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Body Imaging

CT and MR imaging of the greater omentum: Pictorial essay

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ABSTRACT

The greater omentum is a unique anatomical structure that serves a critical function in the containment of inflammatory and infectious processes within the abdominal cavity. It is also a common site of involvement by metastases, as well as the primary location for various pathologic lesions of clinical significance. Its fibroadipose composition, large size, and position in the most anterior aspect of abdomen allow accurate visualization of the greater omentum on CT and MR images. Careful evaluation of the greater omentum can provide important clues to the diagnosis of the underlying abdominal disorder.

The aim of this article is to present the normal appearance of the greater omentum, and the wide spectrum of its pathological features as demonstrated on CT and MRI of the abdomen.

1. Introduction

The greater omentum begins to develop in the first eight weeks of gestational life, when the peritoneal linings of the anterior and posterior gastric walls join along the greater curvature to form a double layer called dorsal mesogastrium. This will grow and extend caudally, then its distal part folds back on itself and become attached to the transverse mesocolon. The subsequent accumulation of adipose tissue and its neurovascular connections within this intraperitoneal pocket will create a fibrofatty apron that hangs from the greater gastric curvature and transverse colon. It spans the width of the abdomen and reaches the pelvis to cover the small bowel. It serves as a barrier to prevent the adherence of the intestinal loops to the parietal peritoneum. Therefore, the greater omentum is visible as the most anterior structure when the abdominal cavity is opened during laparotomy (Fig. 1).^{1–3}

The greater omentum is usually 1–2 cm thick in adults, but subject to considerable variations depending on the age, body habitus and nutritional status of individuals, thus being most prominent in obese adults. It has an average weight of about 0.6 kg, with a reported range of 0.3 to 1.5 kg. The surface area of the greater omentum is usually about 500 cm². However, it can be much larger since it had measured up to 45 cm wide and 36 cm long in some reported cases.^{2,4,5}

2. Normal appearance on CT and MR images

The greater omentum had been a radiologically invisible structure until the introduction of cross-sectional imaging modalities of CT, MR,

and ultrasonography. It is now readily identified on CT and MR examinations as a thick band of fatty structure beneath the anterior abdominal wall, just in front of the bowel loops. Sagittal images demonstrate it extending to the lower abdomen (Figs. 2 and 3). Its CT attenuation is the same as that of subcutaneous fat (–80 to 100 HU).

The greater omentum's limited attachment along its superior border allows it to fold upwards when the patient is in supine position. It will then occupy the upper abdomen or subphrenic regions in front of the liver and stomach. The small blood vessels within the greater omentum are barely visible normally but will be more apparent when engorged in patients with portal hypertension or omental inflammation.^{7,8}

3. Primary tumors of the greater omentum

The main component of the greater omentum is adipose tissue, which is occasionally associated with the development of lipomas. They are usually encapsulated by a very thin fibrous layer, with typical features of fatty composition on CT and MRI (Fig. 4). The omental lipomas can grow slowly to a considerable size, requiring surgical removal if they cause abdominal symptoms or show abnormal activity on PET scan. Giant lipomas weighting up to 3–4 kg have been reported.^{6,7,9}

Other benign tumors of the greater omentum include fibroma, leiomyoma, hemangioma, and hemangiopericytoma. They appear as well-circumscribed soft tissue tumors within the low-attenuated omental fat, often as an incidental finding on imaging studies performed for unrelated abdominal disorders.

Malignant primary tumors of the greater omentum are rare as

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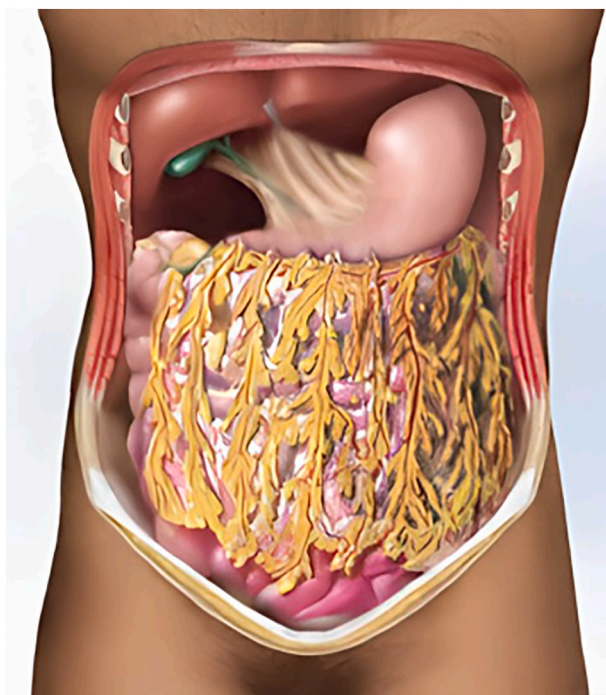


Fig. 1. Anatomical drawing of the greater omentum as a fibrofatty apron that hangs from the stomach and transverse colon over the small bowel loops.

compared to its more frequent metastatic involvement. Omental liposarcoma appears as a mass with distorted fibrofatty configuration on CT and MR images (Fig. 5A), and most reported cases occurred in adult men.^{7,10} Fibrosarcoma and leiomyosarcoma of the greater omentum appear as tumors with mixed fibrotic components and indistinct borders invading the adjacent structures.^{6,7}

Malignant mesothelioma associated with asbestosis typically involves the pleura in about 90% of cases. This rare neoplasm can also originate in the greater omentum or peritoneum of predominantly women, accounting for about 12% of all mesothelioma cases with very poor prognosis. It causes thick peritoneal plaques and confluent nodular omental masses that are usually associated with ascites on abdominal CT examination (Fig. 5B). The involvement of greater omentum can manifest as an omental cake, smudged appearance of its adipose tissue, cystic components, and discrete nodules.^{7,11}

4. Metastatic involvement

The greater omentum is a common site of metastatic involvement. It usually presents on CT and MRI as a diffusely infiltrating process with markedly thickened and nodular appearance replacing the omental fat, and commonly referred to as omental cake (Fig. 6). It is often accompanied by peritoneal thickening and ascites. The metastases are often more readily visible within the low-attenuated omental fat on contrast-enhanced CT. Their appearance is usually determined by the type of primary tumor as well as the mode of dissemination.¹²

The spread of malignancy to the greater omentum occurs through

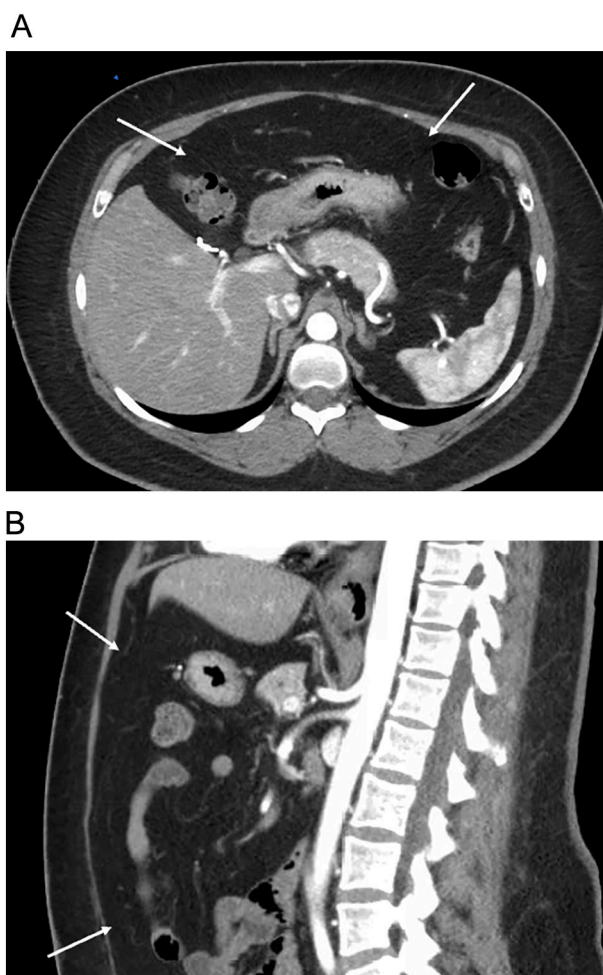


Fig. 2. CT appearance of normal greater omentum in a 43-year-old woman with prior cholecystectomy. A and B. Axial and sagittal sections show the greater omentum as a 3 cm thick fatty structure beneath the anterior abdominal wall (arrows). Its attenuation is the same as the subcutaneous fat (104HU).

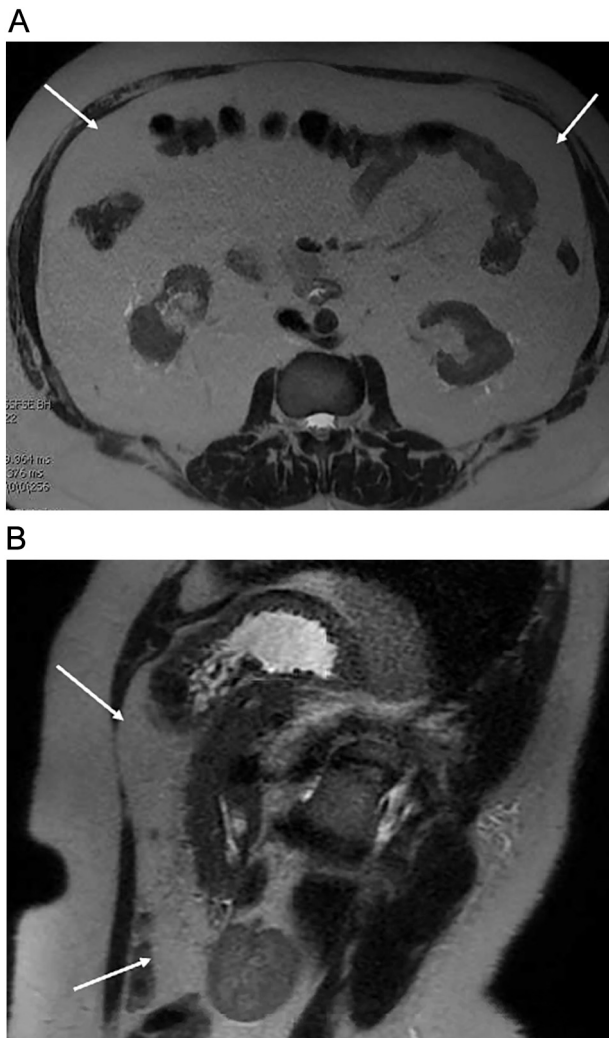


Fig. 3. MR images of the greater omentum in a 38-year-old man. A and B. Axial and sagittal sections demonstrate the uniformly fat composition of the greater omentum. It measures about 2.5 cm in thickness and spans 28 cm across the width of abdominal cavity in front of the small bowel and colon (arrows). T2-weighted with fat suppression.

different routes. Direct extension is usually encountered in carcinomas of the stomach, colon, and gallbladder (Fig. 7).

Intraperitoneal seeding develops most commonly in ovarian and pancreatic cancers. It may also occur with gynecological or genitourinary tumors and carcinomas of the small bowel or appendix. Their malignant cells are easily disseminated through the peritoneal fluid that constantly circulates through the abdominal cavity by gravity, intestinal peristalsis and changing intraabdominal pressure. These tumor cells tend to infiltrate the omental aggregates of macrophage cells known as milky spots and grow into metastatic foci. This occurs particularly in patients with ovarian cancer, hence the common practice to perform omentectomy during their surgical treatment. Almost 90% of patients with ovarian cancer have omental and peritoneal implants and 60–70% have ascites at post-mortem examination.^{4,13,14}

Hematogenous metastases to the greater omentum are encountered in patients with melanoma, breast, or lung cancers. The embolized tumor cells spread via celiac artery and gastroepiploic branches to the

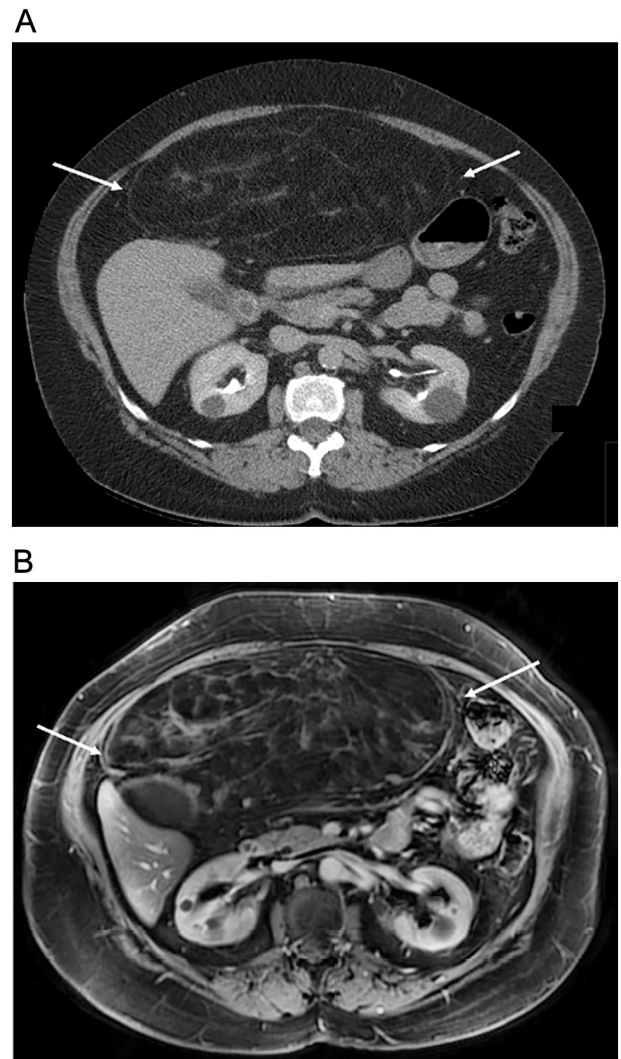


Fig. 4. Giant lipoma of the greater omentum in a 60-year-old woman with breast cancer. A. Axial CT section of the upper abdomen reveals a large lipoma measuring 12 × 22 cm with very thin capsule (arrows). B. MR image shows the fibrovascular components of this lipoma (arrows). T1 with fat suppression and contrast enhancement.

greater omentum where they grow as intramural nodules.

Lymphangitic spread to the greater omentum are seen in cases of lymphoma and Hodgkin's disease, usually coexistent with mesenteric and retroperitoneal lymphadenopathy (Fig. 8).

CT can demonstrate the omental metastases that are a few millimeters in size and detect very small amount of coexistent ascites. It should be noted that the CT and MR appearance of omental metastases is nonspecific, since it can be mimicked by other omental diseases such as mesothelioma and tuberculosis.^{6,7,12} However, the anterior location of omental cake in the abdominal cavity makes it ideally suited for image-guided needle biopsy to determine the underlying pathology. It has been reported that CT diagnosis of omental metastases has about 85% specificity, but only 42–47% sensitivity. In fact, laparoscopy has disclosed omental involvement by early metastatic deposits in some patients whose CT had been unremarkable.^{13,14} Nevertheless, CT is currently the most useful method for detection of omental involvement, providing

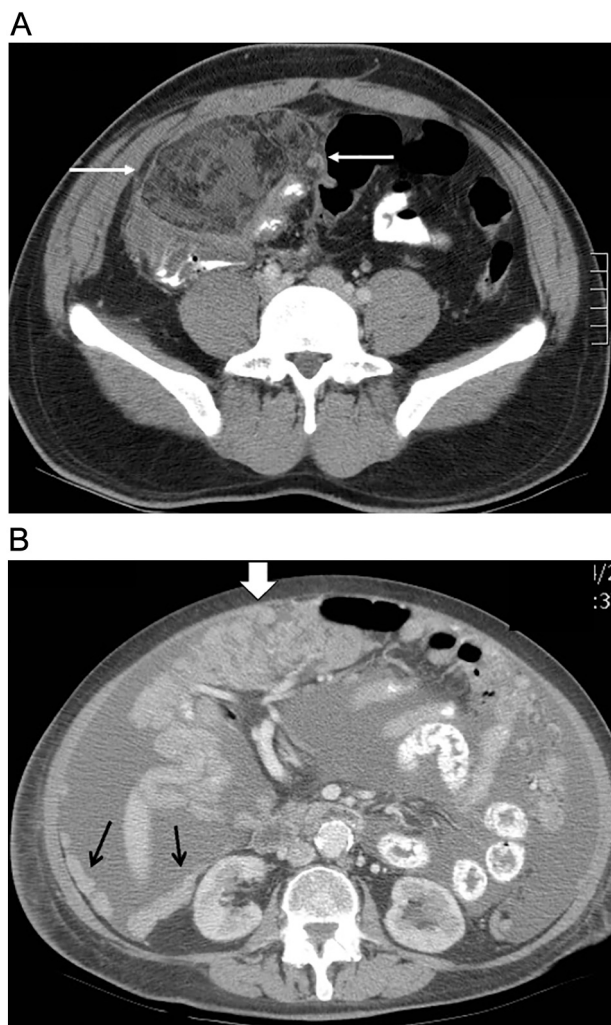


Fig. 5. CT images of 2 primary malignant tumors of the greater omentum. A. Liposarcoma in a 30-year-old man, presenting as an ill-defined mass with prominent fibrotic changes of the omental fat (arrows). It has invaded the adjacent intestinal loops. B. Abdominal mesothelioma in a 76-year-old woman, causing nodular thickening of the greater omentum (white arrow), large peritoneal implants (black arrows), and massive ascites.

important information for staging tumors, assessing resectability, monitoring response to therapy, and revealing any recurrences. MR imaging of the abdomen may have a similar accuracy in staging advanced disease.

5. Inflammatory and infectious processes

An important function of the greater omentum is the containment of infections and repair of inflammations of the abdominal organs. It has been referred to as the “abdominal policeman or guardian”. The mobility of the greater omentum allows it to move towards and adhere to the affected region, thereby walling it off as in cases of perforated duodenal ulcer, diverticulitis, or appendicitis. Further biological actions of the greater omentum are rendered through its “milky spots” that represent perivascular aggregates of macrophages, B and T lymphocytes, mastocytes, and leukocytes. These cells will migrate to the infected areas for the clearance of pathogens and necrotic tissue.^{2–4}

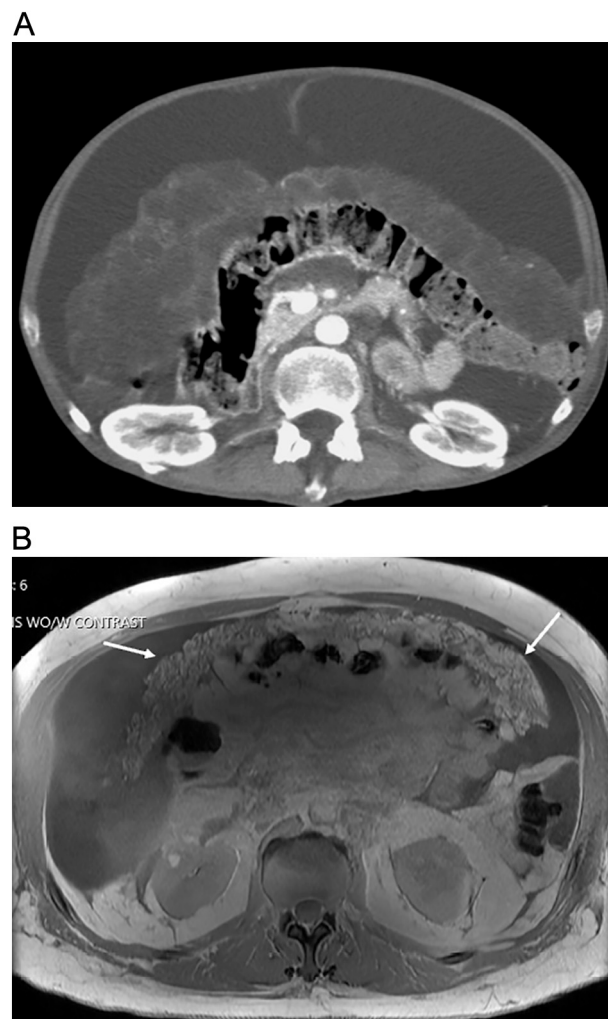


Fig. 6. CT and MRI appearances of omental cake. A. This CT section shows a markedly thickened greater omentum due to metastases from colon carcinoma. Large ascites has separated it from the anterior abdominal wall. B. MR image demonstrates diffuse metastatic nodules of the greater omentum in this 59-year-old man with renal cell carcinoma (arrows). T2-weighted with fat suppression.

Despite the crucial role of the greater omentum in the control of infectious and inflammatory processes of various abdominal organs, it can also be affected by somewhat similar pathological conditions. In fact, many intra-abdominal infections can also involve the greater omentum either by direct contiguous spread or through hematogenous seeding of bacteria.

Inflammation of the greater omentum or epiploic panniculitis can develop as an idiopathic condition or secondary to direct contact with or spread from an intra-abdominal process.^{15,16} Its clinical symptoms are usually diffuse abdominal pain and tenderness, low-grade fever, leukocytosis, and elevated sedimentation rate. CT findings are inflammation-induced edema causing smudged appearance of the omental fat and vascular engorgement (Fig. 9). Some cases of this condition may subsequently lead to chronic inflammation with fibrosis, fat necrosis and pseudo-capsule formation. Omental panniculitis is somewhat similar to the mesenteric panniculitis that is usually a self-limiting condition and managed conservatively.¹⁷

The greater omentum and peritoneum are the most common location

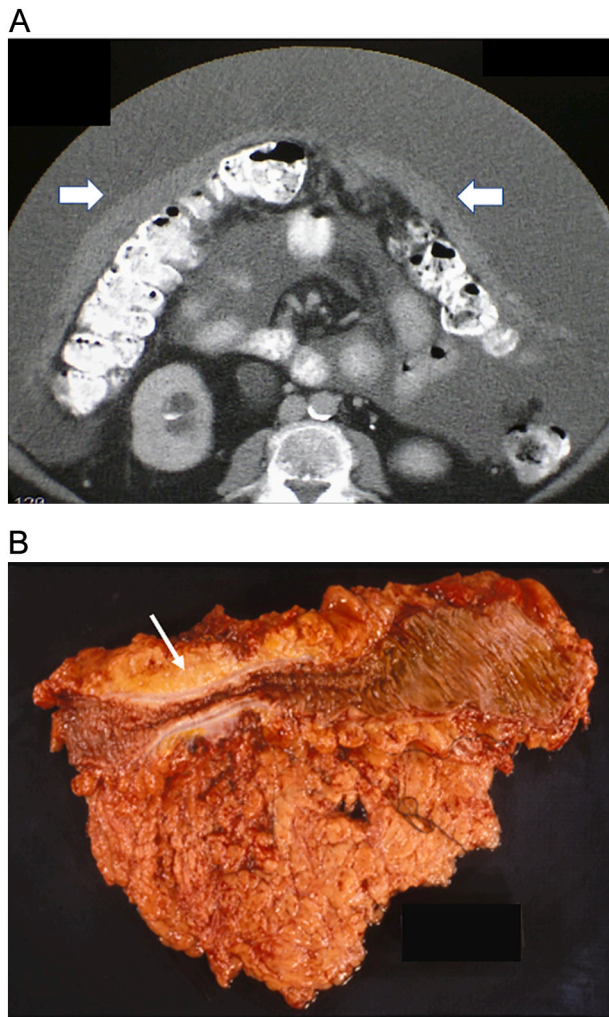


Fig. 7. Metastatic involvement of the greater omentum in a 70-year-old woman. A. CT image shows a diffusely infiltrated greater omentum attached to the transverse colon (arrows). B. Autopsy specimen reveals an infiltrating colon cancer (arrow) which had caused direct metastatic spread to the omentum.

of involvement by abdominal tuberculosis, which can develop due to hematogenous spread from the pulmonary focus or dissemination from infected mesenteric lymph nodes. About 15%–25% of patients with abdominal tuberculosis have concomitant active pulmonary disease, and its incidence has increased over the past several decades as the consequence of HIV infection and usage of immunosuppressive medications.¹⁸ The presenting clinical symptoms include fever (75%), abdominal pain (65%) and weight loss (36%). The imaging features on CT or MR consist of diffuse infiltration and thickening of the greater omentum, marked vascular engorgement, free or loculated ascites, smooth thickening of the mesenteric and peritoneal layers, encapsulation of small bowel loops, and enlarged or necrotic lymph nodes (Fig. 10). These findings often simulate peritoneal carcinomatosis, which can be differentiated mainly by irregular and nodular appearance of thickened peritoneum.¹⁹

Omental abscess is usually associated with peritonitis complicating intestinal perforation or postoperative leakage from a gastrointestinal anastomosis. Several authors have reported omental abscesses due to spilled gallstones after laparoscopic cholecystectomy or appendectomy.²⁰ CT reveals a well-defined cystic mass with enhancing walls,

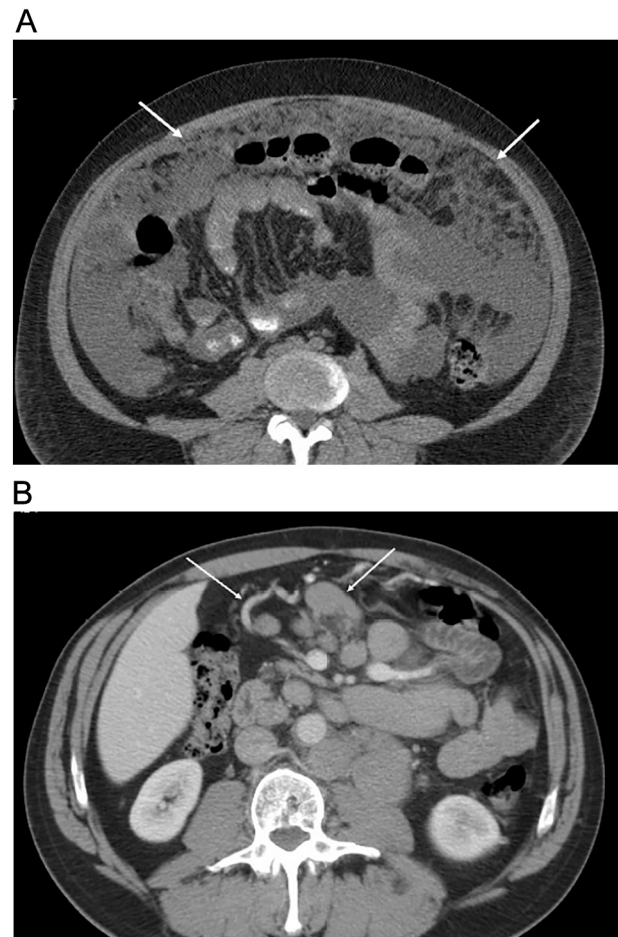


Fig. 8. CT patterns of lymphangitic spread of metastases to the greater omentum. A. This image shows a reticular-nodular appearance of the greater omentum (arrows) due to its metastatic involvement by gastric lymphoma in a 43-year-old man. B. CT demonstrates large lymph nodes and engorged vessels of the greater omentum in a 58-year-old man with Hodgkin's disease (arrows). There is also coexistent lymphadenopathy of the mesenteric and para-aortic regions.

containing fluid or gas, and surrounded by smudged or stranding of the omental fat.

Omental edema usually causes a diffuse clouding and hyperattenuation of the omental fat on CT examination. It can develop patients with liver cirrhosis and portal hypertension, hypoalbuminemia, nephrosis, and heart failure. It can also occur in cases of acute pancreatitis, when the extravasated pancreatic enzymes dissect the transverse mesocolon and spread to the greater omentum to cause its marked edema and hypervascularity (Fig. 11).^{6,21}

6. Vascular abnormalities

The greater omentum is a highly vascularized structure supplied by the right gastroepiploic artery, which is a terminal branch of gastroduodenal artery, and by the left gastroepiploic artery branch of the splenic artery. These vessels and their accompanying veins form an arcade of interconnecting small branches that are difficult to clearly visualize them on contrast-enhanced CT or MRI in normal cases. However, they become more prominent and demonstrable when congested due to portal hypertension or inflammatory and neoplastic processes (Fig. 12). It should be noted that the venous drainage of the greater omentum is

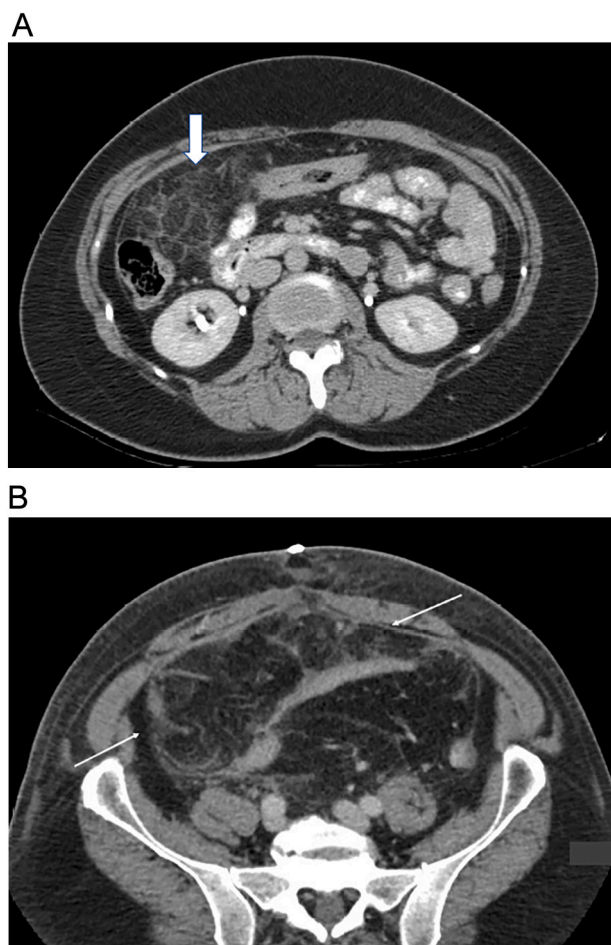


Fig. 9. Inflammation of the greater omentum due to epiploic panniculitis in 2 adult patients. A. CT shows diffuse edema and hyperemia of the greater omentum causing its increased attenuation as compared to the subcutaneous fat (arrows). B. This image demonstrates more advanced fibrotic changes of chronic panniculitis with irregular thickening of the greater omentum (arrow).

through the right and left gastroepiploic veins that are connected to the portal venous system. Therefore, patients with advanced cirrhosis and portal hypertension can develop marked edema, vascular congestion, and varices in their greater omentum.^{6,21}

An omental hematoma may develop following a blunt or penetrating abdominal injury that causes rupture or dissection of omental vessels. It may also occur spontaneously, after laparoscopy or abdominal surgery, and presenting as a painful mass that resolves gradually in 2–3 weeks.^{21,22} The typical CT appearance of it is a hyper-attenuated area (40–60HU) within the low-density omental fat (Fig. 13).

Omental infarction is rarely spontaneous in this highly vascular structure with abundant collaterals. However, it can occur due to a compromised blood supply following spontaneous torsion or intra-operative injury from compression by retractors. Omental torsion may also be caused when it is twisted due to herniation, postoperative adhesions, or pressure by an intra-abdominal mass or cyst. The CT findings of an infarcted omentum include an ill-defined and heterogenous fat stranding in early stage and a more well-defined fat density with rim enhancement that becomes smaller with evolution on follow-up CT (Fig. 14).²³ This condition is usually associated with abdominal pain or tenderness, leukocytosis, and fever. If the lesion is markedly symptomatic, it can be resected through segmental or total omentectomy. Otherwise, it will undergo a gradual resolution and becomes an area of fat necrosis that may occasionally contain calcifications.²⁴

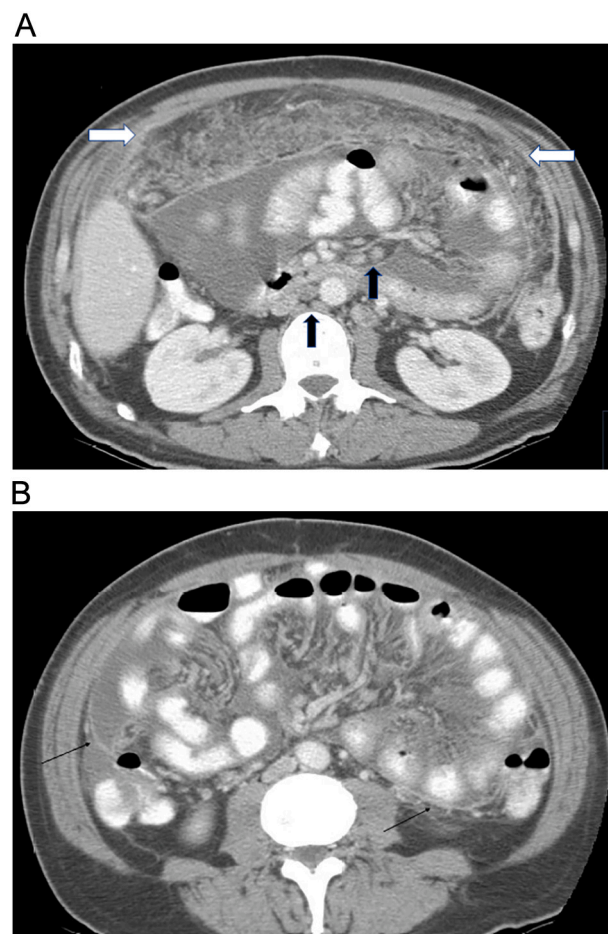


Fig. 10. CT appearance of the greater omentum in a 53-year-old man with abdominal tuberculosis. A. CT section of the upper abdomen reveals a diffusely infiltrated greater omentum with edema and hypervascularity (white arrows). A loculated ascites encapsulates the jejunal loops and there are clusters of lymph nodes in the mesentery and para-aortic regions (black arrows). B. The CT section of mid abdomen shows engorged mesenteric vessels and very smooth peritoneal thickening (arrows).



Fig. 11. Contrast-enhanced CT examination shows marked edema and vascular congestion of the greater omentum in a 43-year-old man with acute pancreatitis (arrows).

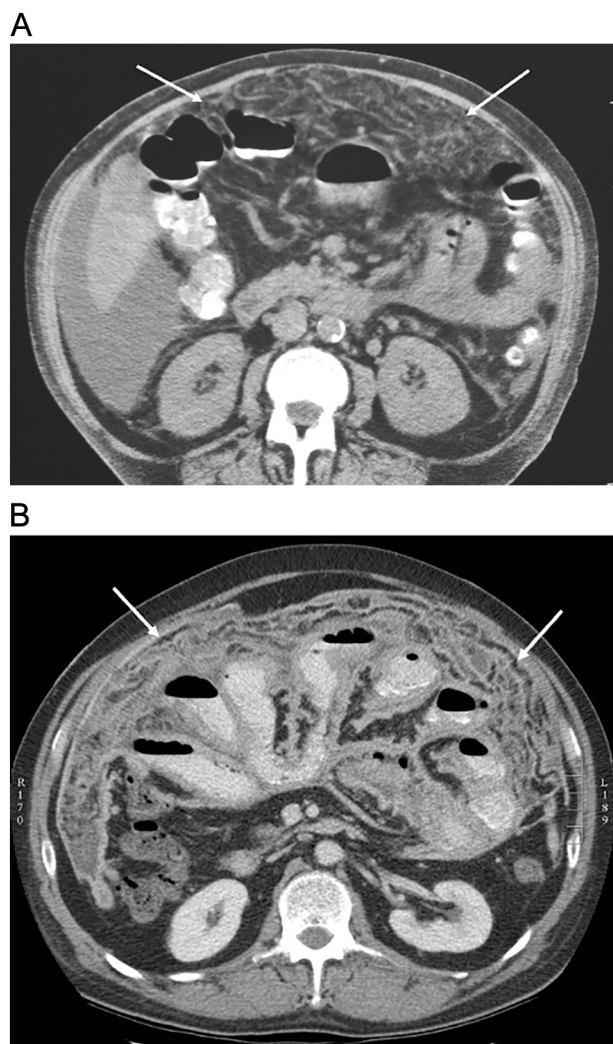


Fig. 12. CT manifestations of omental vascular engorgement. A. This image demonstrates very congested omental vessels due to portal hypertension in a 56-year-old woman with cirrhosis and ascites (arrows). B. Contrast-enhanced CT reveals diffuse thickening and hypervascularity of the greater omentum in a 48-year-old man with advanced pancreatic carcinoma (arrows).

7. Omental herniations

Anatomical location of the greater omentum directly beneath the anterior abdominal wall will predispose it to protrusion through the umbilical or ventral defects. It will initially present as a simple fatty mass in these hernias. Once the hernia becomes incarcerated, however, there will be marked vascular congestion and edema of the protruding greater omentum (Fig. 15).

Less common sites of omental protrusion are in the inguinal and Bochdalek hernias. Congenital or postsurgical defects of the greater omentum can also lead to transomental herniation of the small bowel, causing closed loop obstruction.²⁵

8. Miscellaneous conditions

The attachment of greater omentum to the transverse colon provides a pathway for direct extension of pathological processes from the colon

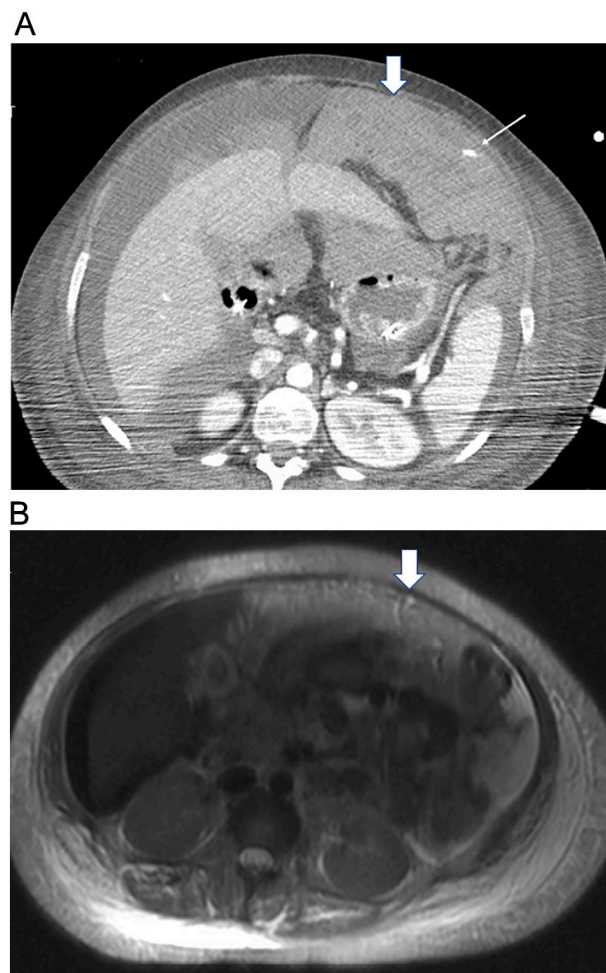


Fig. 13. Hematoma of the greater omentum in a 26-year-old woman with cystic fibrosis. A. CT image shows the omental hematoma as an area of increased attenuation (large arrow). The ruptured small branch of an omental artery (small arrow) and associated hemoperitoneum are visible. B. MRI study 3 weeks later reveals resolution of the omental hematoma (arrow), but residual fluid is seen around the liver. T2-weighted hASTE sequence.

to the omentum. This occurs mainly in the inflammatory or neoplastic lesions. However, some benign conditions such as pneumatosis coli, the intramural gas cysts can also involve the adjoining greater omentum (Fig. 16A).²⁶

In patients with perforated viscus the extraluminal gas is usually trapped under the greater omentum in supine position and easily demonstrable on CT examination (Fig. 16B). These small gas bubbles would make it very difficult to recognize the presence of free air on supine abdominal radiographs. Therefore, it has been the recommended practice that radiographs in upright and left decubitus positions be obtained in patients with suspected intestinal perforation. The reported diagnostic accuracy of abdominal radiographs for detecting pneumoperitoneum remains in the range of 40% to 60% as compared to almost 100% for CT examination.²⁷

Calcifications of the greater omentum are uncommon but may occur due to various conditions. Stippled calcifications are usually due to metastases from serous cystadenocarcinoma of ovary, mucinous adenocarcinomas of the stomach or colon, and mesothelioma (Fig. 16C).

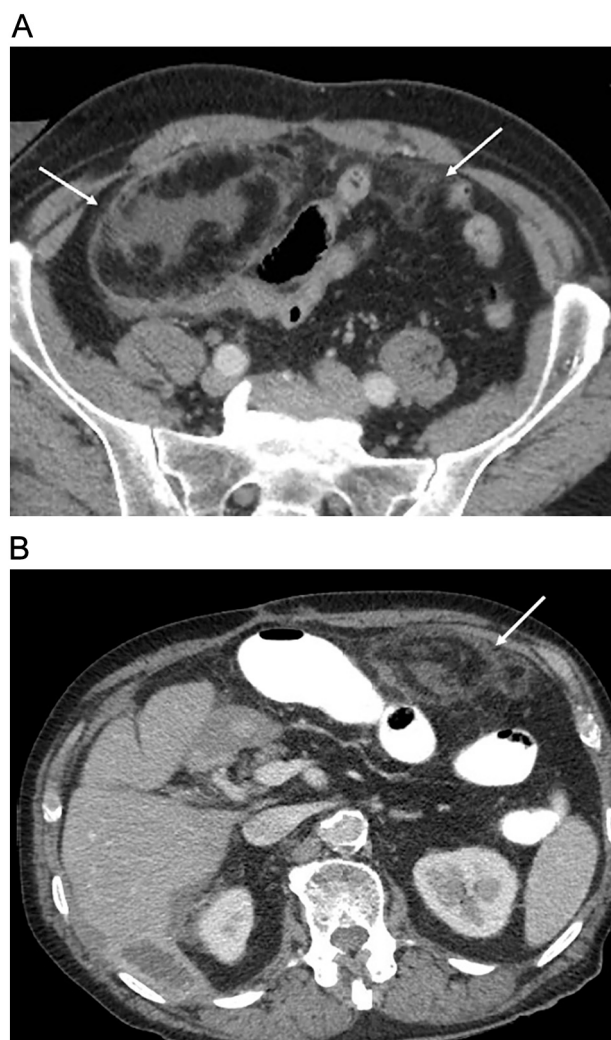


Fig. 14. CT appearance of omental infarct in 2 patients. A. CT examination following right hemicolectomy for cancer in this 63-year-old man demonstrates edema and fluid collection within the greater omentum (arrows). B. CT section of the upper abdomen after surgery for cecal volvulus in this 82-year-old man shows an area of distorted omental fat with contrast-enhanced margins (arrow). A subhepatic abscess cavity with fluid and thick walls is also present.

Larger calcific deposits may be caused by tuberculosis, meconium peritonitis, and peritoneal dialysis.²⁸ On rare occasions an intraperitoneal foreign body, such as spilled gallstone during laparoscopic cholecystectomy, is engulfed by the greater omentum. This will lead to its encasement and formation of a fibrotic or calcified omental granuloma that can be demonstrated on CT.^{7,21,29}

The mobility and biological functions of the greater omentum allows its usage as a patch to seal and shield a perforated ulcer or wrap around the gastrointestinal or vascular anastomotic sites as a protective barrier against leakage. It is also used frequently in regenerative surgery because it can be easily exteriorized as a pedicular graft and to fill the hepatic defects following resection of a solitary liver metastasis (Fig. 16D).^{1,4,30}

A total omentectomy is usually performed in patients with gynecological malignancy because it is involved in up to 37% of cases and indicates a poor prognosis. To reduce the tumor burden, an omentectomy is included in the cytoreductive surgery.^{4,31,32} A partial or complete omentectomy may also be required during resection of the colon, surgical treatment of other intra-abdominal malignancies, and in cases of omental tumors, torsion, and infarct. Furthermore, the omental wrap around the peritoneal dialysis catheter or ventriculoperitoneal shunts

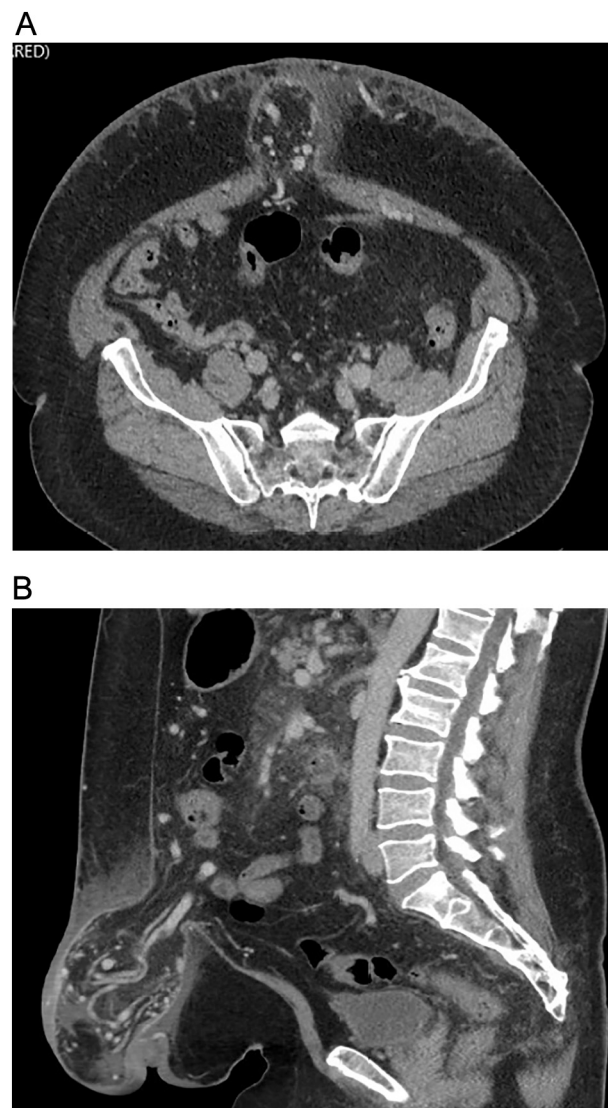


Fig. 15. Greater omentum in an incarcerated umbilical hernia. A. CT examination of this 54-year-old man demonstrates omental protrusion through the umbilical defect associated with periumbilical inflammation. B. Sagittal section shows marked vascular engorgement of the herniated greater omentum.

can cause their malposition and dysfunction, requiring surgical intervention. The clinical indications for omentectomy and its potential effects on morbidity and mortality of patients with various abdominal pathologies was recently reviewed by Atay and Dilek.³³

9. Conclusions

The pathologic conditions affecting the greater omentum are being recognized with increasing frequency since the introduction of CT and MRI. Until a few decades ago this anatomical structure had been invisible on radiographs and could be evaluated only at laparotomy or autopsy. This article presents the imaging features of the greater omentum in its normal state and in various benign and pathological disorders that affect its appearance on CT and MRI studies. It is important for the clinical radiologists to be familiar with the spectrum of these findings because they often provide significant clues to the diagnosis of underlying intra-abdominal process.

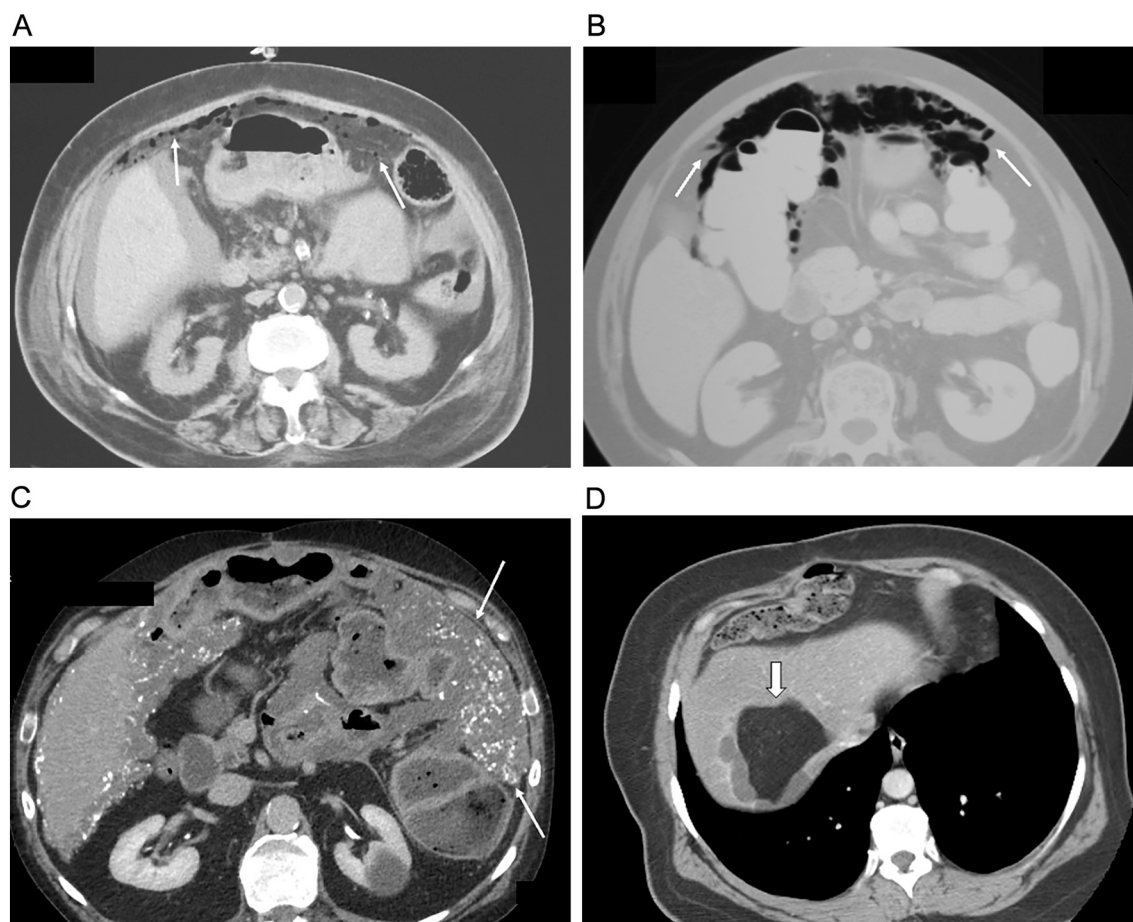


Fig. 16. Miscellaneous conditions involving the greater omentum. A. CT shows the extraluminal gas bubbles that are entrapped in the greater omentum (arrows). The pneumoperitoneum and ascites in this 75-year-old man were due to peritoneal dialysis. B. Pneumatosis coli extending to the greater omentum (arrows) and liver surface caused by metastases from a mucinous adenocarcinoma of the colon in this 58-year-old woman. C. Stippled calcifications of the greater omentum (arrows). D. CT appearance of omental packing into a hepatic defect after resection of a solitary metastasis from colorectal cancer in a 47-year-old woman (arrow). Note that the translocated greater omentum has pulled the attached transverse colon in front of the liver.

Declaration of competing interest

The author declares no conflict of interest and no disclosure relevant to the subject matter of this article.

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