IMAGING EVALUATION OF PRIMARY AND SECONDARY PERITONEAL MALIGNANCIES

EVALUACIÓN POR IMÁGENES DE LAS NEOPLASIAS PERITONEALES PRIMARIAS Y SECUNDARIAS

Catalina Wilches, MD1
Oscar M. Rivero, MD2
Diego A. Aguirre, MD2

SUMMARY

This article is a review of the normal peritoneal anatomy as seen on different cross sectional imaging modalities. The definitions and demographic and imaging characteristics of primary and secondary malignancies involving the peritoneum are discussed for the appropriate assessment of patients with suspected peritoneal pathology.

Introduction

The purpose of this article is to review the basic anatomy of the peritoneum using cross section diagnostic images and its pathological implications, in addition to describing the most frequent peritoneal malignancies.

Just as in other anatomical locations, neoplastic peritoneal processes are divided into: primary (these occur rarely) and secondary. The peritoneum is a usual route for the dissemination of intra-abdominal malignancies including the most frequent GI tract pathology, as well as ovarian cancer, lung and breast cancer and melanoma.

The clinical presentation is unspecific. The patient presents abdominal pain and bloating, palpable masses and ascites. Unfortunately, most patients are in advanced stages of the disease at the time of diagnosis, usually with diffuse peritoneal neoplastic involvement.

There are multiple diagnostic imaging modalities for evaluating the condition. Multi-slice CT scan delivers the best anatomic resolution; MRI provides good soft tissue contrast and better anatomical resolution; positron emission tomography (PET) is not widely available in our environment but it enables staging and restaging, as well as the possibility to differentiate between tumor relapse vs. post-surgical changes. Ultrasound plays a limited role in the assessment of these pathologies but allows for the identification of ascites with retroperitoneal implants and peritoneal pseudomixoma.

Breakthroughs in CT scan allow for fine slices and multiplanar reconstructions. The CT scanner using fine abdomen and pelvic slices identifies sub-centimeter implants and renders 3-D images with less artifacts and adequate evaluation of structures like the diaphragm, parietocolic gutters, the intestine and the posterior cul-de-sac.

Anatomy of the Peritoneum

The peritoneum is a serous membrane covered by a single layer of mesothelial cells that coats the complete abdomen.

The peritoneal spaces are potential spaces not usually visualized unless they are distended by fluid or when there is thickening of the surrounding fascia.

The abdomen can be divided into supracolic, infracolic, pericolic and pelvic spaces. The supra  

---

1 Resident IVth year of Radiology and Diagnostic Imaging. Hospital Universitario Fundación Santa Fe de Bogotá, Bogotá, Colombia.
2 Institutional Radiologist, Body Imaging Department. Hospital Universitario Fundación Santa Fe de Bogotá, Bogotá, Colombia.
and infracolic spaces are divided by the transverse colon and the mesenterium. In front the greater epiplon is located between the peritoneal wall and the intestine (1).

The supracolic space includes the perihepatic spaces and the transcavity of the omenta. The mesenteric root extends right to left from the ligament of Treitz to the iliocecal area, separating the infracolic space into the right and left spaces. On the outside, the pericolonic folds are communicated with the perihepatic spaces and the pelvic region (1) Figs. 1 & 2).

Usually there are less than 50 mL of sterile fluid inside the cavity. This fluid is secreted by the visceral surface of the peritoneum and, similar to lymph, with less than 3,000 cells/mm³ and low protein content.

Inside the peritoneal cavity, the movement of fluid is caused by the negative pressure area in the subphrenic space, due to the movement of the diaphragm. By injecting fluid in the paracolic region, the fluid migrates initially into the subphrenic space and the pelvis; then it goes to the parietocolic gutter and the subhepatic spaces.

The fluid absorption in the peritoneum basically takes place through the lymphatic circulation of the parietal peritoneum. There is also fluid absorption at the diaphragmatic lymphatics,

---

Fig. 1 ab. Anatomy of the peritoneum. Right peritoneal space: a) perihepatic; f) lesser sac. Left peritoneal space: b) anterior perihepatic; c) posterior perihepatic; d) anterior subphrenic; e) posterior subphrenic.

Fig. 2. Anatomy of the peritoneum. Right peritoneal space: a) perihepatic; f) lesser sac. Left peritoneal space: b) anterior perihepatic; c) posterior perihepatic; d) anterior subphrenic; e) posterior subphrenic. Est = stomach.
which are in turn responsible for transporting microorganisms, cells and other particles present in the peritoneal fluid (2).

The peritoneum that covers the muscle portion of the diaphragm has intercellular gaps called stomata, which are located between the mesothelial cells. Their size ranges between 4 to 12 microns, depending on the diaphragm’s stretching and contraction.

When inflammation occurs, the fluid and the substances that cannot be absorbed by the peritoneal membrane are transported by the stomata through fenestrations of the basement membrane into specialized diaphragmatic lymphatic structures called lacunae. The relaxation of the diaphragm during expiration opens the stomata and promotes rapid filling of the lacunae. During inspiration, the contraction of the diaphragm empties the lacunae into the efferent lymphatic channels and passing to the central circulation via the thoracic duct (3, 4).

It has been found in animal models that after injecting bacteria into the peritoneal cavity, these bacteria disappear immediately to be found 6 minutes later in the mediastinum and 12 minutes later in the bloodstream. It has been determined as well that the stomata may get clogged with particles such as platelets or talcum powder.

Then we will discuss the major peritoneal primary and secondary neoplasms, their image presentation and the key diagnostic factors.

**Primary Peritoneal Neoplasms**

**Malignant Peritoneal Mesothelioma**

Malignant mesotheliomas are a rare condition with high mortality rates (5-12 months in untreated patients) (5-7). Usually it affects 50 to 60 year old males, but it may occur at any age (7,8). This condition is found to be associated to asbestos exposure (6,8,9). There are two types of MPM: the diffuse type that behaves as an infiltrating tumor, associated with irregular and nodular thickening of the peritoneum and ascites (10,11); the focal type presents itself as a heterogeneous mass with heterogeneous contrast enhancement. Contrary to pleural mesothelioma, calcified plaques are unusual in the peritoneal mesothelioma (12).

The CT findings are soft tissue masses, nodes, thickened peritoneum, ascites or local invasion of the intestine, the pancreas, and the liver (13, 14) (Fig.3).

![Fig. 3 a,b. Malignant mesothelioma. Axial CT images with evidence of diffuse and nodular thickening of the peritoneum, with associated ascites.](image)

**Liposarcoma**

The liposarcoma is a very frequent tumor of the retroperitoneum and relatively rare in the mesenterium and the peritoneum (15, 16). There are several histological types of which the myxoid is the most common. This condition does not differentiate between genders or typical age of presentation (17).

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 in the images may assist in making a differential diagnosis; i.e., an adipose mass with additional characteristics that rule out the diagnosis of lipoma, including: irregular septa or solid nodes inside (17) (Fig.4).

**Leiomyosarcoma**

This is a very vascularized tumor. It shows up in the images as a heterogeneous mass with areas of necrosis and cystic formations (Fig. 5) that may cause fistulae and perforate towards the intestinal lumen or the peritoneal cavity (18-20). The level of necrosis correlates to the histological grade of the tumor (21). There is no ascites and adenomegaly is rare (21-23). Leiomyosarcomas have a high rate of local recurrence with metastases to the liver and lungs (22,24).
Peritoneal Sarcoma

Peritoneal sarcomas are rare tumors with an incidence of 0.2% among the general population. They represent 50% of the primary mesenteric malignancies and their appearance in images depends on the histological type: liposarcoma, leiomyosarcoma, malignant fibrous histiocitoma or fibrosarcoma, which are far less frequent than in the retroperitoneum (25). The CT usually depicts them as large single masses (26) (Fig. 6 a,b.), frequently infiltrating and poorly defined.

Peritoneal Lymphoma

The involvement of the peritoneum in lymphoma usually occurs in young patients with a classical palpable abdominal mass. The CT shows a group of lymph nodes around the aorta and the inferior vena cava that does not compress the vascular structures (27).

Following the administration of FDG, the PET images depict hypermetabolic nodes (Fig. 7 a.b.).

Primary Benign Peritoneal Neoplasms

Lipoma

The peritoneal lipoma is a benign tumor originating at the sub peritoneal fatty tissue. Usually is an incidental finding (26). The images show a fatty attenuation mass without soft tissue involvement (26,28) (Fig. 8).

Fig. 4a. Liposarcoma. Axial CT showing a peritoneal mass with adipose component and associated septa (atypical lipoma presentation). (b) Retroperitoneal, solid, heterogeneous mass with no evidence of fatty component inside.

Fig. 5 a.b. Leiomyosarcoma. Axial and coronal plane CT scan images depicting a solid and heterogeneous peritoneal mass with lower density areas inside. This is consistent with the confirmed histological diagnosis of leiomyosarcoma.
Fig. 6 a, b. Peritoneal sarcoma. Axial and coronal TC image showing a solid peritoneal irregular and heterogeneous mass, consistent with a confirmed histological diagnosis of sarcoma. Additionally, the fat density caudal to the lesion is altered.

Fig. 7 a, b. Peritoneal lymphoma. CT and PET-CT axial views depicting focal peritoneal hypermetabolic lesions consistent with Hodgkin lymphoma.
Hemangioma

The cavernous hemangioma is the most common hemangioma in the peritoneum, characterized by large pools of blood surrounded by endothelium and blurred margins. It may look like a hypo-dense heterogeneous mass (Fig 9 a,b). The presence of phleboliths in its images is diagnostic (26). Other less common variants are the capillary and the venous hemangiomas (29).

Ganglioneuroma

These peritoneal masses are more frequent in type 1 rather than type 2 neurofibromatosis. The TC evidences a multifocal, low attenuation mass (Fig, 10a), branching out or coalescent, that may mimic adenomegaly (26,30). This tumor has a heterogeneous enhancement with contrast media (Fig. 10b) and may occasionally show a cystic appearance.

Diffuse Peritoneal Leiomyomatosis

This is usually an incidental finding in reproductive age women and it is associated with high estrogen levels; i.e., during pregnancy or contraceptive use (26,31).

The CT depicts multiple well-defined masses with a myoma-like enhancement. The MRI T1-weighted images show as iso-intense muscle masses; contrast media enhancement is variable and T2-weighted images give a low signal (26) (Fig.11a-c).

Secondary Peritoneal Neoplasms

Peritoneal Pseudomixoma

This is a clinical entity that involves the peritoneal surfaces and the omentum. It is characterized by the intraperitoneal accumulation of gelatin-like material produced by the rupture of secondary cystic mucin-producing lesions or by primary mucinous cystadenocarcinoma-like lesions; mostly the cecal
Fig. 10 a, b. Ganglioneuroma. CT axial views evidencing a solid mass and heterogeneous enhancement than can be due to a ganglioneuroma, with histological diagnosis.

Fig. 11. Diffuse peritoneal leiomyomatosis in pregnant patient (*) with intermediate signal diffuse peritoneal malignancy in different sequences. (a) Axial T1-weighted MRI images; (b) T2-weighted coronal images; (c) Axial post-contrast MRI evidencing diffuse enhancement of the peritoneal neoplastic involvement.
or ovarian appendix and less frequently the uterine, urachal or omphalomesenteric appendix (32).

Diagnostic images show a multicystic thick-walled mass or ascites with septa inside and curvilinear or punctuated calcifications (Fig. 12 a,b) (32).

**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.

When associated with peritoneal carcinomatosis, ovarian cancer is usually in an advanced stage, caused by the circulation of peritoneal fluid as previously described. Tumor implants vary in size and can be found from the diaphragm down to the pelvis (33).

The abdomen and the pelvis are evaluated to stage the neoplasms, focusing mainly on the sites that are surgically difficult to assess: the diaphragm, the splenic helix, the stomach, the lesser sac, the liver, the root of the mesenterium and the para-aortic nodes above the renal vessels (34, 35). Detecting these lesions is of clinical value because clinical parameters and CT information are used for cancer staging and to predict the surgical outcome (36).

Adequate tumor resection is achieved when there is evidence of residual disease >1 cm in diameter. Images are also useful to determine whether the patient is a candidate for neoadjuvant chemotherapy prior to surgery.

The diagnostic images show evidence of thickened lymph nodes of the peritoneum and peritoneal enhancement with contrast, associated with loculated ascites (37-40) (Fig. 13).

The most salient non-malignant entities to consider for differential diagnosis are: granulomatous pathologies such as TB and less often, peritoneal histoplasmosis. Although the imaging characteristics are alike, there are some findings such as mesenteric macronodules, omental irregularity, spleen calcifications and splenomegaly that enable the diagnosis of TB (41, 43).

**Peritoneal Metastases**

The peritoneum is the target of multiple metastatic processes, including the GI tract, GIST (gastrointestinal stromal tumor), the ovary (Fig 14 a,b), the breast, the lung and melanoma (44).

CT and MRI are used for staging and evaluation of tumor relapses with peritoneal involvement. The PET-CT is particularly useful in those cases in which CT and MRI are negative and tumor markers are high (45).
It is important to keep in mind that since 18-fluorodeoxyglucose (18 FGD) is mainly cleared through the urine, the kidneys, the ureters and the bladder have an increased uptake. Likewise, the intestine increased uptake is normal because of its own physiological activity but this should not be mistaken by hyper-uptake foci secondary to malignancy. Furthermore, benign conditions involving the intestine, such as duodenal ulcers, colon polyps, intestinal inflammatory disease or diverticulitis, among others, present 18 FDG hyper-uptake (46, 47).

**GIST (Gastro-Intestinal Stromal Tumor)**

The primary tumor is characterized by its exophytic submucosal mass appearance in the GI tract, mostly present in the stomach and the small gut. It may exhibit a hypovascular or hypervascular behavior. 25% of the cases show calcifications, necrosis (42,44,48). The PET image depicts a hypermetabolic mass (Fig. 15 a,b). This modality is more sensitive than the CT scan to assess treatment response (45,49).

**Krukenberg Tumor**

The Krukenberg tumor is a metastatic tumor of a primary adenocarcinoma that involves the ovary and contains mucin-secreting cells in the signet-ring; usually it originates in the breast or the GI tract, but mainly in the stomach (50,51). This tumor presents specific imaging characteristics including complex bilateral masses with a solid component (dense stromal reaction) and internal hyperintensity (mucin) in T1 and T2 (52,53).

**Conclusion**

Peritoneal neoplastic pathology occurs in different clinical scenarios and having an adequate knowledge of the anatomy, the pathophysiology and the appearance on diagnostic images is crucial for a correct interpretation. CT is the method of choice to assess this pathology and it is a useful guide to biopsy those masses. MRI is an alternate diagnostic modality, more costly, does not generate any ionizing radiation and is a good tool for

---

**Fig. 13 a,b. Peritoneal carcinomatosis. Axial CT images. Different patterns of carcinomatosis can be identified due to the presence nodular soft tissue lesions and associated ascites.**

**Fig. 14 a,b. Axial PET-CT images in two patients with a diagnosis of ovarian carcinoma. The images depict focal hypermetabolic solid nodular lesions.**
those cases in which CT is contraindicated. PET is extremely helpful for staging, follow-up and to differentiate between local relapse and surgical changes.

References

14. Lazarus H., Widrich W., Robbins A. Peritoneal mesothelioma with Roentgenographic findings. Volumen 113 Número 1. Boston University School of Medicine, Boston VA Hospital, Boston, Massachusetts.

Fig. 15 a,b. GIST. Axial and coronal PET CT image showing a hypermetabolic mass in the upper left quadrant of the abdomen, consistent with proliferative deposit secondary to GIST.


42. Epstein BM, Mann JH. CT of abdominal tuberculosis. AJR 1982;139:881-6.


Correspondence
Catalina Wilches
Departamento de Radiología
Fundación Santa Fe
Calle 119 # 7-75
Bogotá, Colombia
catalinawilches@yahoo.com.

Recived: June 28th, 2010
Accepted: July 26th, 2010