CT and MRI role in the differential diagnosis of benign and malignant peritoneal mass

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Learning objectives

The purpose of this exhibit is to review the pathophysiology and CT and MRI characteristics of various peritoneal tumors.

Background

The imaging patterns of diffuse peritoneal disease are often nonspecific because primary malignant, secondary malignant, and benign processes commonly result in a similar spectrum of changes.

Secondary tumors of the peritoneum can be classified into three broad categories: metastatic neoplasms, infectious/inflammatory lesions, and miscellaneous tumors and tumorlike lesions (Figure 1). Metastatic disease, especially from carcinomas of gastrointestinal tract and ovary, is the most common malignant process in the peritoneal cavity. In most patients, the suspicious of metastatic disease is obvious because there is evidence of a primary site of origin. However, it may be necessary to distinguish metastatic disease from primary peritoneal malignancies such as malignant mesothelioma or primary peritoneal carcinoma.

Peritoneal tumors display varied CT and MRI presentation depending on the primary etiology of the tumor and treatment received. It is crucial to acknowledge its particular characteristics since they have different prognosis and treatment.

Images for this section:
Fig. 1: List of the most common etiologies of peritoneal masses including primary tumors, secondary tumors and infectious/inflammatory tumorlike lesions. Adapted from Levy et. al. RadioGraphics, 2009.

Findings and procedure details

This exhibit will describe various peritoneal tumors and demonstrate the characteristic CT and MRI appearances of peritoneal tumors using images from patients referred to our institution with histological confirmation.

Introduction

The peritoneum is a thin, translucent serosal membrane of mesodermal origin that covers the surface of the peritoneal cavity and its mesenteries. The peritoneum partially or completely covers the visceral organs contained within the peritoneal cavity.

When peritoneal masses are discovered, the principal diagnostic concern is metastatic disease, which is the most frequently encountered neoplastic process that involves the peritoneal cavity. However, primary peritoneal tumors should be included in the differential diagnosis, particularly when there is no evidence of a visceral primary malignancy.

Neoplastic processes of the peritoneal cavity can disseminate throughout this space with relative ease. Neoplastic cells are typically dispersed by the normal circulation of peritoneal fluid, which is driven by a combination of gravity and diaphragmatic pressure gradients. These hydrostatic forces result in a number of characteristic locations of intraperitoneal seeding including the dome of the liver, the concave surfaces of the anterior abdominal wall, the omentum, and the dependent portions of the pelvis. Neoplastic cells also have a propensity to collect at peritoneal reflections such as the small-bowel mesentery and transverse mesocolon, owing to the relative stasis of fluid in these areas created during normal respiratory motion.

Primary tumors of the peritoneum are a rare and often confusing group of benign and malignant tumors that affect diverse patient populations.

Imaging Technique

MDCT imaging is approximately 90% sensitive in the detection of peritoneal neoplastic lesions greater than 5 mm in diameter. However, the sensitivity of MDCT dramatically decreases for lesions of less than 5 mm in diameter.

MRI with diffusion-weighted imaging and contrast-enhanced sequences significantly improves the detection of peritoneal neoplastic lesions when compared with standard MRI sequences alone. Peritoneal malignant disease often shows moderate to marked diffusion restriction, thereby creating a high lesion-to-background signal ratio, allowing
sufficient detection of deposits larger than 5 mm. Diffusion is restricted in peritoneal malignant deposits with a high cellular density; therefore, sensitivity may be reduced in necrotic or fibrotic lesions or neoplasms with inherently low cellularity such as mucinous adenocarcinomas of the ovary or gastrointestinal tract.

PERITONEAL MASSES

1. Primary Peritoneal Neoplasms

Primary neoplasms of the peritoneum occur much less frequently than do secondary metastases from a known or even occult primary tumor.

Primary malignant mesothelioma, multicystic mesothelioma, primary peritoneal serous carcinoma, leiomyomatosis peritonealis disseminata, and desmoplastic small round cell tumor are the most prominent of these rare lesions.

**Malignant Peritoneal Mesothelioma**

Malignant mesothelioma is an aggressive neoplasm that arises in the serosal membranes of the pleura, peritoneum, pericardium, or tunica vaginalis of the testis. The majority of malignant mesotheliomas originate in the pleura. Ten to fifteen percent of malignant mesotheliomas arise in the peritoneum.

Similar to pleura-based disease, asbestos exposure is the primary cause of malignant peritoneal mesothelioma. Calcified peritoneal plaques are rarely observed, but when they are, thoracic CT should be performed for those patients, and images should be scrutinized for signs of asbestos exposure.

The imaging features of malignant peritoneal mesothelioma can be divided into two discrete patterns: diffuse involvement of the peritoneal cavity; or localized intraperitoneal masses. Classifying malignant mesotheliomas into diffuse and localized subtypes has prognostic significance. Diffuse malignant mesotheliomas are highly aggressive; in contrast, patients with localized malignant mesotheliomas usually have a good prognosis following complete surgical excision of the lesions.

The diffuse pattern is characterized by tumor infiltrating and thickening the peritoneum in a sheetlike fashion. Consequently, there is irregular and nodular thickening of the peritoneum. The focal pattern is characterized by dominant, moderate to large-sized intraperitoneal masses with associated peritoneal studding (**figure 2**). In addition to the primary tumor, omental caking and ascites are usually present. Omental caking may manifest as fine, nodular, soft-tissue studding or coalescent, masslike soft tissue within
the omentum. The amount of ascites associated with diffuse malignant mesothelioma is quite variable, ranging from massive, diffuse ascites to focal, small, loculated collections of fluid. Malignant mesothelioma may infiltrate the small bowel mesentery, thickening the leaves of the mesentery and producing a pleated or stellate appearance on cross-sectional images.

Calcification within diffuse peritoneal malignant mesothelioma is considered rare.

Localized peritoneal malignant mesothelioma appears as a heterogeneous, solid intraperitoneal mass on cross-sectional images. The margins are often irregular. Localized, loculated ascitic fluid may be present, but manifestations of diffuse peritoneal involvement, such as generalized ascites, omental caking, and peritoneal nodularity, do not typically occur.

Evidence of nodal and distal metastases in malignant peritoneal mesothelioma is rare, but local invasion is seen more frequently into adjacent structures such as the abdominal wall, liver, and other intraperitoneal organs. Therefore, the presence of lymph node enlargement in a patient with diffuse peritoneal disease suggests another etiology, such as diffuse peritoneal carcinomatosis or tuberculous peritonitis.

Few case reports in the medical literature describe the MR imaging signal intensity of malignant mesothelioma as intermediate to low on T1-weighted images and intermediate to high on T2-weighted images.

**Multicyastic Mesothelioma**

Multicyastic mesothelioma has many alternative names, including peritoneal inclusion cyst, multilocular inclusion cyst, and benign multicyastic mesothelioma.

Multicyastic mesothelioma is a rare intermediate-grade primary neoplasm of the peritoneum that more commonly arises in women than men and has a distinct radiologic and histologic appearance. It is a multilocular cystic mass that arises from the pelvic peritoneal surfaces.

CT typically reveals a well-defined, fluid-attenuation multicyastic mass, most commonly arising from the pelvic surfaces of the peritoneum, with enhancing but noncalcified septa. Multicyastic mesotheliomas usually measure greater than 10 cm at presentation and may often surround the ovaries, thereby mimicking cystic ovarian neoplasms such as cystadenoma, cystadenocarcinoma, and cystic teratoma. Multicyastic mesothelioma may even completely surround the ovaries such that the ovaries appear entrapped within the cystic lesion.

MRI is useful in the assessment of cystic lesions of the peritoneum, and chemical-shift sequences may exclude the presence of lipid-containing chylous fluid, allowing
differentiation of multicystic mesothelioma from mesenteric or pelvic lymphangiomas. The cysts in multicystic mesothelioma generally have homogeneous fluid signal intensity that is hypointense on T1-weighted images and hyperintense on T2-weighted images. The septations enhance with intravenous administration of gadolinium based contrast material.

Well-Differentiated Papillary Mesothelioma

Well-differentiated papillary mesothelioma is a rare and indolent subtype of peritoneal mesothelioma that occurs exclusively in women of a wide age range without a history of asbestos exposure. The imaging appearances of well-differentiated papillary mesothelioma is limited to a few case reports in the medical literature. The tumors are typically cured with complete surgical resection or follow an indolent course with long survival.

Primary Peritoneal Serous Carcinoma

Primary peritoneal serous carcinoma (primary peritoneal carcinoma or extraovarian pelvic serous carcinoma) occurs almost exclusively in women. It is derived from extraovarian mesothelium and histologically is identical to ovarian serous carcinoma and can be indistinguishable from metastatic ovarian carcinoma at imaging studies.

Ascites, peritoneal nodules and thickening, and omental nodules and masses are the most common cross-sectional imaging features of primary peritoneal serous carcinoma (figure 3).

Liposarcoma

The liposarcoma is a very frequent tumor of the retroperitoneum and relatively rare in the mesenterium and the peritoneum.

Both the CT scan and the MRI show a soft tissue mass with an adipose component in 40% of the cases. Finding an atypical lipoma may assist in making a differential diagnosis: an adipose mass with additional characteristics including irregular septa or solid nodes inside (figure 4).

Desmoid type fibromatosis

Fibromatosis is a rare mesenchymal tumor characterized histologically by proliferation of fibroblasts and myofibroblasts with marked production of intercellular collagen. It
comprises a broad group of fibrous tissue proliferations of similar histologic appearance that has biologic behavior intermediate between that of benign fibrous lesions and fibrosarcoma. Occurring in almost any anatomic location, it can be divided into superficial and deep subtypes. The deep group consists of rapidly growing lesions that often reach a large size and have a high tendency to recur after treatment, hence the term "aggressive fibromatosis."

CT of desmoid type fibromatosis reveals a soft-tissue mass of variable attenuation (**figure 5**). These lesions most frequently are similar in attenuation to that of skeletal muscle.

Desmoid type fibromatosis tumors have been described as having three stages of histologic evolution over time as they mature (**figure 6,7**).

- In the first stage, lesions are more cellular with large extracellular spaces (which appear as decreased T1 and increased T2 MR signal intensity) and have relatively decreased collagen content.
- In the second stage, there is an increase in the amount of collagen deposition (which increases the heterogeneity of T2 signal) in the central and peripheral areas of the tumor.
- In the final stage there is an increase in the fibrous composition (which decreases the T1 and T2 MR signal intensity), with a decrease in cellularity and decrease in the volume of the extracellular spaces and water content. In addition, the higher signal intensity on T2-weighted MR images may be related to myxoid components.

**Solitary Fibrous Tumor**

Solitary fibrous tumors are submesothelial tumors of uncertain origin that most commonly arise in the pleura.

At imaging, solitary fibrous tumor of the peritoneum appears as hypervascular mass with intratumoral cystic changes, necrosis or haemorrhage (**figure 8**). MR imaging include heterogeneous low signal intensity with flow voids on T2-weighted images, representing fibrosis or collagen. Areas of central necrosis are generally seen in large malignant tumors.

**Leiomyomatosis peritonealis disseminata**

It is a rare, benign proliferative process that occurs exclusively in women and is characterized by multiple smooth muscle nodules throughout the peritoneum. Leiomyomatosis peritonealis disseminata is usually discovered incidentally during surgery or imaging examinations of women of childbearing age who have uterine leiomyomas.
Cross-sectional imaging studies show numerous well-circumscribed solid masses in the peritoneal cavity that vary in size. The masses are often heterogeneous in CT attenuation and enhance similar to uterine leiomyomas. At MR imaging, the masses are isointense relative to muscle in T1-weighted sequences, heterogeneously enhance following intravenous administration of gadolinium, and are low signal intensity with T2-weighted sequences.

**Desmoplastic small round cell tumor**

It is a rare and highly aggressive malignancy of unknown origin that occurs most often in the peritoneal cavity of young men.

2. **Secondary Peritoneal Neoplasia**

It has long been established that diffuse or focal peritoneal disease is statistically much more likely to represent secondary involvement from a known or even an occult primary neoplasm. Secondary disease may result from direct invasion and intraperitoneal seeding via the circulation of peritoneal fluid or from hematogenous metastases.

Primary ovarian, colonic, and gastric carcinomas metastasize by direct invasion and peritoneal seeding, whereas hematogenous metastases to the peritoneum are typically caused by malignant melanoma and lung and breast carcinomas.

Diffuse peritoneal lymphomatosis and sarcomatosis are also recognized.

In the absence of detection of a primary lesion, imaging features of secondary peritoneal malignancy are entirely nonspecific, and histologic confirmation will ultimately be required in the majority of cases.

**Peritoneal Carcinomatosis**

The term peritoneal carcinomatosis refers to the presence of soft-tissue implants over the peritoneal surface (omentum cake). These implants originate in a primary tumor; usually breast, stomach, colorectal, pancreatic or ovarian cancer.

The diagnostic images may also show evidence of thickened lymph nodes of the peritoneum and peritoneal enhancement most often associated with loculated ascites.

Because ascites is a common finding in peritoneal carcinomatosis, the discovery of new-onset ascites should lead to a careful search for findings that would indicate a malignant etiology. In a patient with a known primary malignancy who lacks ascites, careful inspection of the anatomic regions of peritoneal cavity where stasis of peritoneal
fluid occurs is important during staging CT because peritoneal tumors can be subtle and difficult to identify, especially when ascites is not present. The pouch of Douglas or retrovesical space, ileocecal region, paracolic gutters, subhepatic space, right subdiaphragmatic space, and root of the small bowel mesentery are important sites of occult tumor.

The imaging findings of peritoneal carcinomatosis vary from multifocal discrete nodules to infiltrative masses (figure 9, 10, 11, 12, 13). Small bowel obstruction is the most common complication of peritoneal carcinomatosis and may be secondary to diffusely infiltrating tumor or focal tumor masses.

**Lymphomatosis**

Lymphomas may involve the peritoneal surfaces as a primary or secondary process. Nodal or extranodal non-Hodgkin lymphomas, such as small B-cell lymphoma, diffuse large B-cell lymphoma, and Burkitt lymphoma, may have a secondary peritoneal involvement.

Primary lymphomas of the peritoneum are uncommon and nearly exclusively found in immunocompromised patients.

Peritoneal lymphomatosis secondary to a preexisting lymphoma is characterized by diffusely thickened peritoneal surfaces with multifocal nodules and masses that mimic peritoneal carcinomatosis.

Other CT features include ascites, peritoneal enhancement and thickening, omental caking, infiltration of the small bowel mesentery, and fine nodularity in the mesenteric and omental fat (figure 14).

The presence of extensive adenopathy in lymph node chains typically involved with lymphoma suggest lymphomatosis over carcinomatosis.

In contrast, the most common imaging manifestation of primary lymphoma of the peritoneum is malignant ascites without associated lymphadenopathy, reason why it is also denominated primary effusion lymphoma.

**Pseudomyxoma Peritonei**

Pseudomyxoma peritonei is a clinical syndrome characterized by the presence of often large volumes of gelatinous ascites produced by a low-grade primary mucinous adenocarcinoma of the appendix, resulting in distinct imaging changes. Pseudomyxoma peritonei is regarded as a separate entity from disseminated mucinous carcinomatosis (which results from invasive, high-grade adenocarcinomas of the ovary or colon).
On CT, the mucinous ascites has a characteristic low attenuation and typically exerts mass effect on adjacent structures, leading to scalloping of the solid viscera (mainly the liver), displacement of hollow viscera, and formation of septations (figure 15, 16, 17, 18). On MRI, mucin has an intermediate-to-high signal intensity on T1-weighted images and a high signal intensity on T2-weighted images, thereby allowing the radiologist to distinguish it from simple fluid.

3. Infectious and Inflammatory Conditions of the Mesentery and the Peritoneum

Although not the primary focus of this exhibit, a number of inflammatory and infectious conditions involving the peritoneal cavity may result in identical imaging changes as seen with neoplastic lesions.

**Granulomatous peritonitis**

The term granulomatous peritonitis encompasses a wide range of unusual forms of peritoneal inflammation and infection that have overlapping clinical, pathologic, and imaging features.

Tuberculous peritonitis may be a complication of the early bacillemia that accompanies silent pulmonary tuberculosis, when regional lymph nodes fail as a barrier to mycobacterial infection, but can also arise secondary to locally advanced ileocecal or miliary tuberculosis.

Imaging findings suggestive of mycobacterial infection include enlarged lymph nodes with necrotic centers and rim enhancement after IV contrast administration or calcified lymph nodes, thickening of the terminal ileum and cecum, or microabsceses in the liver or spleen in the setting of diffuse peritoneal disease.

Classically, tuberculous peritonitis has been described as having three imaging patterns (wet, fibrotic fixed, and dry plastic); the pattern depends on the relative amount of ascites and soft-tissue component. The absence of ascites results in the dry plastic or fibrotic fixed patterns, which have peritoneal and omental nodules and masses and fibrotic fixation of the small bowel as the predominant features. Ascites in the wet form may be diffuse or loculated. Ninety percent of patients with tuberculous peritonitis will have ascites.

Pathogens such as *histoplasma* or *Pneumocystis* should be considered in immunocompromised patients. Other causes of granulomatous peritonitis include foreign-body reactions to barium, talc, bile, or ruptured ovarian cysts and, rarely, sarcoidosis, Crohn disease, and Whipple disease.
Sclerosing Encapsulating Peritonitis

Sclerosing encapsulating peritonitis is a rare chronic inflammatory disorder of the peritoneum that occurs most commonly in patients who undergo continuous ambulatory peritoneal dialysis. The peritoneum becomes dense, opaque, and thick in sclerosing encapsulating peritonitis. CT reveals a diffusely thickened peritoneum and ascites; small bowel may be tethered or matted within loculated fluid collections. Multiple foci of linear calcification may develop as the disease progresses.

Images for this section:

Table 1
Classification of Primary Tumors of the Peritoneum

<table>
<thead>
<tr>
<th>Mesothelial tumors</th>
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<tr>
<td>Peritoneal malignant mesothelioma</td>
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<tr>
<td>Well-differentiated papillary mesothelioma</td>
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<tr>
<td>Multicystic mesothelioma</td>
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<tr>
<td>Adenomatoid tumor</td>
</tr>
<tr>
<td>Epithelial tumors</td>
</tr>
<tr>
<td>Primary peritoneal serous carcinoma</td>
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<tr>
<td>Primary peritoneal serous borderline tumor</td>
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<tr>
<td>Smooth muscle tumor</td>
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<tr>
<td>Leiomyomatosis peritonealis disseminata</td>
</tr>
<tr>
<td>Tumors of uncertain origin</td>
</tr>
<tr>
<td>Desmoplastic small round cell tumor</td>
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<tr>
<td>Solitary fibrous tumor</td>
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Table 2
Classification of Secondary Tumors and Tumorlike Lesions of the Peritoneum

| Metastatic neoplasms |
| Carcinomatosis |
| Pseudomyxoma peritonei |
| Lymphomatosis |
| Infectious and postinfectious lesions |
| Tuberculous peritonitis |
| Disseminated histoplasmosis |
| Inflammatory pseudotumor |
| Miscellaneous |
| Endometriosis |
| Glialomas peritonei |
| Osceous metaplasia |
| Cartilagenous metaplasia |
| Melanos |
| Splenosis |
Fig. 1: List of the most common etiologies of peritoneal masses including primary tumors, secondary tumors and infectious/inflammatory tumorlike lesions. Adapted from Levy et al. RadioGraphics, 2009.


Fig. 17: 56-year-old woman with previous mucocoele of appendix. CT axial images obtained 2 years after resection show a fairly lobular mucinous peritoneal mass displacing small bowel loops and the aorta. No contrast material was given due to chronic kidney injury. Note the calcified foci (arrows).

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Fig. 15: Typical pseudomyxoma peritonei in a 44-year-old man who complained of abdominal distention. Contrast-enhanced CT images showing mucinous material
infiltrating the omentum, nodular thickening of the lesser omentum and mucinous ascites that scallops the margin of the liver (small arrow) and the spleen (big arrow).

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**Fig. 13: Peritoneal carcinomatosis mimicking a pseudomyxoma peritonei.** CT images of a 75 years-old patient with gastric adenocarcinoma showing marked thickening of the gastric wall with several peritoneal nodular lesions (arrows) and large implants on the hepatic capsule (scalloping-like) mimicking a pseudomyxoma peritonei.

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Fig. 18: Pseudomyxoma peritonei secondary to a mucinous adenocarcinoma of the appendix mimicking a multicystic mesothelioma. Contrast-enhanced CT scan show low-attenuation mucinous ascites that scallops the margins of the liver (horizontal arrow), spleen (vertical small arrow), displacing small bowel and pancreas. The greater omentum (curved arrow) has increased attenuation from omental infiltration or fibrosis. Note the large pseudonodular presentation of the mucinous ascites (vertical large arrow) mimicking a multicystic mesothelioma.

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Fig. 16: Large pseudomyxoma peritonei. Axial CT images showing a large mucinous ascites scalloping the liver, the spleen, infiltrating the falciform ligament and the omentum.

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Fig. 2: Focal pattern malignant peritoneal mesothelioma. Axial contrast-enhanced CT image showing a dominant, moderate sized intraperitoneal mass (arrow) with associated peritoneal studding and slightly omental soft-tissue thickening. There is moderate volume of ascites consistent with "wet" form of disease.

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Fig. 9: Peritoneal carcinomatosis from adenocarcinoma of the colon in a 46-year-old woman. Contrast material-enhanced CT image show moderate amount of ascites and nodular enhancing soft-tissue thickening of the greater omentum.

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**Fig. 7:** Desmoid type fibromatosis. Axial MR images showing a homogeneous well-defined ovoid mass in the peritoneal cavity. It presents low signal intensity on T2-weighted images and slightly contrast enhancement due to intermediate phase of maturation.

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**Fig. 6:** Desmoid type fibromatosis. Axial MR images showing a homogeneous well-defined ovoid mass anterior to the spleen. It presents low signal intensity on T2-weighted images due low cellularity (mature phase).

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Fig. 5: Deep fibromatosis of the peritoneum (desmoid type). Axial contrast-enhanced CT image of abdomen shows an intra-abdominal large, slightly heterogeneous, hypodense
soft-tissue. The mass was fully resected confirming diagnosis of a intraabdominal fibromatosis. No recurrence was seen to date.

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**Fig. 11:** Peritoneal metastasis in a patient with a neuroendocrine tumor of the terminal ileum. PET-CT showing 18F-FDG uptake in a well-defined nodular peritoneal lesion.

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**Fig. 14:** Lymphomatosis. Axial (a) and coronal (b) CT images showing several peritoneal well-defined nodules. The presence of extensive adenopathy in lymph node chains typically involved with lymphoma is highly suggestive of lymphomatosis.

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**Fig. 12:** Peritoneal implants. Axial CT images showing two lobular peritoneal implants in the small bowel mesentery (vertical arrows). There is a thick walled enteric loop
(horizontal arrow) due to non-Hodgkin lymphoma (mantle-cell lymphoma). Note how the loop is not stenotic although the striking thick wall (typical of lymphoma).

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**Fig. 8:** Solitary fibrous tumor of the peritoneum. Axial (a) and coronal (b) contrast material-enhanced CT scan shows a well-defined enhancing mass in the pelvis with internal nonenhancing areas of necrosis (arrows). It was resected confirming diagnosis of a solitary fibrous tumor.

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**Fig. 3:** Primary peritoneal serous carcinoma in a 73 years-old woman. Axial CT images showing two lobular enhancing peritoneal nodules (arrows). No ascites is seen. They were biopsy proven to be peritoneal serous carcinoma nodules.

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Fig. 4: Peritoneal liposarcoma. Axial CT image shows a large well-defined heterogeneous low attenuation mass (with areas of negative attenuation) in the left peritoneal cavity. Surgical resection proved to be a dedifferentiated liposarcoma.

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Fig. 10: Peritoneal carcinomatosis. Axial CT images showing micronodular thickening of the great omentum (vertical arrows) and left mesentery (horizontal arrow) due to gastric carcinoma peritoneal spreading.

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Conclusion

Knowledge of the CT and MRI characteristics of various peritoneal tumors will allow a more accurate diagnosis and provide valuable information for prognosis and treatment planning. For instance, at MRI pseudomyxoma secondary to an appendiceal cancer is hyperintense on T2, restricts diffusion, and shows faint delayed enhancement, whereas primary peritoneum mesothelioma is hypointense on T2, restricts diffusion, and demonstrates avid contrast enhancement.

Secondary peritoneal tumors and tumorlike lesions are indeed more common than primary peritoneal tumors. Metastatic disease should be the initial concern in a patient with ascites, omental nodularity and peritoneal masses at imaging. Careful review of the patient's clinical history and imaging studies for a primary neoplasm may help establish the diagnosis.

Infectious conditions such as disseminated tuberculosis or histoplasmosis should be considered if the clinical history is appropriate or if supportive findings are present.

Percutaneous imaging-guided biopsy of peritoneal masses is often required and is a safe and effective procedure that may be of benefit even in patients with a known primary malignancy.

Personal information

References


