Key Points of CT/MR imaging: Non-neoplastic and Inflammatory Diseases of the Peritoneum, Omentum, and Mesentery

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Learning objectives

1. To understand the development of the peritoneum

2. To understand the normal anatomy of the peritoneum, omentum, and mesentery.

3. To summarize imaging findings of non-neoplastic and inflammatory diseases of the peritoneum, omentum, and mesentery
Background

Various diseases arise from the peritoneum, omentum, and mesentery, and these organs can be an important common site of extention of disease from adjacent organs or systemic disease. It is well known that neoplastic lesions account for a large percentage of typical peritoneal, omental, and mesenteric diseases; however, some non-neoplastic and inflammatory lesions also affect these organs.

In this presentation, following a review of the anatomy, we present imaging findings and discuss the diagnostic features of non-neoplastic and inflammatory diseases arising from the peritoneum, omentum, and mesentery.
Findings and procedure details

What is the Peritoneum?

The peritoneum is a smooth serous membrane that lines the body cavity that extending from the abdomen to the pelvis. The peritoneum is made up of two layers. One is the parietal peritoneum which covers the abdominal wall. The other is the visceral peritoneum and it covers the organs. The arteries and veins which supply the organs run between the two layers. Most of the intestine, liver, and spleen are invested by peritoneum and are connected to the abdominal wall by the mesentery. However, the retroperitoneal organs, such as the ascending or descending colon, duodenum, pancreas, and kidneys, are covered by the peritoneum only anteriorly.

The peritoneal cavity is a space between the parietal peritoneum and visceral peritoneum. That space is divided into the greater and lesser sacs. The greater sac is the peritoneal cavity, and the lesser sac is the omental bursa. The peritoneal cavity contains a small amount of fluid. In response to injury or infection, the peritoneum exudes fluid and cells and tends to isolate infection. The peritoneal cavity is completely closed in the male, whereas in the female it communicates with the fallopian tubes and hence indirectly with the exterior of the body.

Anatomic considerations 1), 2), 3)

Development of the peritoneum (Fig. 1 on page 12, Fig. 2 on page 12)

The embryo forerunner of the intestinal tract is suspended from the posterior abdominal wall by the dorsal mesentery. The caudal part of the foregut develops another mesentery known as the ventral mesentery, which connects between the foregut and the ventral abdominal wall. The dorsal mesentery covers most of the intestines, and develops into the greater omentum, mesentery, and mesocolon. The liver develops within the ventral mesentery and divides the ventral mesogastrium. The mesentery lying between the stomach and liver is the lesser omentum, and lying between stomach and the spleen is the gastroplenic ligament, and lying between the spleen and the kidney is the splenorenal ligament. The part of mesentery lying between the liver and the ventral wall is the falciform ligament.

Structure of the peritoneum (Fig. 3 on page 13, Fig. 4 on page 14, Fig. 10 on page 20)

The mesentery and the peritoneal fold and ligaments:
The mesentery is a double layer of peritoneum that arises from the posterior cavity wall of the peritoneal cavity and attaches to the intestinal tract.

The peritoneal fold is a part of the peritoneum that is raised from the abdominal wall by the underlying blood vessels and ducts. Some peritoneal folds are called peritoneal ligaments when they connect the organ to the abdominal wall or to another organ.

**The mesentery:** (Fig. 5 on page 15, Fig. 6 on page 16)

The mesentery mainly comprises the small intestinal mesentery, the right, left and transverse mesocolon, mesosigmoid and mesorectum. The small intestinal mesentery, transverse and sigmoid mesocolon terminate at their insertions into the posterior abdominal wall.

The small intestinal mesentery (g) is the fold of peritoneum connecting the loops of jejunum and ileum to the posterior abdominal wall. The superior mesenteric artery and vein run between the layers.

The transverse mesocolon (j) is the broad fold of peritoneum connecting the transverse colon to the posterior wall of abdominal cavity. It is formed by the ascending layer of greater omentum. One layer passes in front of the pancreas. The posterior layer turns downward, reaches the transverse colon, which it surrounds, and then passes backward to the abdominal wall. The middle colic artery and vein run between the layers.

The sigmoid mesocolon (l) is the fold of peritoneum, connects the sigmoid flexure with the posterior wall of the extreme lower portion of the abdominal cavity and with the posterior wall of the pelvic cavity. The sigmoid artery and vein run between the layers of the sigmoid mesocolon.

* The epiploic appendices are small pouches of the peritoneum filled with fat and situated along the colon.

**The greater and lesser omentum:** (Fig. 7 on page 17)

The greater omentum (h) is the largest of all the peritoneal folds. It is suspended from the greater curvature of the stomach and the transverse colon. It usually covers the small intestine as far as the pelvis, and serves to limit the spread of infectious processes. It consists of a double descending and a double ascending layer. Between the two layers of the anterior layer of the greater omentum, along the greater curvature of the stomach, is the arterial loop formed by the anastomosis between the right and left gastroepiploic arteries. The greater omentum connects the greater curvature of the stomach with the transverse colon.
The greater omentum (h) is made up of the following ligaments:

- **Gastrophrenic ligament**: This ligament extends between the greater curvature of the stomach and the diaphragm.

- **Gastrosplenic ligament (d)**: This ligament extends between the fundus of the stomach and the hilum of the spleen. It consists of two layers of peritoneum. The short gastric artery and vein run between the two layers.

- **Gastrocolic ligament (i)**: This ligament extends from the greater curvature of the stomach and the superior part of duodenum to the transverse colon. The gastroepiploic artery and vein run between the two layers.

- **Splenorenal ligament (e)**: This ligament extends between the left kidney to the spleen, and consists of the peritoneal cavity and the omental bursa. The Splenic artery and vein run between the layers.

The lesser omentum (b) is the fold of peritoneum extending from the porta hepatis of the liver to the lesser curvature of the stomach and the superior part of the duodenum.

The lesser omentum (b) is divided into two parts:

- **Hepatogastric ligament (c)**: This ligament extends between the liver and the lesser curvature of the stomach. The arterial loop formed by the anastomosis of the left gastric artery and the right gastric artery runs between the layers.

- **Hepatoduodenal ligament (f)**: This ligament extends between the liver and the superior part of the duodenum. The proper hepatic artery, the portal vein, and common bile duct run between the two layers.

The perihepatic space: (Fig. 8 on page 18)

The liver is covered by visceral peritoneum except at the bare area, bed of the gallbladder, and porta hepatis. The falciform ligament (a) is a double fold of peritoneum that connects the liver with the anterior abdominal wall and diaphragm. The left layer of the falciform ligament (a) becomes the superior layer of the left coronary ligament (k), and the right layer of that ligament is also continuous with the right coronary ligament (k) in the right side. These coronary ligaments (k) are continuous with the left and right triangular ligament (m). Posteriorly, the bare area of the liver, which is not covered by peritoneum, consists of the two layers of the coronary ligament (k).

Female genital tract: (Fig. 9 on page 19)
Broad ligament of the uterus (n) is the two-layered peritoneal fold that connects the sides of the uterus to the lateral walls and floor of the pelvis. This ligament contains the fallopian tubes, ovaries, uterine artery and vein, ovarian artery and vein, and the round ligament of the uterus.

Broad ligament of the uterus (n) is divided into three parts:

- **Mesometrium (o):** This ligament is the mesentery of the uterus and forms the largest portion of the broad ligament

- **Mesosalpinx (p):** This ligament is the mesentery of the fallopian tubes. It extends between the fallopian tubes and the mesovarium.

- **Mesovarium (q):** This ligament is the mesentery of the ovary.

**Case review**

**Inflammation**

Mesenteric inflammation due to:

- Appendicitis (Fig. 11 on page 20, Fig. 12 on page 21, Fig. 13 on page 21, Fig. 14 on page 22)

- Diverticulitis

- Small intestinal diverticulitis (Fig. 15 on page 23)

- Sigmoid diverticulitis (Fig. 16 on page 24, Fig. 17 on page 25)

- Meckel diverticulitis (Fig. 18 on page 26)

- Epiploic appendagitis (Fig. 19 on page 27, Fig. 20 on page 28)

- Mesenteric panniculitis (Fig. 21 on page 29)

- Peritoneal actinomycosis (Fig. 22 on page 30)

- Continuous ambulatory peritoneal dialysis peritonitis (Fig. 23 on page 31)

- Pancreatitis (Fig. 24 on page 32)

- Cholecystitis (Fig. 25 on page 33)

**Pelvic inflammatory disease (PID)**
- Salpingitis (Fig. 26 on page 34, Fig. 27 on page 35)
- Douglas abscess (Fig. 27 on page 35)
- Perihepatitis: Fitz-Hugh-Curtis syndrome (Fig. 28 on page 36)

Others

Tuberculosis (Fig. 29 on page 37, Fig. 30 on page 38)
Encapsulating peritoneal sclerosis (Fig. 31 on page 39, Fig. 32 on page 40)
Inflammatory pseudotumor (Fig. 33 on page 42)
IgG4 related disease (Fig. 34 on page 41)

Appendicitis 4),5),6)

Appendicitis essentially means inflammation or infection of appendix. CT image in acute appendicitis demonstrate the enlarged appendix (>6mm in diameter); thickened appendiceal wall with enhancement; and periappendiceal fat stranding (Fig. 11 on page 20). Inflammation is usually adjacent and medial to the appendix, however, sometimes it is spreading to the mesentery (Fig. 12 on page 21). Focal defect of the wall, appendicolith outside the appendix, periappendiceal fluid collection, extraluminal air near the appendix indicates perforation of the appendix. Severe inflammation or perforation of the appendix may lead to periappendiceal abscess forming (Fig. 13 on page 21, Fig. 14 on page 22).

Diverticulitis 4),5), 7)-9)

Diverticulitis is inflammation or infection of the small luminal out-pouches called diverticula that develop along the walls of the intestine. The small intestinal diverticula are much less common than their colorectal region. The colonic diverticula are common in older people, and most of them occur in the sigmoid colon. Non-traumatic small intestinal perforation is rare entity, and small intestinal diverticula are one of the causes of perforation (Fig. 15 on page 23). CT findings in acute diverticulitis demonstrate focal wall thickening of the intestinal wall with enhancement; peridiverticular mesenteric fat stranding; and localized abscess formation (Fig. 16 on page 24). Tiny extraluminal air is present adjacent to the involved diverticulum, or extraluminal air and fluid is present in the peritoneal cavity and pelvis in case with perforation (Fig. 15 on page 23, Fig. 17 on page 25).
Meckel diverticulitis

Meckel diverticulum is the most common congenital anomaly of the small intestine caused by incomplete obliteration of the omphalomesenteric duct. CT findings of uncomplicated Meckel diverticulum generally resemble a normal loop of the intestine. The presence of a blind-ending, tubular, round or oval structure adjacent to small intestine may help to diagnosis. The complications related to Meckel diverticulum are hemorrhage, intussusception, inflammation, and perforation. Acute Meckel diverticulitis shows similar CT findings with acute appendicitis, and can result in perforation. The mesenteric fat stranding is present surrounding the inflamed Meckel diverticulum. The extraluminal air and fluid is present in the peritoneal cavity and pelvis in case with perforation (Fig. 18 on page 26).

Epiploic appendagitis

Epiploic appendages are peritoneal pouch that arise from the serosal surface of the colon, and composed of the adipose tissue and blood vessels. Epiploic appendagitis occurs as a result of spontaneous torsion, ischemia, or inflammation of the epiploic appendages. CT findings in epiploic appendagitis demonstrate a fat-density oval structure adjacent to colon, usually 1.5-3.5 cm in diameter, with surrounding inflammatory fat stranding. Thickening of the visceral peritoneum also observed as a result of the spread of inflammation (Fig. 19 on page 27). The presence of a central high attenuation dot due to venous thrombosis is occasionally useful for diagnosis (Fig. 20 on page 28).

Mesenteric panniculitis

Mesenteric panniculitis is a nonspecific inflammatory and fibrotic process affecting the fatty tissue of the mesentery. The CT findings of the mesenteric panniculitis can range from a well-defined soft tissue mass to ill-defined areas of high attenuation in the mesenteric fat related to inflammation and fibrosis (Fig. 21 on page 29).

Peritoneal actinomycosis

Actinomycosis is a slowly progressive infection cased by anaerobic gram-positive bacteria, primary of the genus Actinomyces, which colonize the mouth, colon, and vagina. Mucosal disruption can lead to infection at any site in the body. CT findings demonstrate an aggressive infiltrative soft tissue mass with marked enhancement (Fig. 22 on page 30).

Continuous ambulatory peritoneal dialysis (CAPD) peritonitis
Peritonitis is the most common complication of CAPD and causes by the bacterial or fungal infection. CT findings demonstrate peritonitis include gas; fat stranding; and enhancement of peritoneal wall. Occasionally, the peritoneum, omentum, or mesentery may appear diffusely thickened in presence of infection (Fig. 23 on page 31).

Pancreatitis

Acute pancreatitis often shows widespread inflammatory change in CT images. Mesenteric abnormalities consisting of the inflammation and fluid in the mesentery occur as a result of extending intraperitoneal secondary to digestive enzymes (Fig. 24 on page 32). The transverse mesocolon is most affected.

Cholecystitis

CT findings of acute cholecystitis demonstrate gall bladder wall thickening; gallbladder distension; pericholecystic fluid; inflammatory stranding; and subserosal edema. Gallbladder perforation is one of the most severe complications of acute cholecystitis and may show widespread inflammatory change in the peritoneal space (Fig. 25 on page 33).

Pelvic inflammatory disease (PID)

PID is a broad term indicating infection of the female upper genital tract and the surrounding structures. Patient with PID have high risk factor for ectopic pregnancy. CT findings of early in the course of PID are mild pelvic edema and mild salpingitis. Pelvic edema is result in thickening of the uterusacral ligament and haziness of the pelvic fat. Mild salpingitis with inflammatory thickening of the fallopian tubes is also observed (Fig. 26 on page 34). Periovarian or peritubal stranding and enhancement of the adjacent peritoneum are occasionally seen. Later in the course of PID, the fallopian tubes show enlargement with wall thickening and enhancement, and fill with complex fluid. Ultimately, tubo-ovarian and pelvic abscess forms in the pelvis (Fig. 27 on page 35). PID may progress to the peritonitis and perihepatitis so-called Fitz-Hugh-Curtis syndrome (FHCS). FHCS shows intense enhancement of the arterial surface of the liver in the dynamic CT (Fig. 28 on page 36). The enhancement on early-phase may reflect increase blood flow blood caused by inflammation, whereas, the enhancement on delayed-phase may reflect early capsular fibrosis.

Tuberculosis

Peritoneal tuberculosis may be seen in the patients with pulmonary tuberculosis or gastrointestinal tuberculosis. CT images in peritoneal tuberculosis demonstrate nodular
or thickening of the perineum and mesentery, abnormal peritoneal or mesenteric enhancement; enlarged lymph nodes of low attenuation; and ascites (Fig. 29 on page 37, Fig. 30 on page 38). The manifestation of CT finding can be separate into three types; a "wet type" characterized by exudative high attenuation ascites; a "dry type" characterized by fibrous peritoneal thickening; and a "fibrotic type" characterized by omental and mesenteric masses.

**Encapsulating peritoneal sclerosis (EPS)**

EPS is an inflammatory process that leads to the chronic fibrotic thickening of the peritoneum, and most cases associate with CAPD. Smooth thickening and enhancement of the peritoneum is the most common findings of EPS on CT images (Fig. 31 on page 39). Peritoneal calcification is often seen (Fig. 32 on page 40). The diffuse inflammatory process also involves the small intestine, and leads to fibrosis and adhesive small intestinal obstruction.

**Inflammatory pseudotumor (IPT)**

IPT is a benign chronic inflammatory lesion of unclear pathogenesis. It most frequently occurs in the lung and orbit, but it can also occur in many regions including the mesentery. The imaging characteristics of the IPT are nonspecific, and vary from an ill-defined infiltrating process to a well-circumscribed soft-tissue mass (Fig. 33 on page 42). Calcification may be seen on CT images. IPT shows variety contrast enhancement patterns on CT images: non-enhancement, heterogeneous enhancement, and peripheral enhancement. These findings depend on the presence of necrosis or fibrosis.

**IgG4-related sclerosing disease (ISD)**

ISD is a recently described as a multisystem immune-mediated sclerosing disease characterized by extensive inflammation with IgG4-positive cells and proliferative fibrosis. Autoimmune pancreatitis (AIP) is the most common manifestation of ISD, and multiple other conditions such as retroperitoneal fibrosis (RPF), sclerosing mesenteritis, and sclerosing cholangitis may occur in the abdomen with ISD. RPF shows the fibrotic plaque extending to the retroperitoneal space on CT images. The CT findings of sclerosing mesentery demonstrate range from haziness of the mesentery to a soft-tissue mass in the mesentery (Fig. 34 on page 41).
**Fig. 1:** Develop of the peritoneum (horizontal section) *Illustration based on the human anatomy*

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Fig. 2: Develop of the peritoneum (sagittal section) *Illustration based on the human anatomy

b: Lesser omentum
   (c: Hepatogastric ligament)
g: Mesentery
h: Greater omentum
i: Gastrocolic ligament
j: Transverse mesocolon
L: Liver
St: Stomach
P: Pancreas
D: Duodenum
S/I: Small intestine
T/C: Transverse colon
*: Omental bursa

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Fig. 3: Horizontal section of the abdomen *Illustration based on the human anatomy

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Fig. 4: Sagittal section of the abdomen *Illustration based on the human anatomy

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Fig. 5: Structure of the mesentery (1) *Illustration based on the human anatomy

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Fig. 6: Structure of the mesentery (2) *Illustration based on the human anatomy

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Fig. 7: Structure of the greater and lesser omentum *Illustration based on the human anatomy

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**Fig. 8:** Structure of the perihepatic space *Illustration based on the human anatomy

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**Fig. 9:** Structure of the female genital tract *Illustration based on the human anatomy
Fig. 10: CT findings of the peritoneum (A)-(D) axial images, (E)-(G) coronal images, and (H) sagittal image
**Fig. 11:** Acute appendicitis in a 9-year-old boy.

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**Fig. 12:** Acute appendicitis in a 61-year-old man.

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**Fig. 13:** Acute appendicitis with abscess formation in a 12-year-old girl.

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Fig. 14: Ruptured acute appendicitis with abscess formation in a 83-year-old man.

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**Fig. 15:** Perforated small intestinal diverticulitis in a 77-year-old woman.

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Fig. 16: Perforated sigmoid diverticulitis in a 41-year-old man.

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Fig. 17: Perforated sigmoid diverticulitis in a 50-year-old woman.

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Fig. 18: Perforated Meckel diverticulitis in a 5-year-old boy.
Fig. 19: Epiploic appendagitis in a 48-year-old woman.

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**Fig. 20:** Epiploic appendagitis in a 38-year-old man.

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**Fig. 21:** Mesenteric panniculitis in a 64-year-old man.

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Fig. 22: Actinomycosis in a 37-year-old woman.

Fig. 23: Fungal peritonitis related to CAPD in a 87-year-old man.
Fig. 24: Acute pancreatitis in a 86-year-old man.

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**Fig. 25:** Ruptured acute cholecystitis in a 90-year-old man.
Fig. 26: Salpingitis in a 41-year-old woman.

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Fig. 27: Salpingitis with abscess formation in 56-year-old woman.

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Fig. 28: Fitz-Hugh-Curtis syndrome in a 23-year-old woman.

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Fig. 29: Peritoneal tuberculosis in a 56-year-old woman.

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Fig. 30: Peritoneal tuberculosis in a 75-year-old woman.

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Fig. 31: Encapsulating peritoneal sclerosis in a 42-year-old woman.

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Fig. 32: Encapsulating peritoneal sclerosis in a 54-year-old man.

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Fig. 34: IgG4-related sclerosing disease in a 65-year-old man.

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Fig. 33: Inflammatory pseudotumor in a 65-year-old man.

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Conclusion

Non-neoplastic and inflammatory diseases of the peritoneum, omentum, and mesentery are occasionally difficult to distinguish from neoplastic lesions. Understanding the developmental process of non-neoplastic and inflammatory lesions is very useful in the interpretation of imaging findings. Further, understanding the anatomy of peritoneal or retroperitoneal space can provide an important source of information for diagnosis.
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