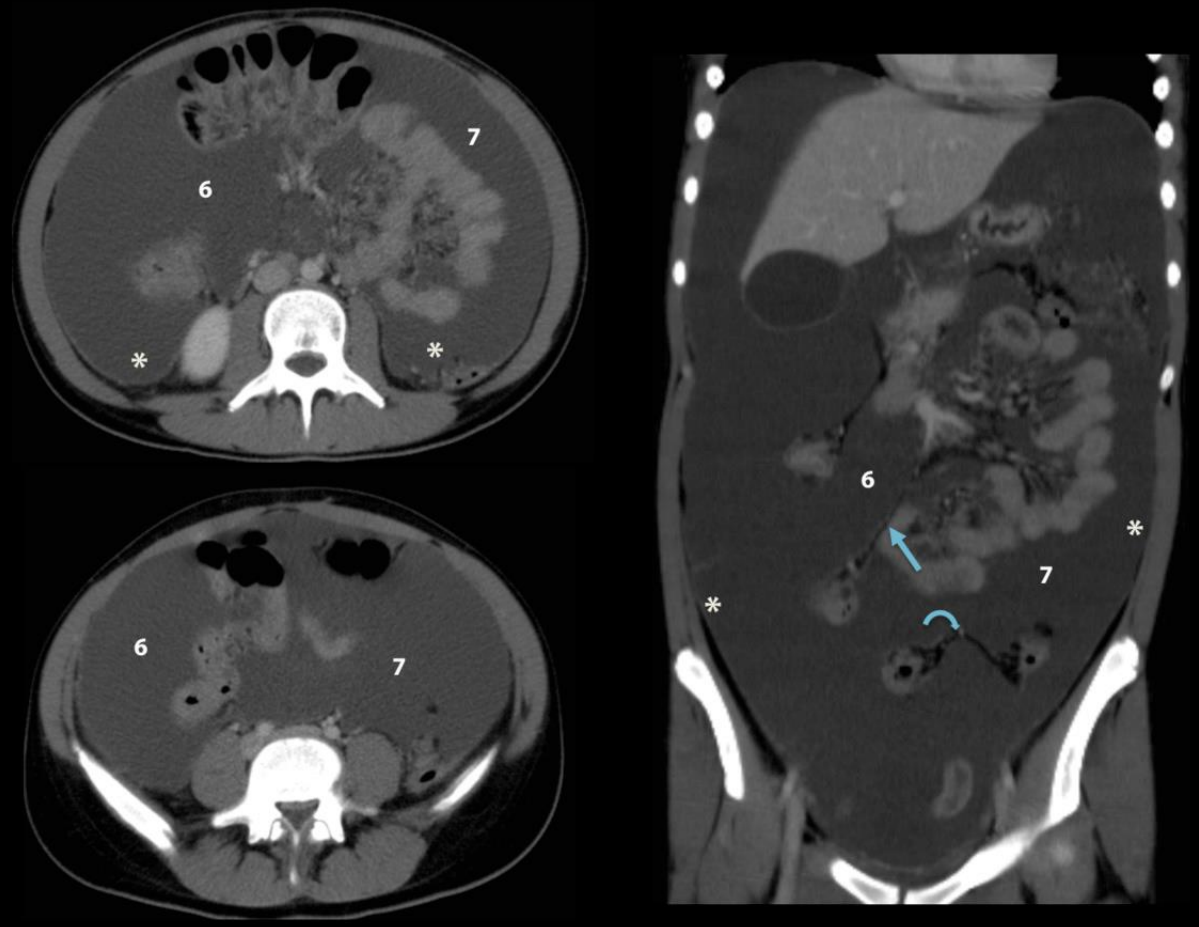


Fig. 7, 8 and 9: Anatomy of the peritoneal cavity: The inframesocolic compartment. Axial and Coronal CT images illustrating (6) the right and (7) left inframesocolic spaces, divided by the small bowel mesentery (arrow).
The left inframesocolic compartment (7) communicates with the pelvis to the right of the midline, as the sigmoid mesocolon (curved arrow) forms a barrier to the left of the midline. Note also both paracolic gutters (*), the right one communicating freely with the right subhepatic and subphrenic spaces. Both gutters extend inferiorly to the pelvic peritoneal spaces.

References: Radiology Department, Centro Hospitalar São João, Faculdade de Medicina da Universidade do Porto – Porto/PT

Background - Anatomy

The pelvic peritoneal spaces

The peritoneum reflects inferiorly over the dome of the bladder, the anterior and posterior surfaces of the uterus and the upper vagina (in females) and the superior portion of the rectum. The urinary bladder divides the pelvic cavity into the left and right paravesical spaces.

- **In women**, there are two potential spaces of fluid accumulation: posteriorly to the bladder (uterovesical pouch) and the rectouterine pouch (of Douglas).

- **In men**, there is one potential space of fluid collection only, the rectovesical pouch.

- The pelvis is the most dependent portion of the peritoneal cavity in the erect position.

Background - Anatomy

The pelvic peritoneal spaces

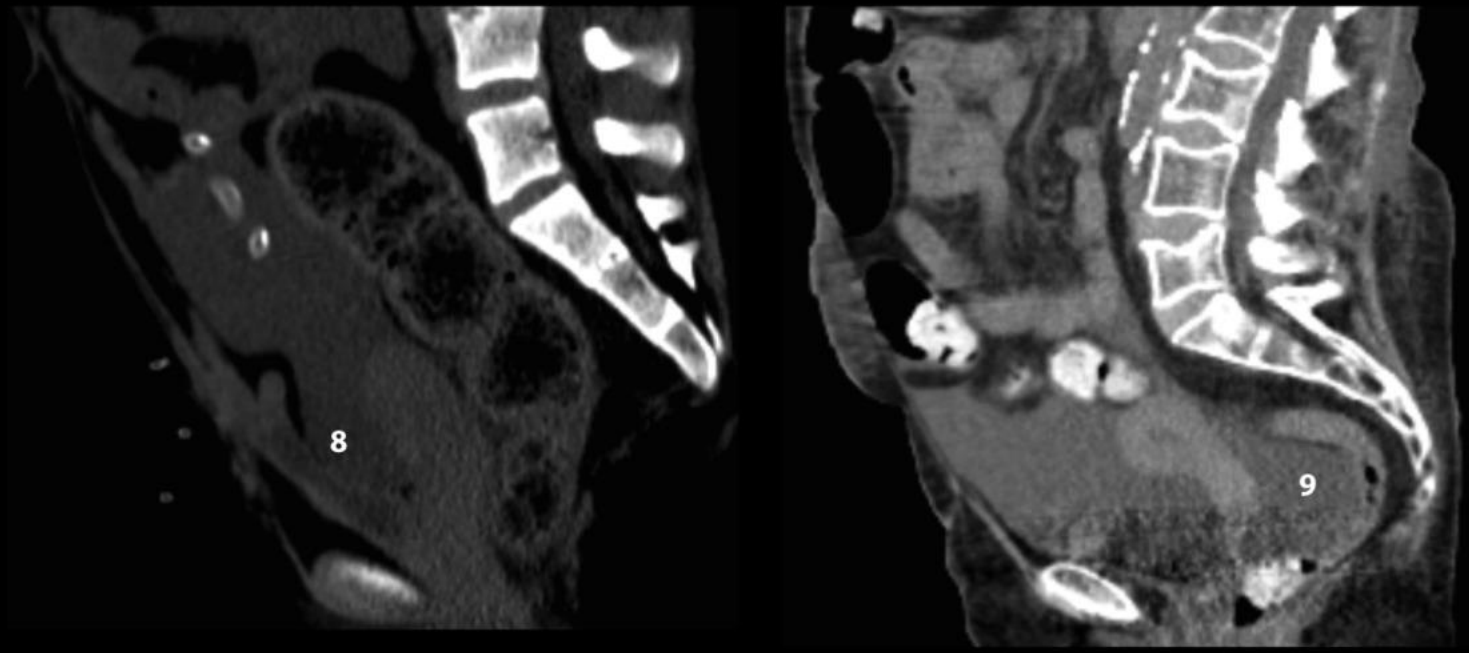


Fig. 10 and 11: Anatomy of the peritoneal cavity: The pelvic recesses. Sagittal scan in a female patient with medium volume ascites shows the more anterior vesicouterine pouch (8) and the rectouterine pouch (Douglas) (9). These are the most dependent portions of the peritoneal cavity in the upright position.

References: Radiology Department, Centro Hospitalar São João, Faculdade de Medicina da Universidade do Porto – Porto/PT

Background - Anatomy

The pelvic peritoneal spaces

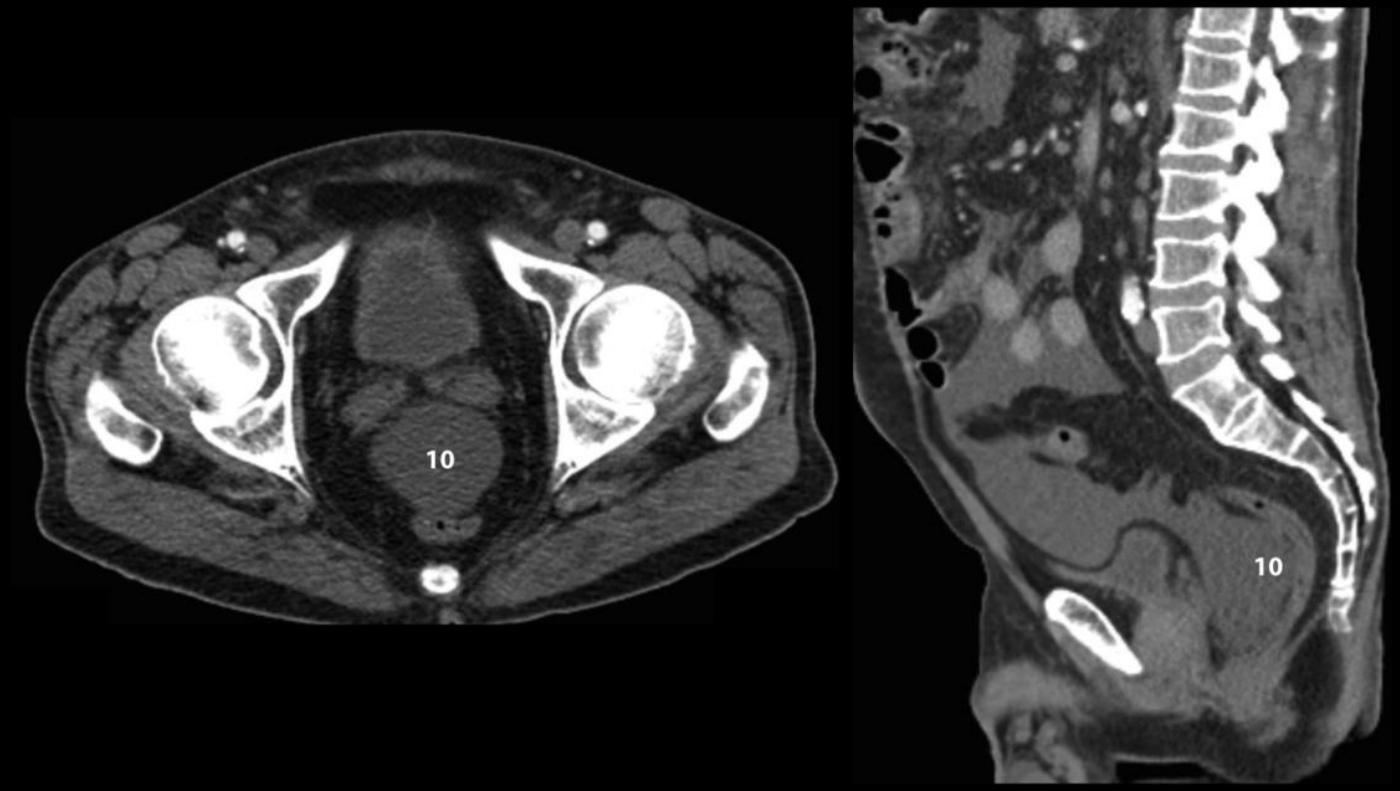


Fig. 12 and 13: Anatomy of the peritoneal cavity: The pelvic recesses. In men, the rectovesical pouch (10) is the only potential space for fluid collection in the pelvic cavity.

References: Radiology Department, Centro Hospitalar São João, Faculdade de Medicina da Universidade do Porto – Porto/PT

Background - Anatomy

Peritoneal Fluid Circulation

The normal peritoneal cavity contains a small volume of sterile fluid.

An understanding of the routes by which peritoneal carcinomatosis is disseminated and the dynamics of peritoneal circulation is an indispensable foundation for gaining a better understanding of the key signs of peritoneal carcinomatosis.

While initially the peritoneal fluid collects in the gravity dependent spaces (pelvic peritoneal spaces, such as the rectouterine and rectovesical pouches), it then ascends through the paracolic gutters to reach the subphrenic compartments.
The right paracolic gutter is the preferred way up because the phrenicocolic ligament acts as a partial barrier on the left and th falciform ligament prevents passage of fluid from the right to the left subdiaphragmatic compartments.

Fluid is then driven inferiorly to the inframesocolic space, completing the circuit.

Background - Anatomy

Peritoneal Fluid Circulation

There are four dissemination routes:

- **haematogenous route** is the main route for primary tumours with a high grade of malignancy. They are able to invade the vascular walls, then disseminate and implantin the peritoneum because the tumour secretes a factor that increases capillary permeability: Vascular Permeability Factor (VPF).

- **contiguous spread** consists of local or regional carcinomatosis that originates from a large tumour and crossesthe serous membrane to invade neighbouring organ

Background - Anatomy

Peritoneal Fluid Circulation

There are four dissemination routes:

- **lymphatic route**: there are two main routes for lymphatic dissemination:
  - the lymphatic system of the greater omentum

  - predominantly, the right side of the subphrenic lymphatic system, a site for true tumour cell entrapment, which drains into the anterior mediastinal lymphatic chain, then the right lymphatic duct, and the subclavian vein. When the subphrenic lymphatic system becomes obstructed, ascites result because peritoneal fluid is prevented from being reabsorbed.

- **peritoneal surface spread**:
  - by redistribution secondary to gravity, the carcinomatosis implants in the superior part of the sigmoidmesocolon, the inferior part of the mesentery, the ileo-cecal junction, the pouch of Douglas, and the right paracolic gutter

  - using peristaltic motion, the carcinomatosis follows the peritoneal circulation and implants along the paracolic gutter, passing back up into the undersurface of the diaphragm, becoming implanted in Morison’s pouch, the omental bursa, and along the left paracolic gutter.

Imaging Findings or Procedure Details

Peritoneal carcinomatosis is the term used to describe metastatic implants in the visceral peritoneal lining from a variety of malignant etiologies.

Peritoneal spread of tumour is commonly encountered in oncological imaging.
Secondary peritoneal malignancies far outnumber primary peritoneal neoplasms, such as peritoneal mesothelioma.

Peritoneal carcinomatosis, or spread from epithelial malignancies is the most frequently encountered, primarily from ovarian, colorectal, gastric, and breast cancer. However, peritoneal spread can also occur from sarcomas (sarcomatosis) and lymphomas (lymphomatosis).

Gastrointestinal stromal tumours (GIST), liposarcoma, and leiomyosarcoma are the most common sarcomas that give rise to peritoneal sarcomatosis.
Peritoneal lymphomatosis is the least common and is usually seen in aggressive non-Hodgkin's lymphomas (NHL) such as diffuse large B-cell lymphoma (DLBCL).

In some instances, however, the tumor may be of unknown origin.

Imaging Findings or Procedure Details

Radiographs

The sensitivity of abdominal radiographs for detecting peritoneal carcinomatosis is low.

When radiographs detect peritoneal carcinomatosis, it is through indirect findings: ascites, pleural effusions, bulging of flanks, central displacement of small bowel, and indistinct psoas margins.

Ultrasound

Ultrasound detects hypoechoic masses in cases of omental deposits or iso- to hyperechoic masses when ascites is present.

However, ultrasound can be limited in the setting of small volumes of ascites and is operator dependent.

Computed Tomography

Unquestionably the modality of choice to evaluate peritoneal carcinomatosis.
CT is almost 90% sensitive in the detection of peritoneal neoplastic lesions greater than 5 mm in diameter, decreasing significantly for lesions less than 5 mm.

Imaging Findings or Procedure Details

Magnetic Resonance Imaging

Optimal evaluation of peritoneal carcinomatosis with magnetic resonance imaging (MRI) requires intravenous Gadolinium, fat suppressed, and gradient echo sequences.

The hallmark of peritoneal carcinomatosis is presence of peritoneal thickening and omental cake.

Imaging Findings or Procedure Details

Ascites

Non-specific, free or loculated and present in 70% of cases, there are two main mechanisms causing ascites:

- **main cause**: subphrenic lymphatic vessels obstructed by carcinomatosis, unabling to carry out their usual function of draining peritoneal fluid

OR

- Excess production of peritoneal fluid, resulting from an increase in capillary permeability, which is caused by the tumour cells secreting vascular permeability factor, with protein and albumin accumulating in the abdominal cavity.

Loculation is one of the most helpful features indicating a malignant etiology

Imaging Findings or Procedure Details

Ascites

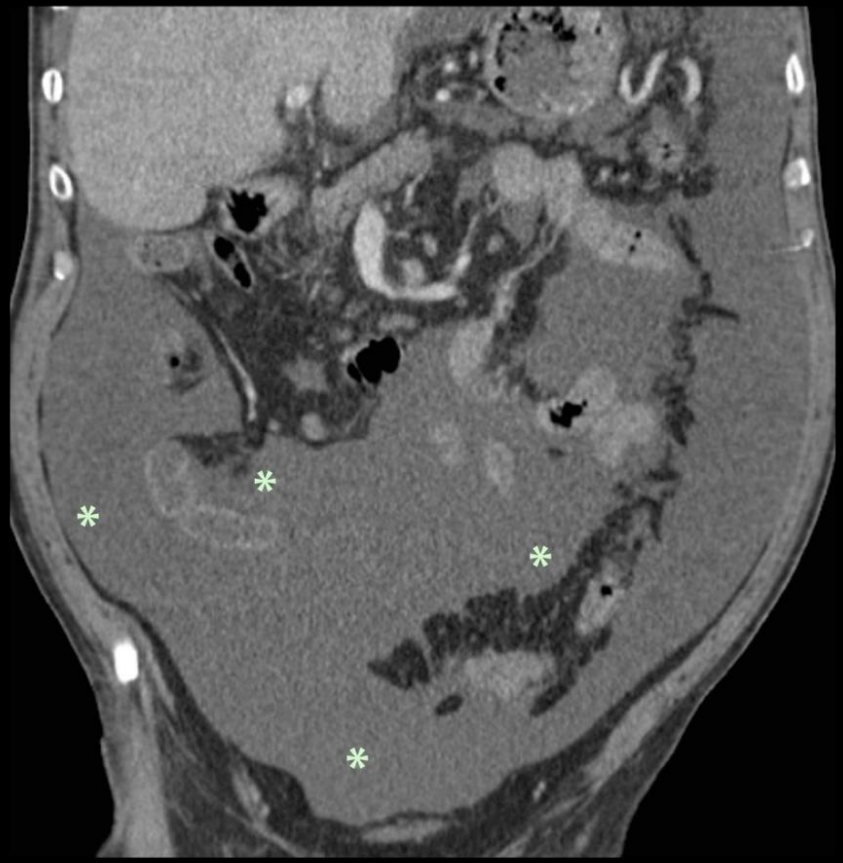


Fig. 14: Where to look for ascitic fluid in the peritoneal cavity?
These are the four most common well-defined areas of stasis (asterisks): The right paracolic gutter and the ileocecal junction, the pelvis and the superior aspect of the sigmoid mesocolon.

References: Radiology Department, Centro Hospitalar São João, Faculdade de Medicina da Universidade do Porto – Porto/PT

Imaging Findings or Procedure Details

Ascites

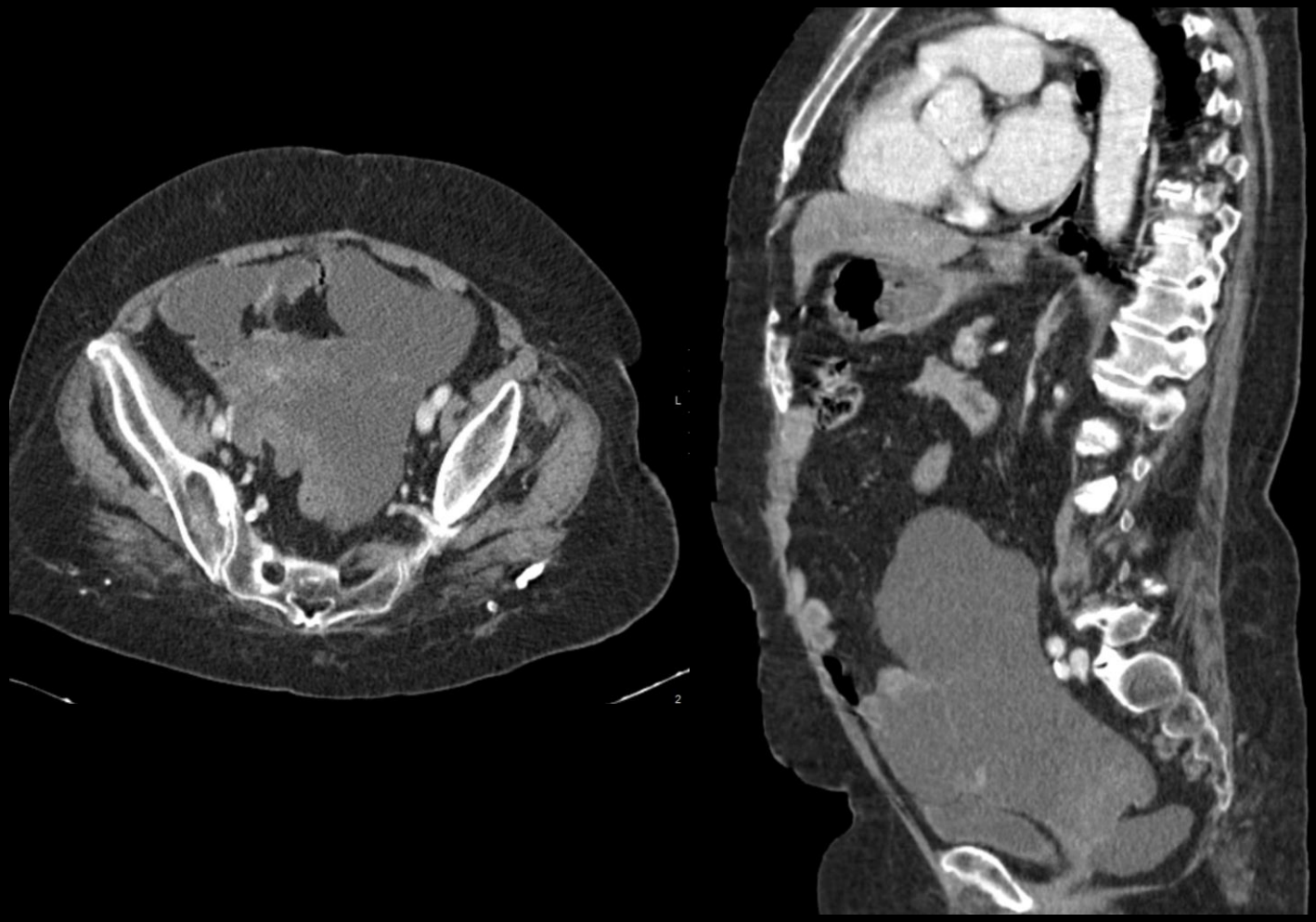


Fig. 15 and 16. Loculated ascites in a patient with a colonic cancer known.

References: Radiology Department, Centro Hospitalar São João, Faculdade de Medicina da Universidade do Porto – Porto/PT

Imaging Findings or Procedure Details

Ascites

Fig. 17. Loculated ascites in a patient with a colonic ovarian known.

References: Radiology Department, Centro Hospitalar São João, Faculdade de Medicina da Universidade do Porto – Porto/PT

Imaging Findings or Procedure Details

Greater Omentum Involvement

Greater omentum

Peritoneal structure formed by the attachment of the two mesenteries of the visceral peritoneum.

It hangs like an apron from the greater curvature of the stomach and the proximal part of the duodenum, so that it covers the majority of the abdominal organs, in particular, the colon and the loops of the small intestine.

In the beginning: invasion of omental fat, sometimes accompanied by small nodules within the fat.

In later forms: omental fat is replaced by a solid mass that separates the colon or the small intestine from the anterior abdominal wall, giving the classic appearance of an “omental cake”

Imaging Findings or Procedure Details

Greater Omentum Involvement

Fig. 18: Omental "cake". Mild thickening and fat stranding around the greater omentum (arrow) in a female patient with a history of serous adenocarcinoma of the fallopian tube.

References: Radiology Department, Centro Hospitalar São João, Faculdade de Medicina da Universidade do Porto – Porto/PT

Imaging Findings or Procedure Details

Greater Omentum Involvement

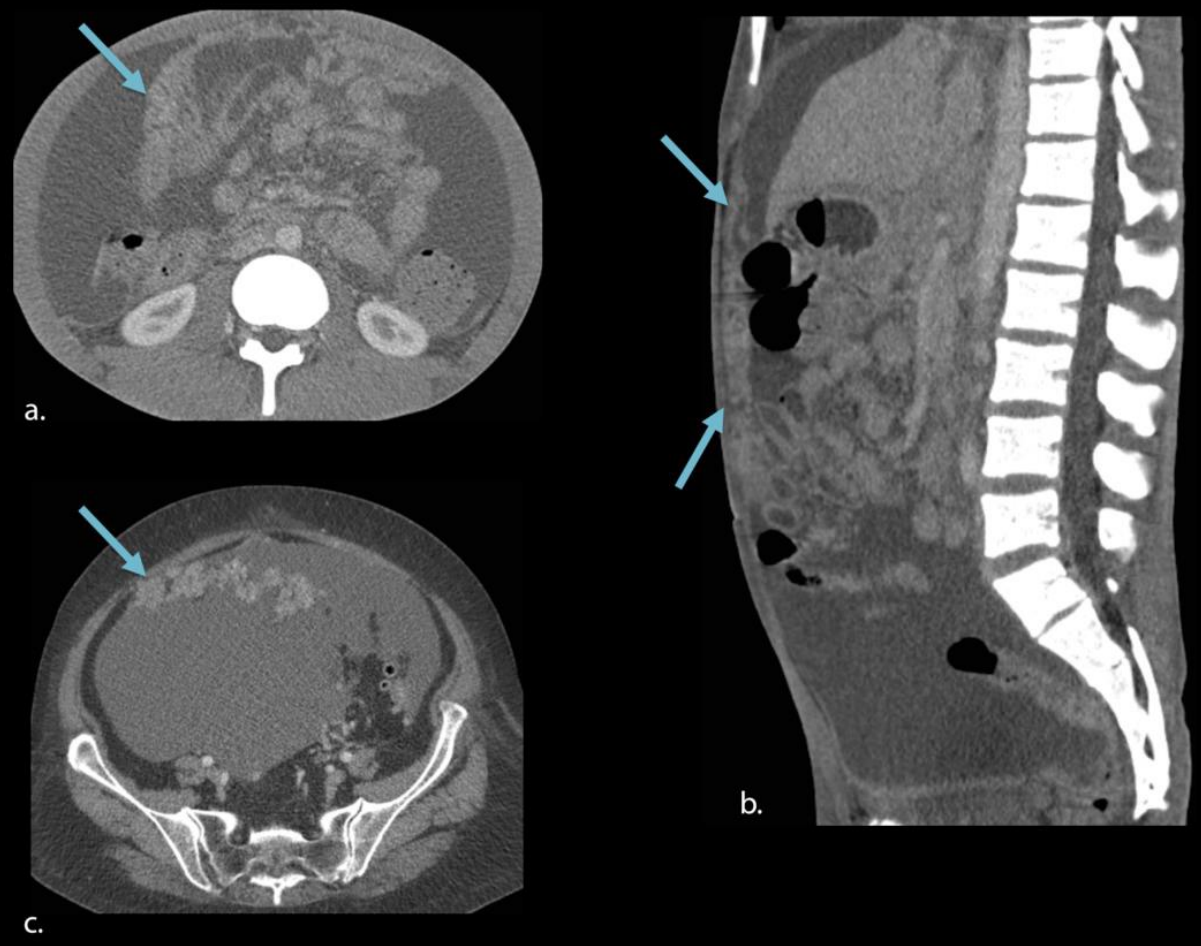


Fig. 19, 20 and 21: Omental "cake". More expressive thickening and enhancement of the greater omentum, displacing the bowel away from the abdominal wall.

Axial (a) and sagittal (b) scans from a 17 year-old male, illustrating voluminous ascites as well as marked thickening of the greater omentum (arrows) from signet-ring cell gastric adenocarcinoma.

Axial (c) CT image from a female patient with a history of adenocarcinoma of the gallbladder showing similar findings.

References: Radiology Department, Centro Hospitalar São João, Faculdade de Medicina da Universidade do Porto – Porto/PT

Imaging Findings or Procedure Details

Greater Omentum Involvement

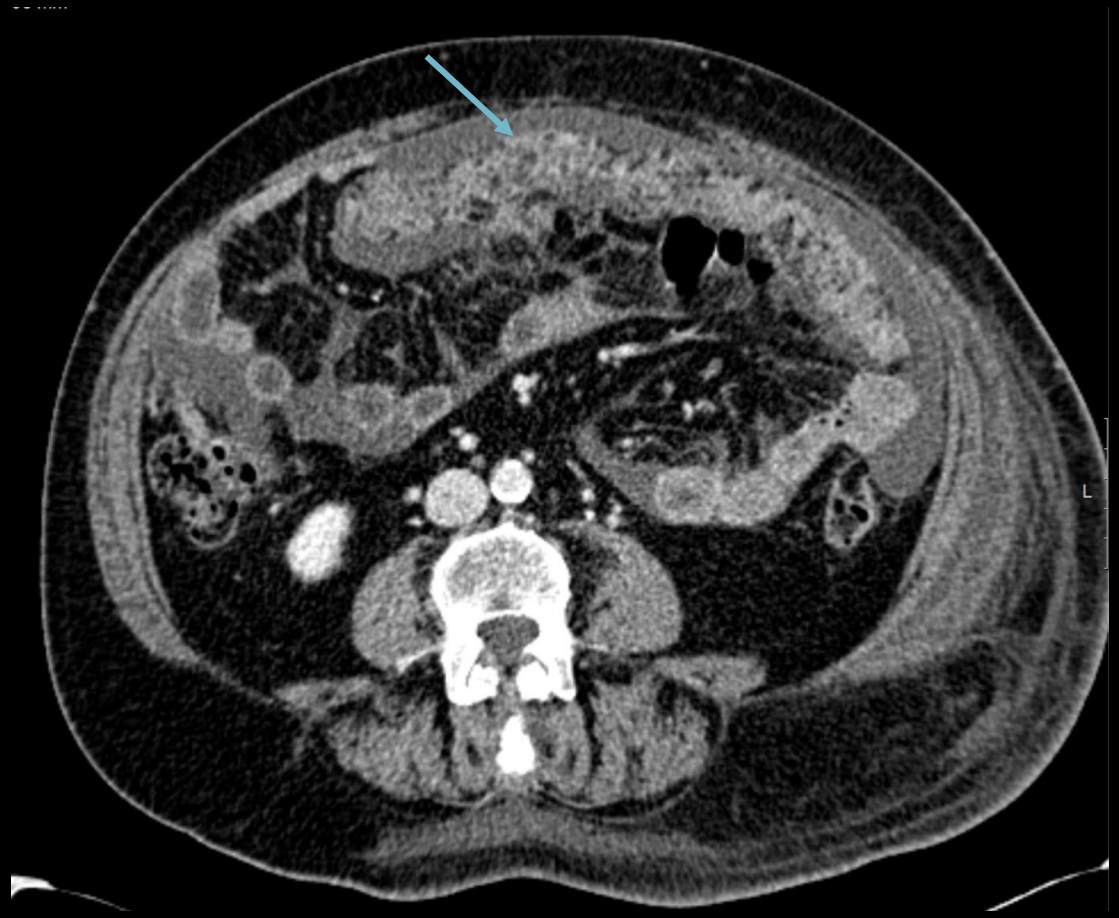


Fig. 22: Omental "cake". More expressive thickening and enhancement of the greater omentum, displacing the bowel away from the abdominal wall.
Axial scans from a 63 year-old male with colon adenocarcinoma, illustrating medium volume ascites as well as marked thickening of the greater omentum.

References: Radiology Department, Centro Hospitalar São João, Faculdade de Medicina da Universidade do Porto – Porto/PT

Imaging Findings or Procedure Details

Greater Omentum Involvement

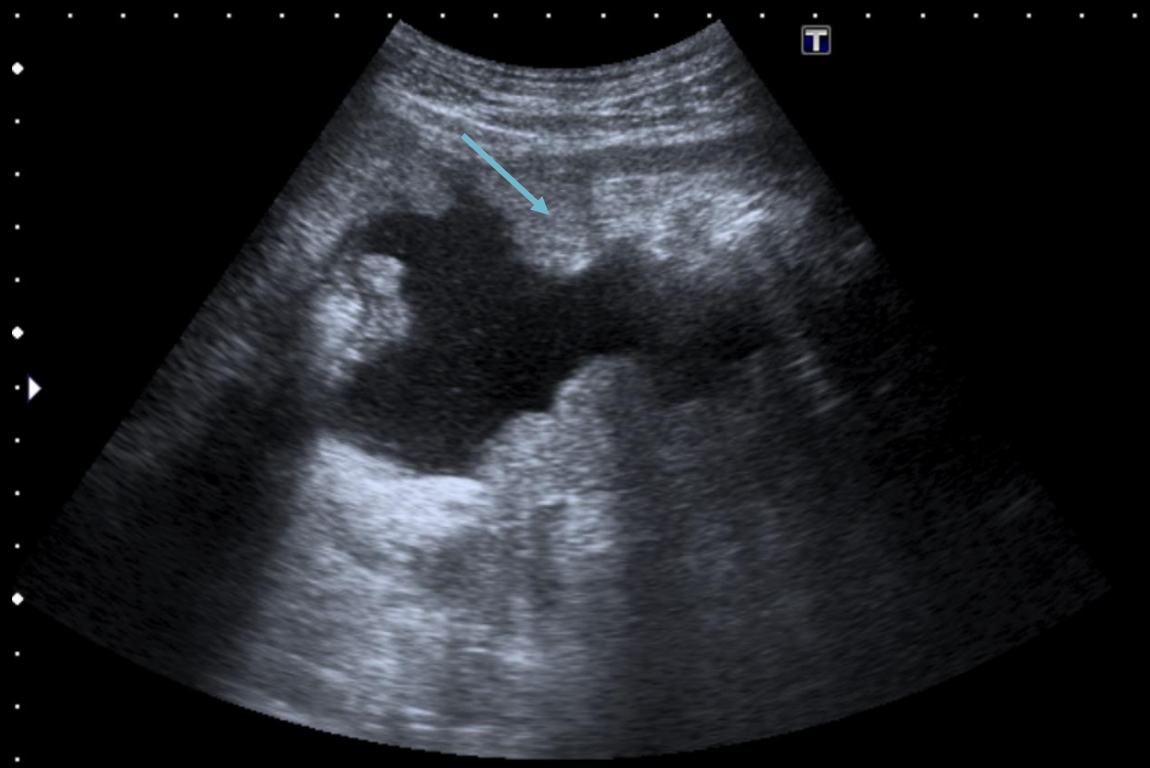


Fig. 23: Omental "cake".
Ultrasound.
Expressive thickening of the greater omentum, displacing the bowel away from the abdominal wall.

References: Radiology Department, Centro Hospitalar São João, Faculdade de Medicina da Universidade do Porto – Porto/PT

Imaging Findings or Procedure Details

Invasion of Mesentery

The mesentery is a long double layer of peritoneal tissue that suspends the jejunum and the ileum from the posterior wall of the abdominal cavity.

Invasion of the mesentery can manifest as:

- anomalous fixation of the small intestine
- thickening of the stomach walls
- increased mesenteric fat density
- presence of a stellate mesenteric mass or one or more mesenteric nodules that are more or less confluent

- lymphadenopathy may also be a prominent feature

Imaging Findings or Procedure Details

Invasion of Mesentery

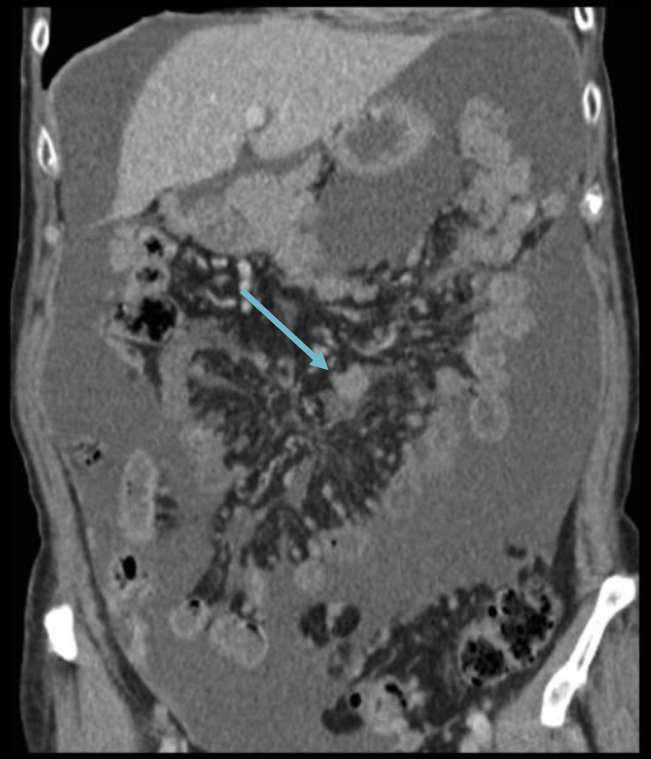


Fig. 24 and 25: Omental "cake".
Mesenteric lymphadenopathy. Axial and coronal scans of a female patient with breast cancer shows ascites and multiple rounded lymph nodes in the small bowel mesentery.

References: Radiology Department, Centro Hospitalar São João, Faculdade de Medicina da Universidade do Porto – Porto/PT

Imaging Findings or Procedure Details

Tumour implants in the peritoneal serous membrane

One of the indirect signs of serous membrane invasion is the adhesion of the small intestine or a segment of bowel becoming fixed to the wall, which blocks the free circulation of ascitic fluid.

Soft tissue masses that can appear as solitary or multiple nodules that can coalesce and form plaques near the surface of the viscera.

- Implants may enhance with intravenous contrast administration.
- Most common locations are the right diaphragmatic surface, right paracolic gutter, bowel, omentum and pelvic cavity.
- Extension of omental disease into the anterior abdominal wall may result in umbilical masses (Sister Mary Joseph nodule).
- Krukenberg tumor is a rare subtype of metastatic tumor to the ovary, usually arising from signet-ring type gastric cancer.

Imaging Findings or Procedure Details

Tumour implants in the peritoneal serous membrane

Fig. 26: Discrete infracentimetric right subphrenic nodule which was assumed to represent peritoneal carcinomatosis in a patient with widespread metastatic melanoma.
Note the hypoattenuating liver lesion (*) representing distant metastization. There was also medium-volume ascites (not shown).

References: Radiology Department, Centro Hospitalar São João, Faculdade de Medicina da Universidade do Porto – Porto/PT

Imaging Findings or Procedure Details

Tumour implants in the peritoneal serous membrane

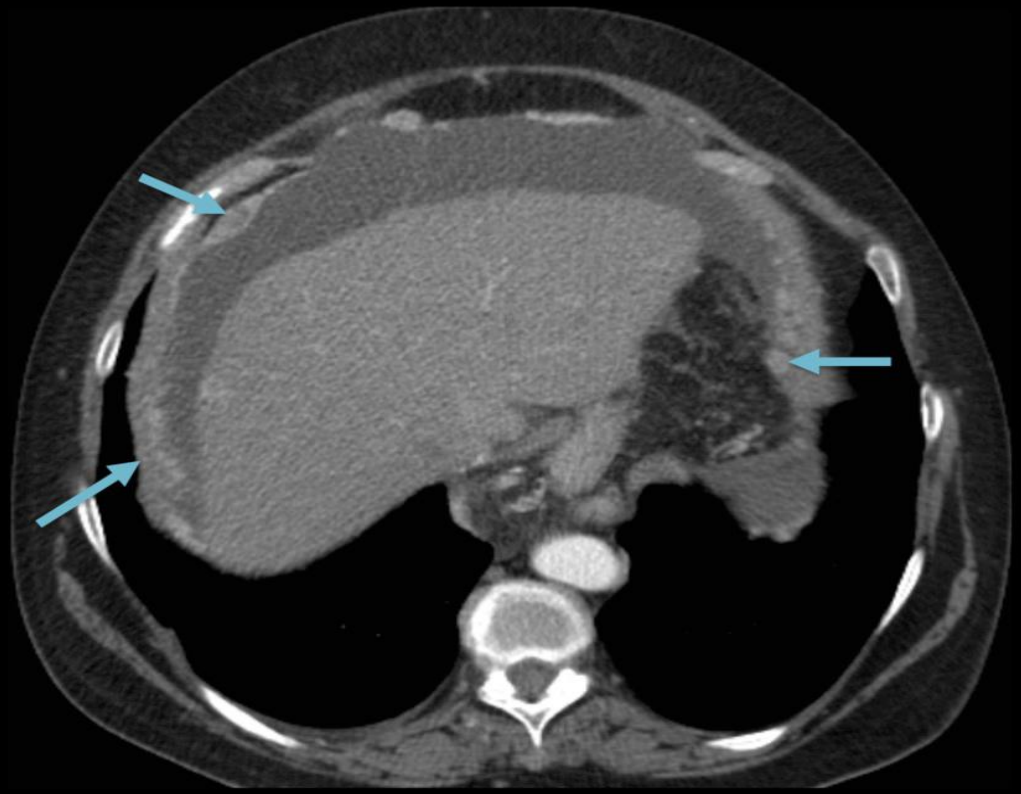
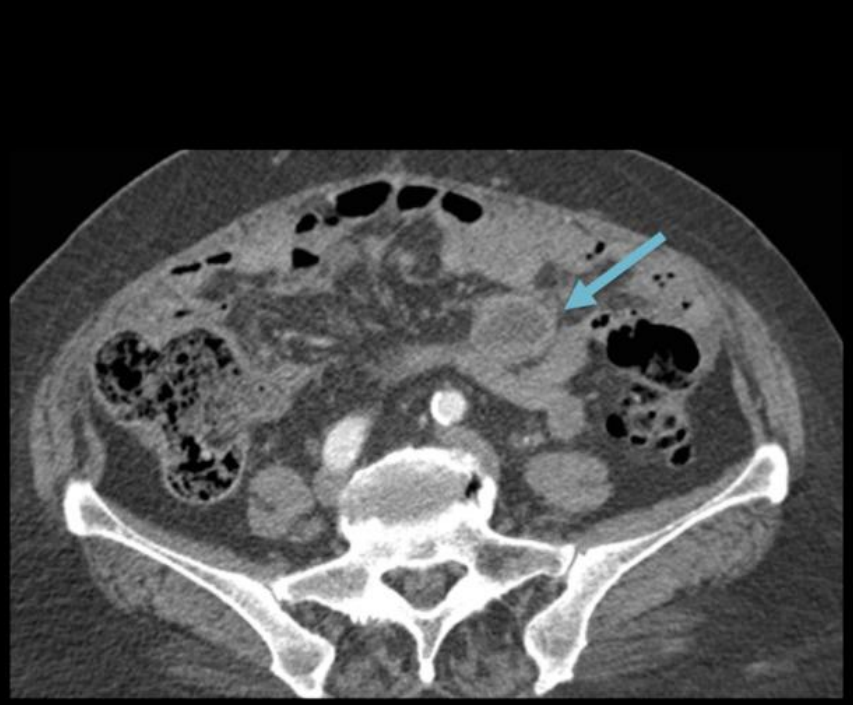


Fig. 27: Thickening and nodularity of the peritoneum. Axial CT image from a patient with widespread metastases from gallbladder carcinoma showing diffuse thickening, enhancing and nodularity of the peritoneum (arrows). This is a typical finding in peritoneal carcinomatosis.

References: Radiology Department, Centro Hospitalar São João, Faculdade de Medicina da Universidade do Porto – Porto/PT

Imaging Findings or Procedure Details

Tumour implants in the peritoneal serous membrane



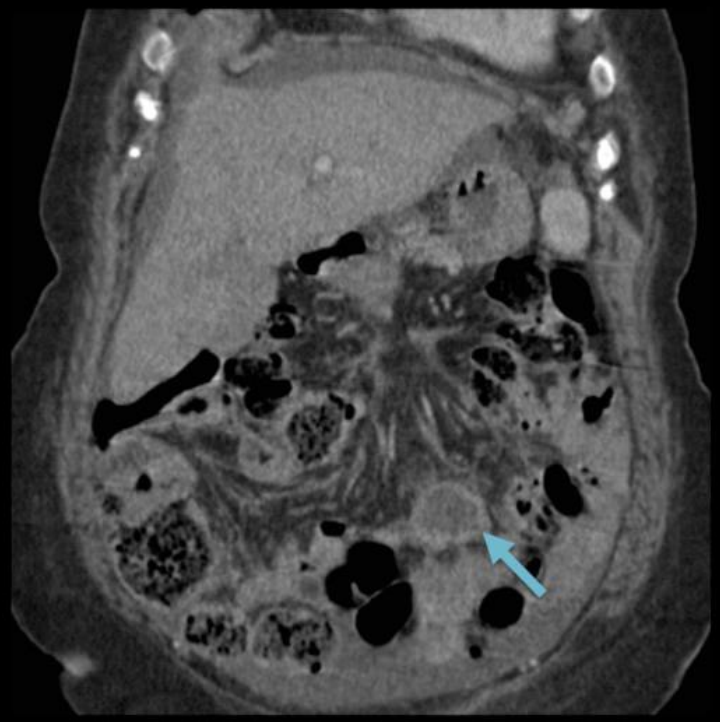


Fig. 28 and 29: Nodular implant. Axial and coronal view in a female patient with a history of mixed Mullerian tumor. Note the nodular lesion with peripheral rim enhancement and necrotic center in the small bowel mesentery (arrow). Mild ascites is also presente.

References: Radiology Department, Centro Hospitalar São João, Faculdade de Medicina da Universidade do Porto – Porto/PT

Imaging Findings or Procedure Details

Tumour implants in the peritoneal serous membrane

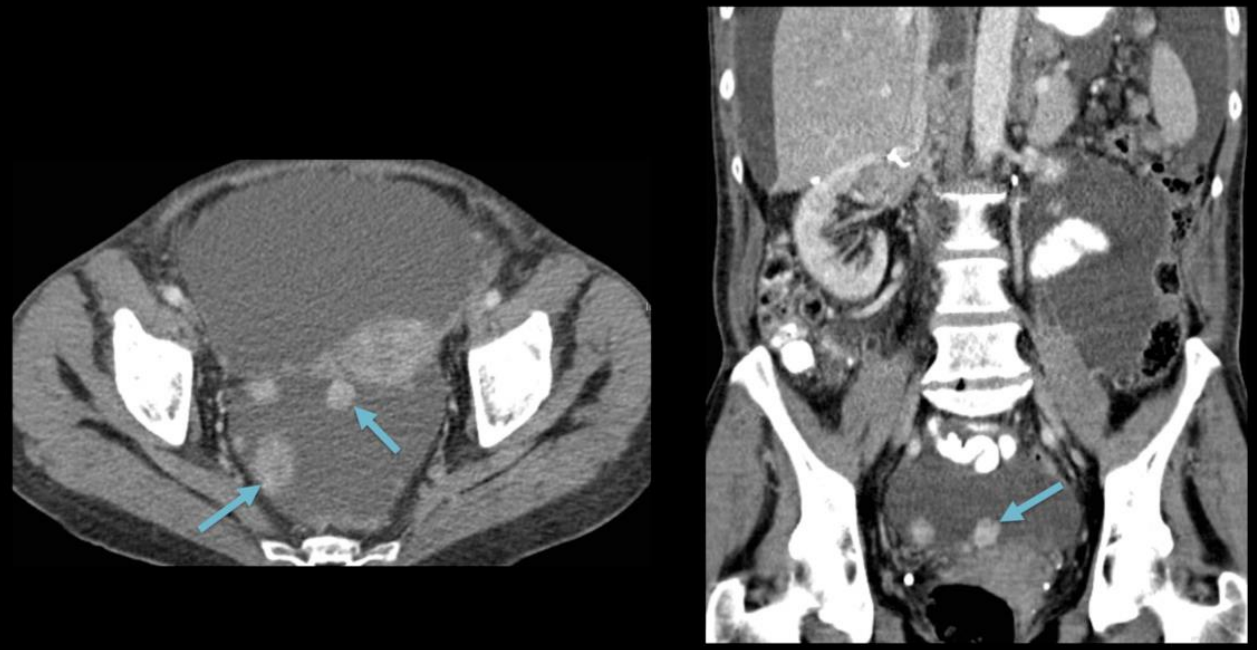


Fig. 30 and 31: Nodular implants in Douglas pouch. Axial and coronal CT images in a female patient with advanced adrenocortical carcinoma showing ascites and multiple enhancing nodular masses in the rectouterine recess, representing peritoneal implants.

References: Radiology Department, Centro Hospitalar São João, Faculdade de Medicina da Universidade do Porto – Porto/PT

Imaging Findings or Procedure Details

Tumour implants in the peritoneal serous membrane

Fig. 32: Implant. Axial image of a patient with a history of colonic adenocarcinoma, illustrating an ill-defined enhancing mass (arrow) in the rectovesical pouch, invading the rectum and posterior bladder wall. There was left hydronephrosis (not shown), consistent with invasion of the ureteral meatus.

References: Radiology Department, Centro Hospitalar São João, Faculdade de Medicina da Universidade do Porto – Porto/PT

Imaging Findings or Procedure Details

Tumour implants in the peritoneal serous membrane

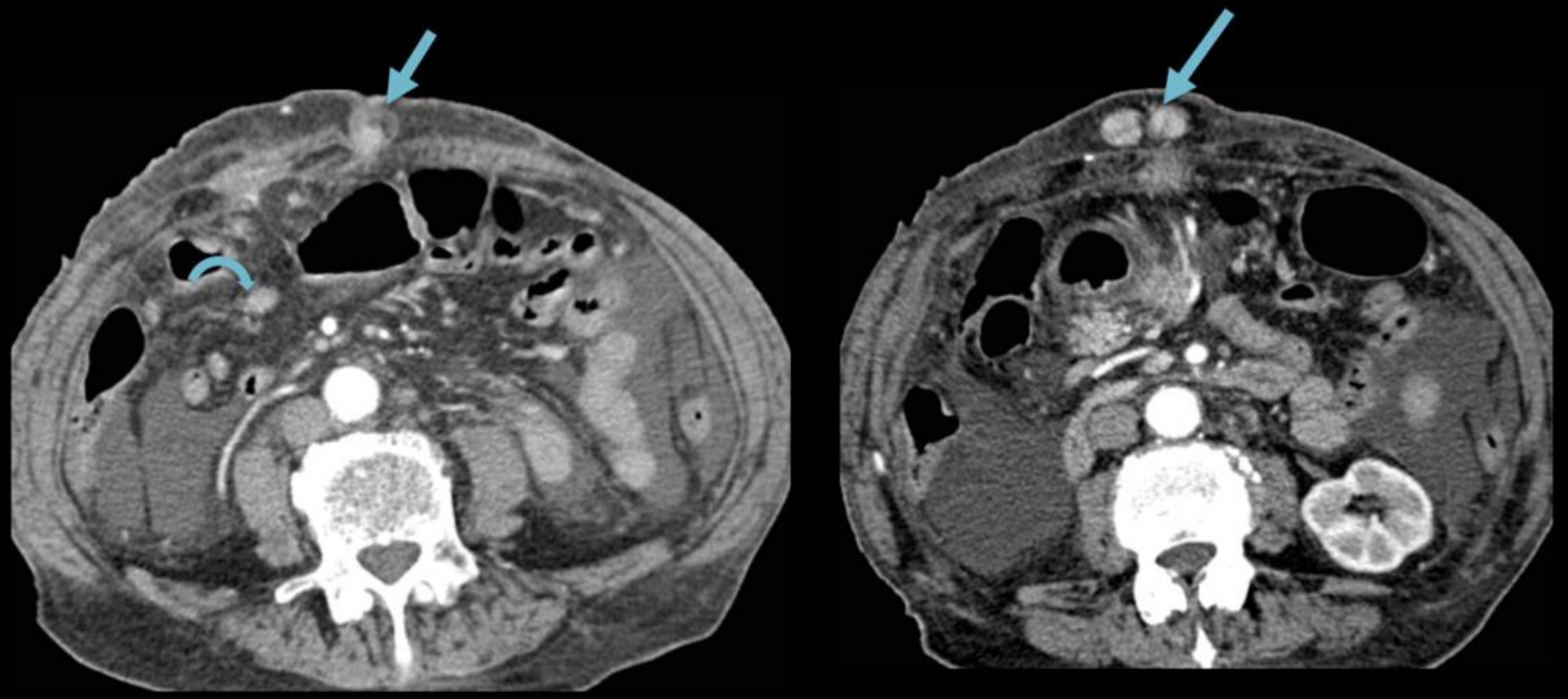


Fig. 33 and 34: Sister Mary Joseph nodules. Two axial CT images in a patient with gastric adenocarcinoma illustrating soft tissue enhancing nodules in the umbilical region (arrows). There was also ascites and a 15 mm nodularity in the peritoneum (curved arrow). These findings are suggestive of diffuse carcinomatosis through the peritoneal cavity.

References: Radiology Department, Centro Hospitalar São João, Faculdade de Medicina da Universidade do Porto –

Imaging Findings or Procedure Details

Tumour implants in the peritoneal serous membrane

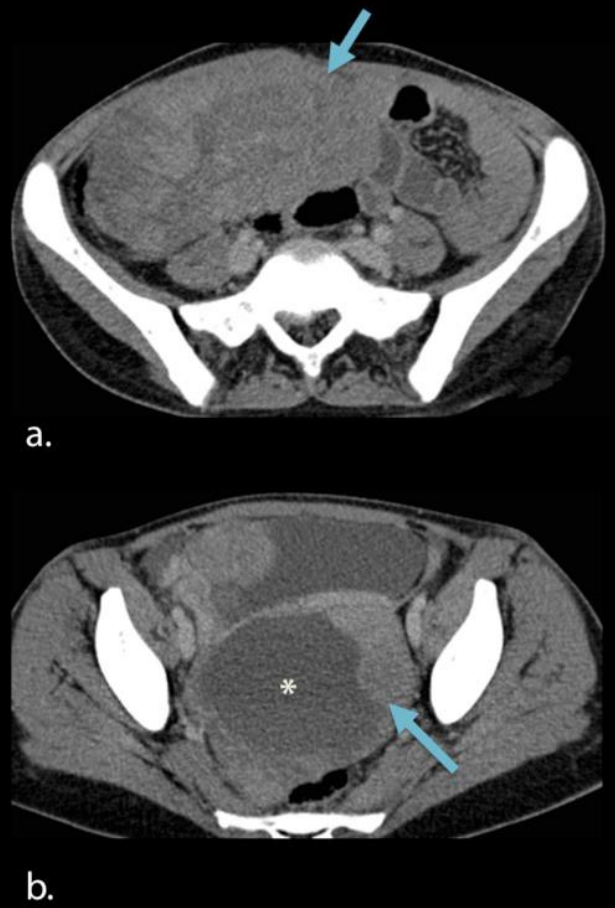


Fig. 35, 36 and 37: Peritoneal carcinomatosis: Krukenberg tumors.
Axial scans of the right (a) and left (b) adnexa and coronal view (c) in a female patient with a history of gastric adenocarcinoma of the signet-ring cell type illustrating voluminous bilateral heterogeneous enhancing masses (arrows).
On the left, there is central necrosis (*).

References: Radiology Department, Centro Hospitalar São João, Faculdade de Medicina da Universidade do Porto – Porto/PT

Imaging Findings or Procedure Details

Tumour implants in the peritoneal serous membrane

Diffuse peritoneal invasion may also remain unseen on CT, especially when it consists of a scattered micronodules covering the peritoneum, and these would then only be diagnosed during surgery.

Imaging Findings or Procedure Details

Differential Diagnosis

Benign etiologies may mimic peritoneal carcinomatosis such as in cases of disseminated peritoneal endometriosis, leiomyomatosis, and tuberculosis.

Radiologists should recognize this entity given its significant implications in the staging, management, and prognosis in cases of malignant origin.

Radiologists should try and identify the primary tumor in such instances to help characterize the etiology of the peritoneal involvement.

Imaging Findings or Procedure Details

Differential Diagnosis

Pseudomyxoma Peritonei

Represents extensive intraperitoneal mucin due to involvement of the peritoneum with from a primary mucinous malignancy most commonly arising from the appendix.

In females, any concomitant involvement of the ovary is thought to be linked instead to a metastatic process that spreads mucinous tumour cells secondary to a ruptured appendix. However, the theory of an ovarian origin has not been entirely excluded.

Radiographs
Bulging of flanks, central displacement of small bowel, and indistinct psoas margins.

Ultrasound
May present as highly echogenic intraperitoneal fluid.
The internal echoes do not change with body position.
Multiple echogenic septations in a laminated concentric appearance are pathognomonic

Imaging Findings or Procedure Details

Differential Diagnosis

Pseudomyxoma Peritonei

Computed Tomography

Signs of pseudomyxoma peritonei are not specific, combining peritoneal effusion, peritoneal nodules, and invasion of the greater omentum.

Although these features are very similar to those seen in peritoneal carcinomatosis, there are, however, a number of signs that point to pseudomyxoma peritonei:

- the extent to which there is scalloping, which indicates extrinsic compression of the liver by gelatinous masses
- loculation of intraperitoneal effusion
- calcifications, which are particularly suspicious when they are curvilinear
- lesions predominating in the greater omentum and the diaphragmatic peritoneum, while the serous membrane of the digestive system is rarely involved
- VIsualisation of a fluid or soft-tissue mass on the appendix

Imaging Findings or Procedure Details

Differential Diagnosis

Pseudomyxoma Peritonei

Magnetic Resonance Imaging

Lesion's intensity varies with mucin concentration but in general most are hypointense on T1-weighted images and hyperintense on T2-weighted images.

Delayed-enhancing fat-suppressed sequences allow detection of cellular components within the pool of ascites and mucin.

Merging conventional MRI protocols plus diffusion-weighted imaging with a b-value of at least 400 s/mm2 improves the sensitivity and specificity for detecting pseudomyxoma peritonei when compared to conventional MRI protocols alone.

Imaging Findings or Procedure Details

Differential Diagnosis

Pseudomyxoma Peritonei

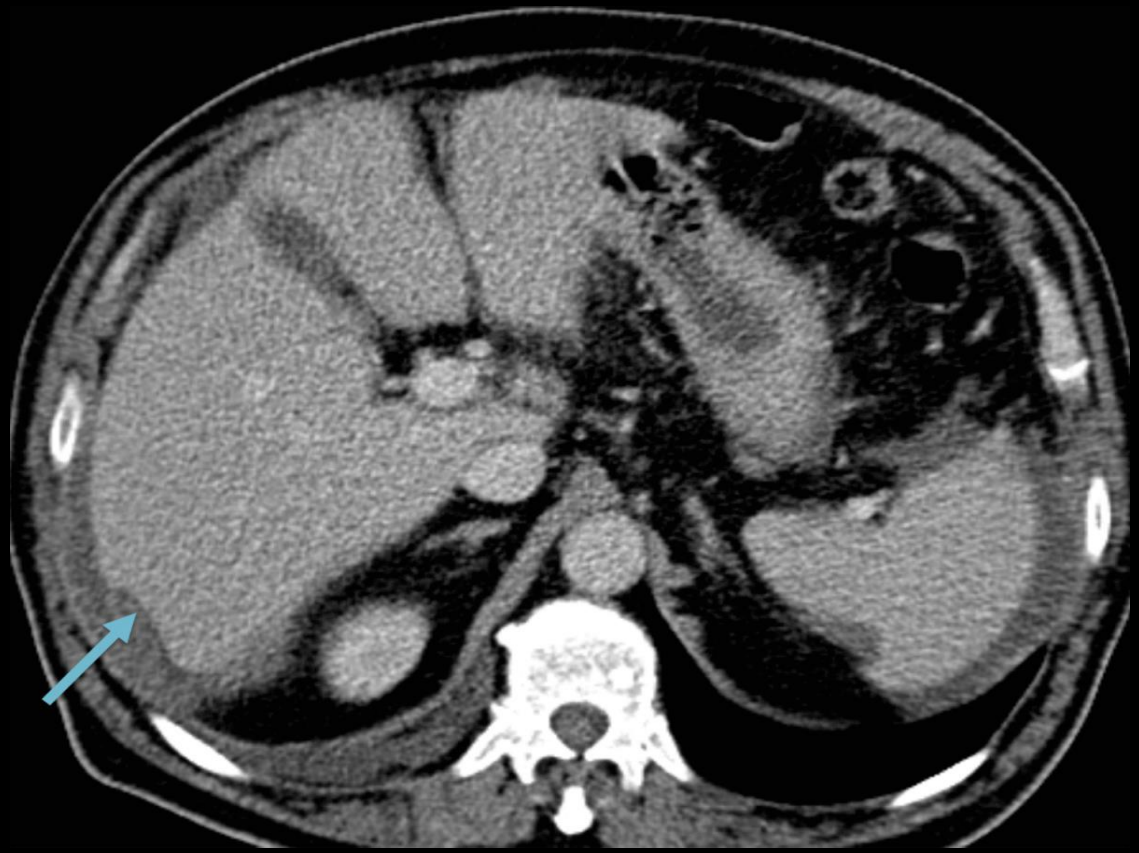


Fig. 38: Pseudomyxoma peritonei. Axial CT image of a patient with a history of mucinous adenocarcinoma of the appendix shows small amount of perihepatic and perisplenic fluid. Note the mass effect (scalloping) on the posterior surface of the liver (arrow). This is characteristic of pseudomyxoma peritonei.

References: Radiology Department, Centro Hospitalar São João, Faculdade de Medicina da Universidade do Porto – Porto/PT

Imaging Findings or Procedure Details

Differential Diagnosis

Pseudomyxoma Peritonei

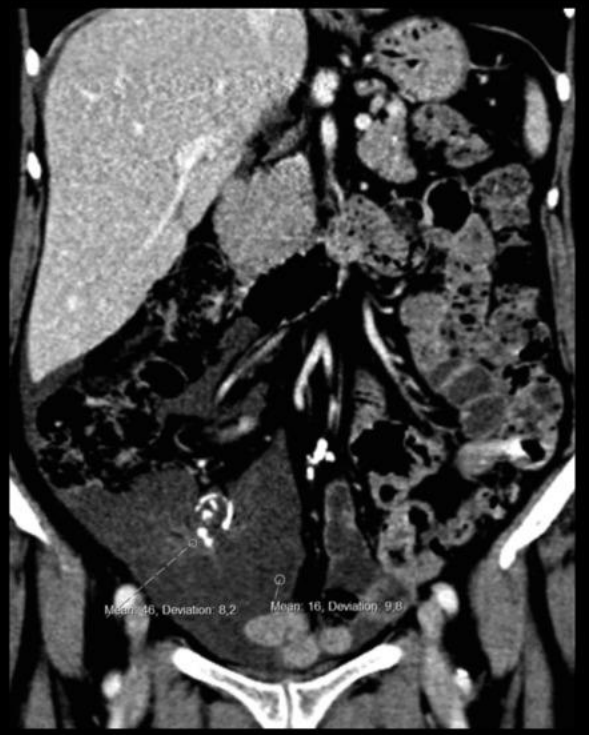


Fig. 39 and 40: Pseudomyxoma peritonei. There is loculated heterogenous ascitic fluid in the right lower quadrant with areas of gross calcification. These findings are suggestive of pseudomyxoma peritonei in this patient with a history of appendiceal mucinous adenocarcinoma.

References: Radiology Department, Centro Hospitalar São João, Faculdade de Medicina da Universidade do Porto – Porto/PT

Imaging Findings or Procedure Details

Differential Diagnosis

Pseudomyxoma Peritonei

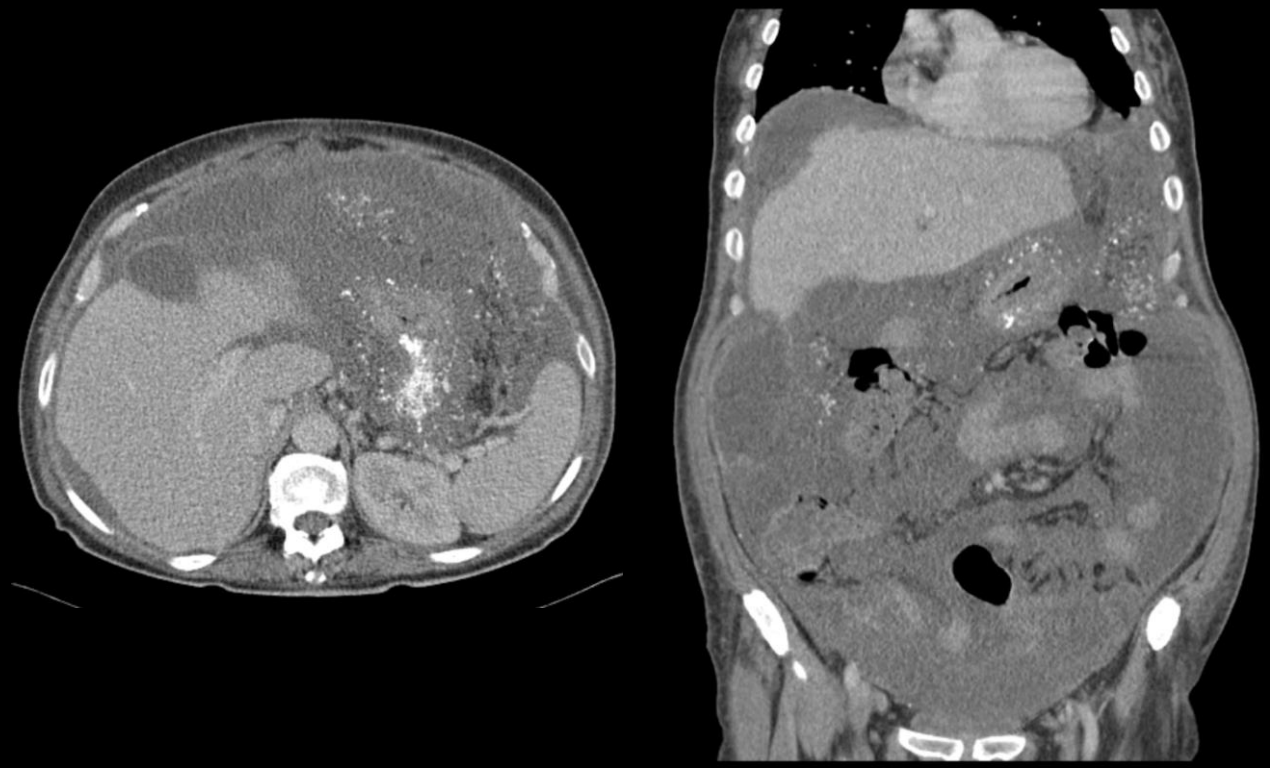


Fig. 41 and 42: Pseudomyxoma peritonei. Ascitis with punctiform calcifications in a case of mucinous gastric adenocarcinoma.

References: Radiology Department, Centro Hospitalar São João, Faculdade de Medicina da Universidade do Porto – Porto/PT

Imaging Findings or Procedure Details

Differential Diagnosis

Pseudomyxoma Peritonei

Correctly diagnosing pseudomyxoma peritonei is important, because these patients have prolonged survival if an aggressive surgical approach is taken:

- **surgical reduction of the tumour** aims to remove the maximum amount of mucinous masses and tumours by dissection; it is general restricted to a right hemicolectomy, partial resection of the greater omentum, and, for women, a hysterectomy with bilateral salpingo-oophorectomy. This ‘‘debulking’’ must be as thorough as possible, as this is an essential precondition for achieving longer-term survival.

- **cytoreduction surgery combined with HIPEC** with or with-out immediate postoperative intraperitoneal chemotherapy is recommended in the majority of centres, specialising in the therapeutic management.

Imaging Findings or Procedure Details

Differential Diagnosis

Peritoneal Mesothelioma

Mesothelioma is a rare primary tumour of the connective tissue that can originate in the serous membranes of the pleura, peritoneum, or pericardium.

Peritoneal involvement is reported in 25% of cases.

Peritoneal mesothelioma, as with other forms of mesothelioma, is encouraged by asbestos exposure.

There are three types of peritoneal mesotheliomas; malignant mesothelioma, well-differentiated mesothelioma, and multicystic mesothelioma.

Imaging Findings or Procedure Details

Differential Diagnosis

Peritoneal Mesothelioma - Malignant Mesothelioma

Most common form.

The tumor originates from the superficial layer of mesothelial cells in the peritoneum.

Risk factors include exposure of asbestos, therapeutic irradiation, and chronic peritoneal irritation.

The prognosis of this tumor mainly depends on cell morphology and spread pattern.

Better prognosis if epithelial cell morphology (vs sarcomatous or mixed types) and localized pattern.

Imaging Findings or Procedure Details

Differential Diagnosis

Peritoneal Mesothelioma - Malignant Mesothelioma

The imaging features of peritoneal malignant mesothelioma do not predict cell morphology.

The role of the radiologist is mainly to describe the pattern, the extent, as well as the complications of this tumor.

While a confirmed diagnosis is not generally established based on pathological assessment, there are, however, a certain number of features from clinical examination and other investigations that point to mesothelioma:

•occupational exposure to asbestos;

•the presence of pleural abnormalities, such as calcified plaques, that are suggestive of exposure to asbestos;

•the absence of a detectable primary tumour or secondary lesion of the liver or lymph nodes.

Imaging Findings or Procedure Details

Differential Diagnosis

Peritoneal Mesothelioma - Malignant Mesothelioma

Computed Tomography

- pleural plaques in individuals with asbestos exposure;
- abdominal viscera infiltration;
- peritoneal local thickening >1 cm, irregular thickening, or nodules of the peritoneum;
- caked thickening of the omentum.

Imaging Findings or Procedure Details

Differential Diagnosis

Peritoneal Mesothelioma - Malignant Mesothelioma

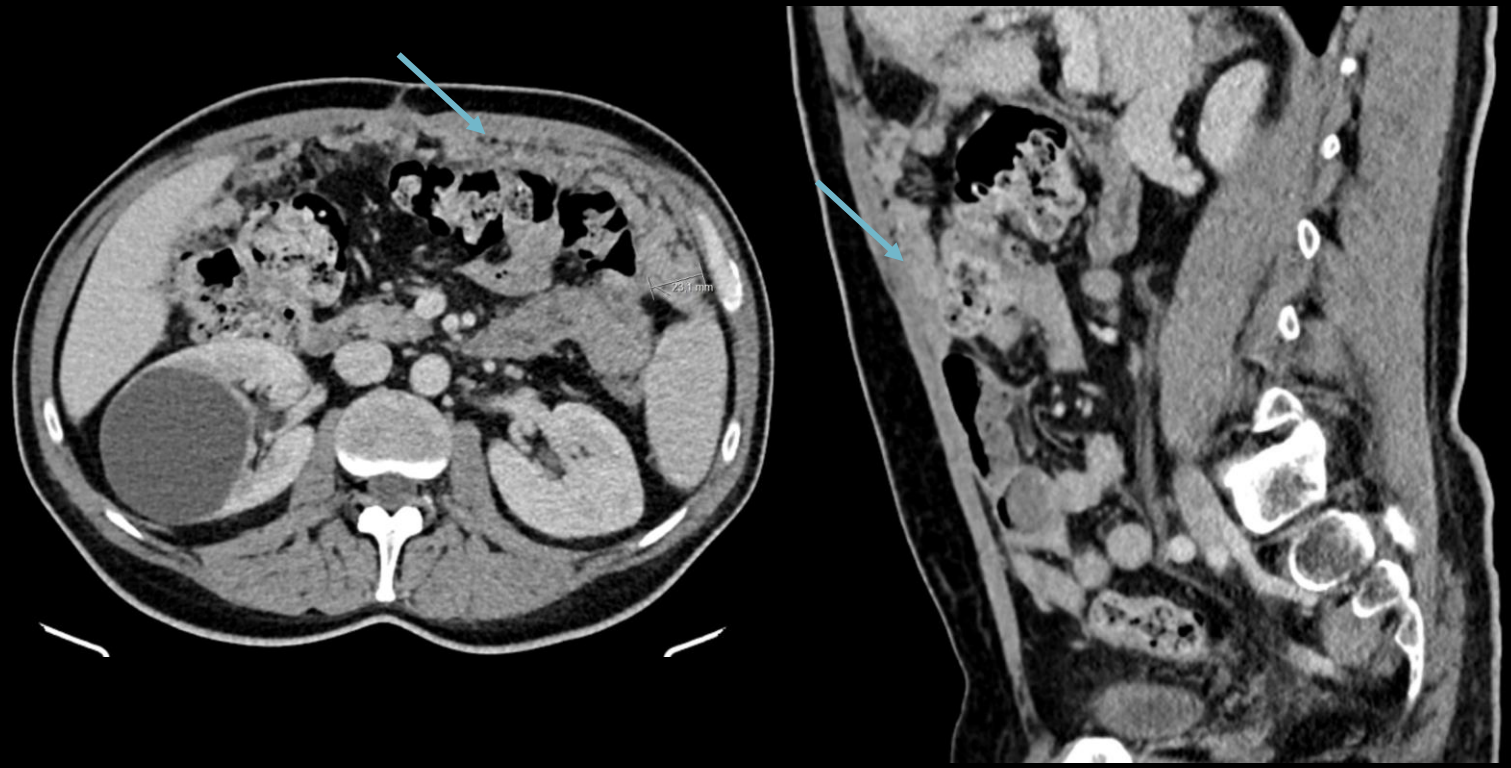


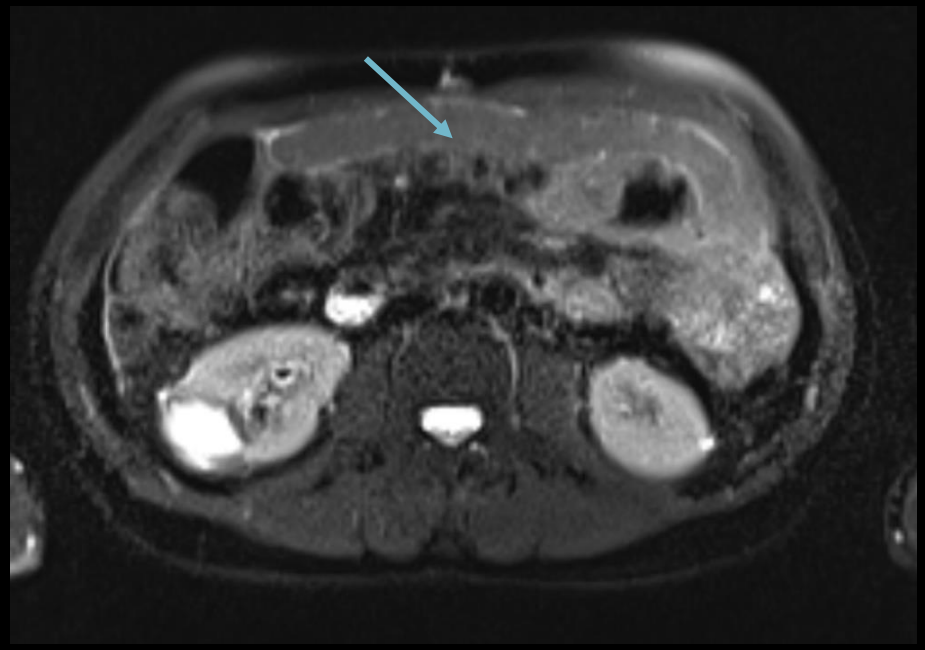
Fig. 43 and 44: Malignant Mesothelioma. Axial (left) and sagital (right) CT scans shows caked thickening of the omentum, with indistinguishable features from peritoneal carcinomatosis.
The presence of pleural calcified plaques (not shown) raised the suspicion, confirmed by biopsy, of malignant mesothelioma.

References: Radiology Department, Centro Hospitalar São João, Faculdade de Medicina da Universidade do Porto – Porto/PT

Imaging Findings or Procedure Details

Differential Diagnosis

Peritoneal Mesothelioma - Malignant Mesothelioma



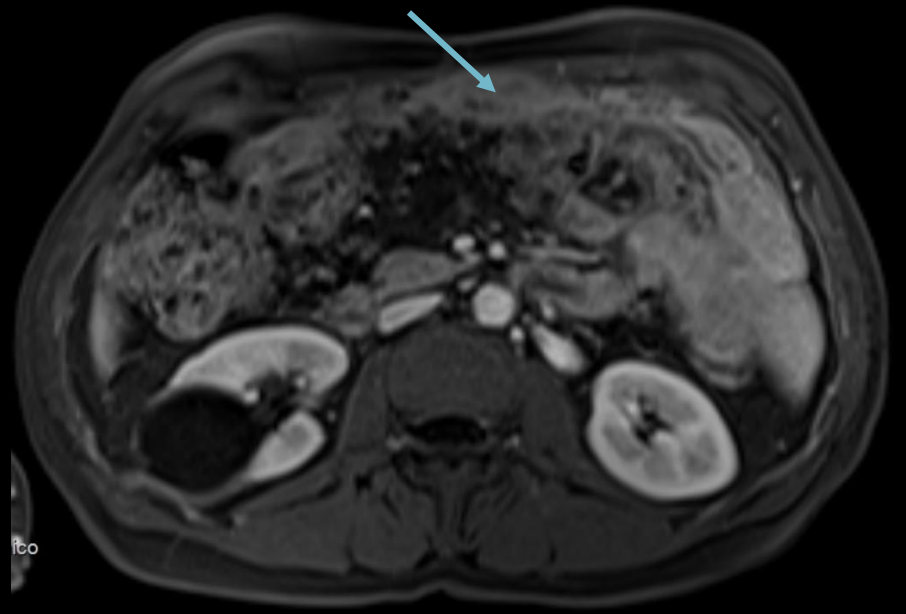


Fig. 45 and 46: Malignant Mesothelioma.
T2-weighted images (left) and T1-weighted images with contrast (right) CT scans shows caked thickening of the omentum, with indistinguishable features from peritoneal carcinomatosis.
The presence of pleural calcified plaques (not shown) raised the suspicion, confirmed by biopsy, of malignant mesothelioma.

References: Radiology Department, Centro Hospitalar São João, Faculdade de Medicina da Universidade do Porto – Porto/PT

Imaging Findings or Procedure Details

Differential Diagnosis

Peritoneal Mesothelioma – Other Forms

Well-differentiated peritoneal mesothelioma

Multicystic peritoneal mesothelioma

Peritoneal papillary serous carcinoma

Imaging Findings or Procedure Details

Differential Diagnosis

Peritoneal Lymphomatosis

Lymphoma, known to be a great mimicker, is a common haematological malignancy that can involve any part of the body.

However, diffuse infiltration of the peritoneum by lymphoma is rare.

The question of how lymphoma invades the peritoneum is controversial.

A current theory postulates that lymphoma spreads from bowel epithelium via ligaments and peritoneal folds. For example, it is believed that, gastric lymphoma reaches the omentum through the gastrocolic ligament and through the transverse mesocolon.

Diffuse large B-cell lymphoma and Burkitt's lymphoma are the most common subtypes associated with peritoneal lymphomatosis.

Imaging Findings or Procedure Details

Differential Diagnosis

Peritoneal Lymphomatosis

Primary peritoneal lymphoma without visceral involvement is known as body cavity lymphoma or primary effusion lymphoma.

It is seen almost exclusively in patients with human immunodeficiency virus (HIV).

In contrast to peritoneal carcinomatosis, peritoneal lymphomatosis can be cured with no surgical intervention.

Imaging Findings or Procedure Details

Differential Diagnosis

Peritoneal Lymphomatosis

The imaging features of peritoneal lymphomatosis that are highly indistinguishable from peritoneal carcinomatosis include omental caking as well as peritoneal and mesenteric soft tissue nodularity and enhancement, with or without ascites.

Other signs that allow this diagnosis to be proposed:

- **frequent lymph node involvement**, associating preaortic and retroperitoneal lymphadenopathy. It appears as confluent masses encasing the mesenteric vasculature, producing the ‘‘sandwich.
These masses are bulky, soft, non-obstructing, homogeneous without significant necrosis, and they seem to be less vascularised than carcinomatosis.

- **splenomegaly**, although this is not always present.

- **the presence of tumours in the gastrointestinal tract**, especially the stomach and the terminal ileum.

Imaging Findings or Procedure Details

Differential Diagnosis

Tuberculous Peritonitis

Peritoneal tuberculosis accounts for 1 - 3% of cases, making it the sixth most common extra-pulmonary site of tuberculosis.

Many theories explain how Mycobacterium tuberculosis spreads to the peritoneum.
Most common theory: peritoneal tuberculosis arises from reactivation of previously established latent foci.
Other theories believe in hematogenous spread from remote or near primary sites and/or spilling from involved mesenteric lymph nodes.

Peritoneal tuberculosis can be a difficult and elusive diagnosis to make and may mimic metastases from ovarian cancer and other nontuberculous granulomatous diseases because of the vague symptoms and nonspecific radiographic, pathologic, and laboratory findings.

Imaging Findings or Procedure Details

Differential Diagnosis

Tuberculous Peritonitis

Signs that may point to tuberculous peritonitis:

- Presence of mesenteric macronodules;
- Enhancement and regular thickening of the parietal peritoneum being identified;
- Splenomegaly and calcifications of the spleen;
- Associated involvement of the ileocecal wall;
- Retroperitoneal and peri-pancreatic lymphadenopathy with a hypodense centre and ring-enhancement.

Compared to that seen in peritoneal carcinomatosis, peritoneal thickening is smoother and more regular in tuberculosis.

There are three forms of peritoneal tuberculosis:

- **"wet" type**: abundant ascites and increased density (20—45 HU) due to a high concentration of proteinand cells;
- **"fixed fibrotic" type**: peritoneal masses adhering to the adjacent structures of the digestive system and sometimes with loculated ascites;
- **"dry" or "plastic" type**: is less common and causes a fibrous reaction in the peritoneum.

Imaging Findings or Procedure Details

Differential Diagnosis

Tuberculous Peritonitis

Fig. 47: Tuberculous Peritonitis.
Axial CT scans from a 47 years old male patient with a known lung cancer. There is a heterogenous mass adhering to the mesentery.
Biopsy confirmed tuberculous peritonitis (“fixed fibrotic type”).

References: Radiology Department, Centro Hospitalar São João, Faculdade de Medicina da Universidade do Porto – Porto/PT

Imaging Findings or Procedure Details

Differential Diagnosis

Diffuse peritoneal leiomyomatosis

Rare and benign disorder of unknown origin that is characterised by the presence of myoma nodules in the peritoneum that have similar histologic features to those of uterine leiomyomas (smooth muscle fibres).

Incidence is the highest in women of reproductive age.

Risk factors include high estrogen levels, uterine leiomyoma, and prior hysterectomy or myomectomy.

Although principally located in the pelvic peritoneum and greater omentum, they can also be found in the uterus, ovaries, and on the visceral side of the intestinal peri-toneum.

Nodules are less common in the superior areas of the peritoneum.

Imaging Findings or Procedure Details

Differential Diagnosis

Diffuse peritoneal leiomyomatosis

Computed Tomography

Multiple diffuse peritoneal nodule, associated with a pelvic soft-tissue mass with multiple lobules that displaces the pelvic organs.

The tumour shows delayed enhancement.
There is no associated lymphadenopathy or gas
tric wall thickening.

The absence of ascites and hepatic metastasis points diagnosis away from peritoneal carcinomatosis.

Generally has a good prognosis, with nodules regressing once oral contraceptives are discontinued.

Imaging Findings or Procedure Details

Differential Diagnosis

Diffuse peritoneal leiomyomatosis

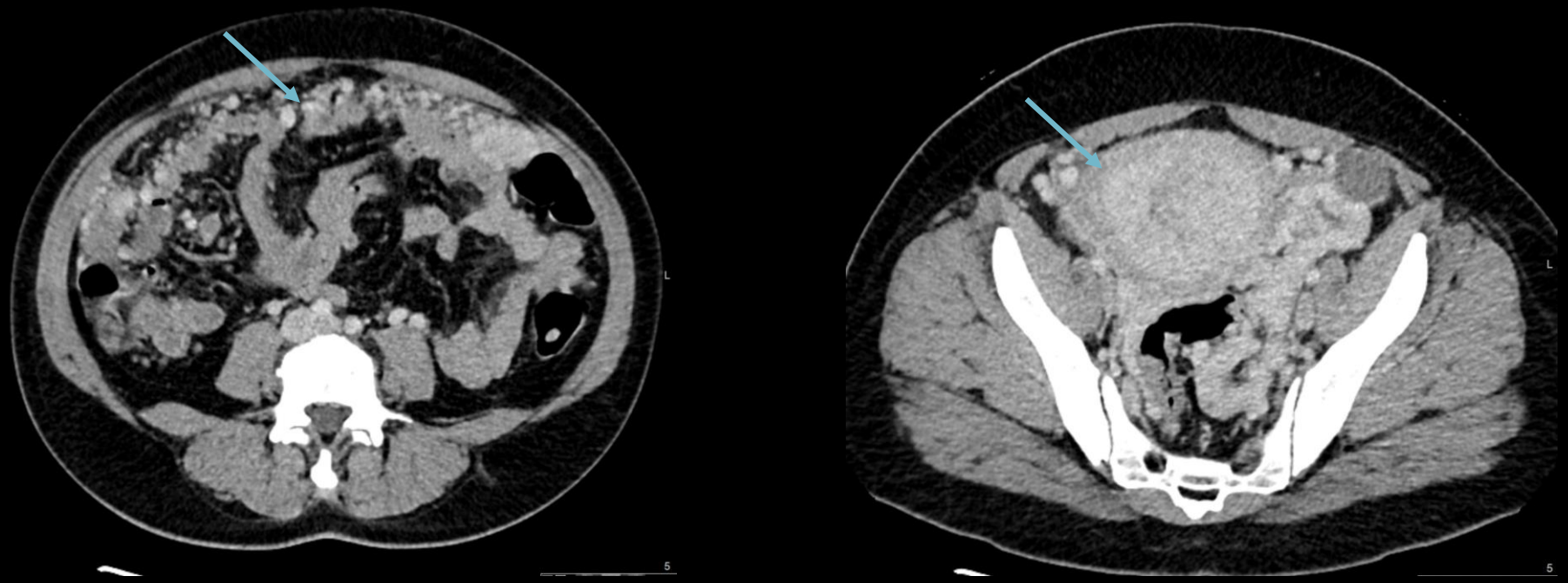


Fig. 49 and 50: Diffuse peritoneal leiomyomatosis.
Axial CT scans from a 46 years old female patient with known diffuse peritoneal leiomyomatosis. Note some nodule implants on mesentery and marked enlarged uterus.

References: Radiology Department, Centro Hospitalar São João, Faculdade de Medicina da Universidade do Porto – Porto/PT

Imaging Findings or Procedure Details

Differential Diagnosis

Peritoneal Sarcomatosis

Peritoneal sarcomatosis is the rare spread of sarcoma to the peritoneum.

The imaging characteristics vary depending on the sarcoma type, but in general, there is minimal or no ascites.

GIST Sarcomatosis

Multiple, hypervascular, heterogeneous, necrotic lesions with almost no ascites.
Ascites may be seen during therapy with tyrosine kinase inhibitors.
Complications of GIST sarcomatosis include gastrointestinal hemorrhage, hemoperitoneum, and fistulization.

Leiomyosarcoma

Bulky masses or peritoneal thickening.
The large masses usually heterogeneously enhance and may demonstrate calcifications.

Peritoneal implants from sarcomas are more often spherical and deforming, often vascular, and associated with minimal ascites, whereas carcinomatosis implants tend to be flat or ovoid and conform to the adjacent structures.

Imaging Findings or Procedure Details

Differential Diagnosis

Splenosis Implants

Implants of splenosis can mimic tumour implants in the peritoneum, but an assessment of the context looking above all at whether there is a history of splenectomy will allow the correct diagnosis to be made.

Often asymptomatic, diagnosis will usually be made incidentally and should not lead to aggressive management.

Imaging features follow what is expected for normal spleen parenchyma.

A technetium-99 m red blood cell scintigraphy will also allow the diagnosis of splenosis to be confirmed.

Conclusions

Invasive peritoneal disease includes more than just peritoneal carcinomatosis, and the radiologist should be aware of the main differential diagnosis to ensure a proper patient management.

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