Review Article
pISSN 1738-2637 / eISSN 2288-2928
J Korean Soc Radiol 2016;75(1):1-11
http://dx.doi.org/10.3348/jksr.2016.75.1.1
대한영상의학회지

CT Findings of Benign Omental Lesions Following Abdominal Cancer Surgery
복부 암종 수술 후 대망에서 발생한 양성 병변의 전산화단층촬영 소견

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The greater omentum is the largest peritoneal fold and can be the origin of primary pathologic conditions, as well as a boundary and conduit for disease processes. Most diseases involving the omentum manifest with nonspecific and overlapping features on computed tomography (CT). In particular, varying benign disease processes of traumatic, inflammatory, vascular, or systemic origin can occur in the omentum during the follow-up period after surgery for intra-abdominal malignancy. It can be challenging for radiologists due to various spectrum of CT findings. Thus, we reviewed the CT findings of various benign omental lesions after surgery for intra-abdominal malignancy.

Index terms
Omentum
Abdomen
CT

Received December 22, 2015
Revised February 23, 2016
Accepted April 6, 2016
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INTRODUCTION

The greater omentum is frequently involved in the intra-abdominal dissemination of gastrointestinal and ovarian malignancies, either during primary seeding or as a site of recurrent cancer after surgical treatment (1-4). Therefore, the greater omentum, historically, was totally resected during surgery for abdominal cancer. However, several studies of omentum-preserving operations show a lower rate of postoperative complications and no statistically significant difference in patient survival, as compared with total omentectomy (5-7). Therefore, the use of omentum-preserving operations has recently been increasing, especially for gastric cancer surgery. However, a variety of benign lesions of traumatic, inflammatory, vascular, or systemic origin can occur in the remnant omentum. Various findings are visible on computed tomography (CT), including hazy stranding, nodules, mass formation, and diffuse infiltration.

In this article, we review the CT findings of a variety of benign omental lesions after abdominal cancer surgery. The appearances of benign omental lesions on CT are classified into four categories, according to the etiopathogenic mechanism: 1) traumatic omental lesions; 2) inflammatory omental lesions; 3) vascular omental lesions; and 4) omental lesion from systemic causes.

ANATOMY

The greater omentum is the largest peritoneal fold and is composed of descending and ascending portions that fuse to form a four-layer vascular fatty apron (8, 9). The greater omentum extends from the greater curvature of stomach, covers the small bowel, and then folds back to fuse with the transverse colon and transverse mesocolon (Fig. 1). Blood is supplied to the greater omentum from the right and left gastroepiploic arteries, which branch into three vessels: right, left, and middle omental arteries (10).

On CT, the greater omentum normally appears as a band of fatty tissue with a variable width, located just beneath the anterior abdominal wall and anterior to the stomach, transverse colon, and small bowel.

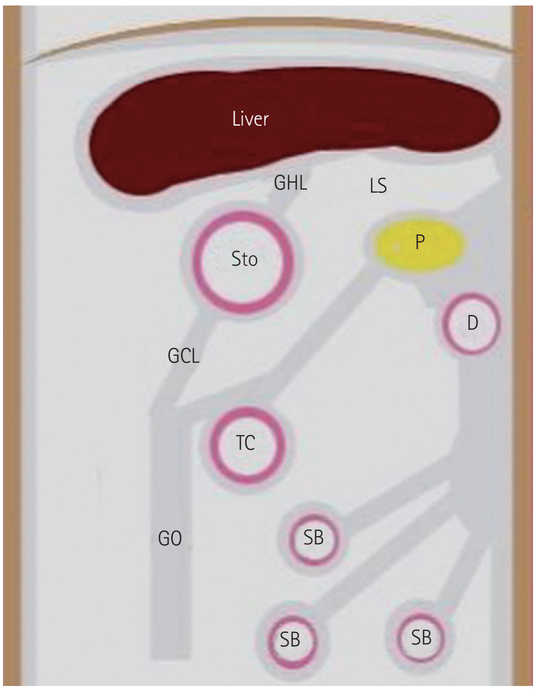


Fig. 1. Illustrations show sagittal anatomy of abdominal cavity.
D = duodenum, GCL = gastrocolic ligament, GHL = gastrohepatic ligament, GO = greater omentum, LS = lesser sac, P = pancreas, SB = small bowel, Sto = stomach, TC = transverse colon

TRAUMATIC OMENTAL LESION

Omental Contusion

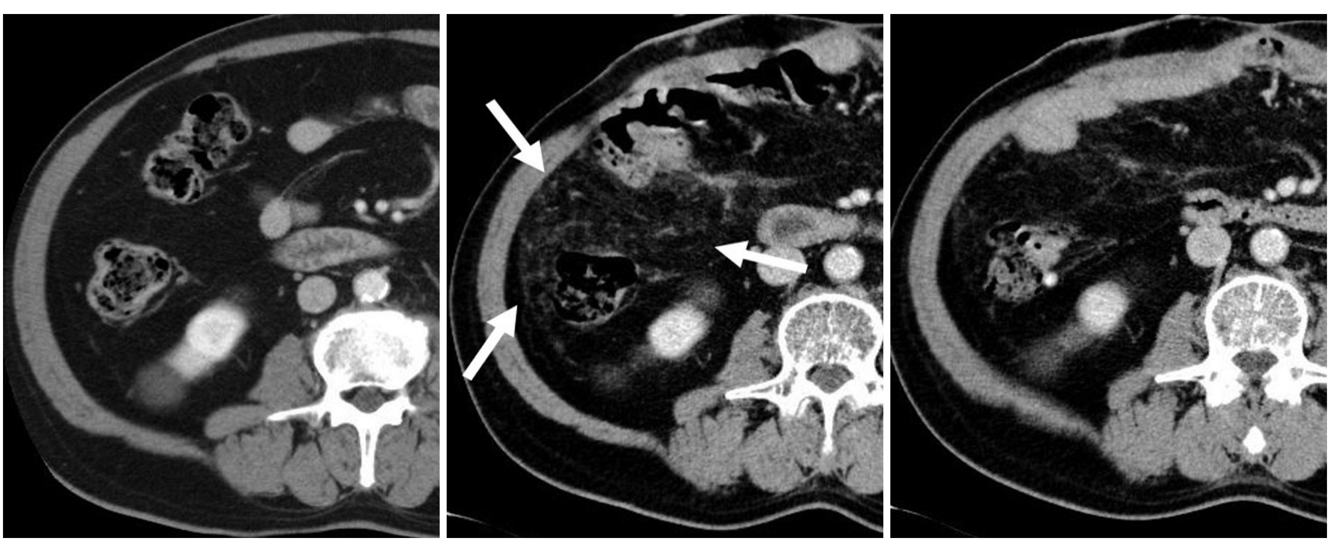
Postoperative omental contusion is reportedly related to intraoperative mechanisms, ranging from retraction injury to omental manipulation (11). Omental contusion is a temporary and self-limiting post-surgical change.

On CT, the linear soft tissue density stranding and higher attenuation of omental fat can be seen in the early postoperative period (Fig. 2). These findings correspond to a contusive edema or hemorrhagic infiltration of the omentum (12).

On short-term follow-up CT, complete resolution of these findings can be favorable for diagnosis of omental contusion. Persistence of omental lesions on follow-up CT can reliably exclude the diagnosis of omental contusion.

Omental Hematoma

Omental hematoma usually occurs during penetrating or blunt trauma, including seat belt-related injuries in high-speed deceleration events. It is caused by rupture or dissection of the omental vasculature (13, 14). Omental hematoma can also occur as a postoperative condition by a similar mechanism. In laparoscopic surgery, omental hematoma can occur near the trocar port site, as a result of direct injury to the omental vasculature. Additionally, it might also be related with failed surgical hemostasis of



A B C

Fig. 2. Omental contusion in a 74-year-old man who underwent low anterior resection for rectal cancer.
A. Preoperative CT reveals no omental lesion.
B. Contrast-enhanced CT scan obtained 15 days after operation shows ill-defined haziness (arrows) in the right side of the greater omentum.
C. Follow-up CT at 2 months after operation shows resolution of the omental lesions.

the omentum, such as slippage of the hemostatic suture or clip.

The CT findings of omental hematoma are similar to those of hemorrhage in other sites. During active bleeding, contrast-enhanced CT shows extravasation of contrast material, and non-enhanced CT shows a high-attenuated (40–60 Hounsfield unit), mass-like lesion in the omentum (Fig. 3). The diagnosis of omental hematoma is facilitated by locating the hematoma near the trocar site of laparoscopic surgery. The follow-up CT reveals gradual resolution of the hematoma.

Heterotopic Omental Ossification

Heterotopic ossification is abnormal bone formation in tissues that do not normally ossify. Most intra-abdominal heterotopic ossification occurs in the mesentery, which is called heterotopic mesenteric ossification. Omental involvement of heterotopic ossification is an extremely rare event that is called heterotopic omental ossification and considered one type of heterotopic mesenteric ossification (15).

The pathogenesis remains unknown, but is generally accept-

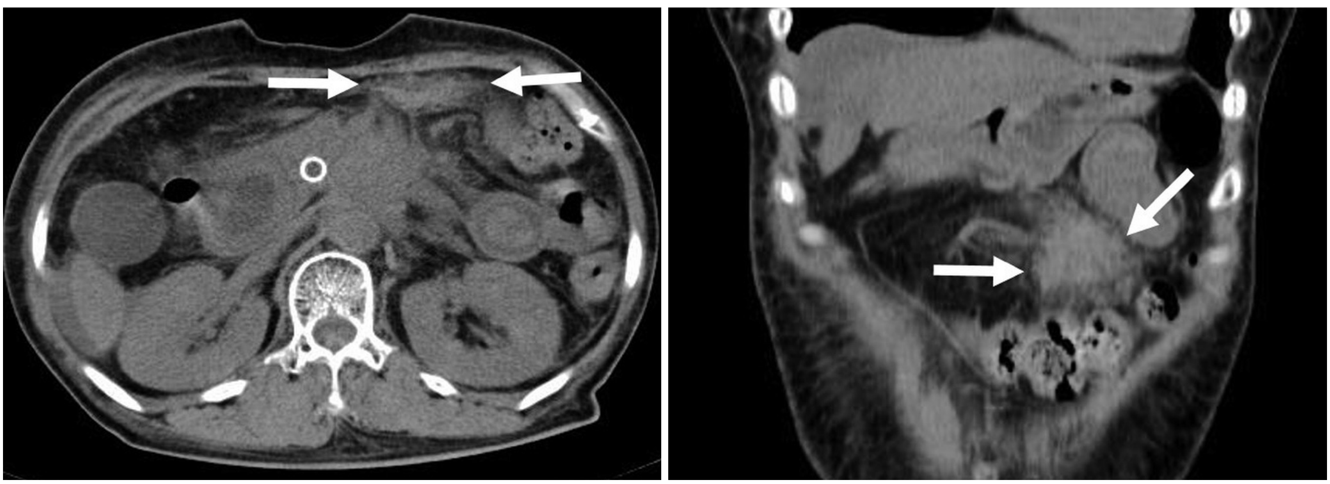


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Fig. 3. Omental hematoma in a 57-year-old woman after laparoscopic biopsy for pancreatic cancer.
A. Non-contrast CT scan shows high density lesion (arrows) in the greater omentum. The metallic stent is inserted in the CBD.
B. Coronal reformatted image reveals ill-defined high density lesion (arrows) in the left side of the greater omentum.
CBD = common bile duct

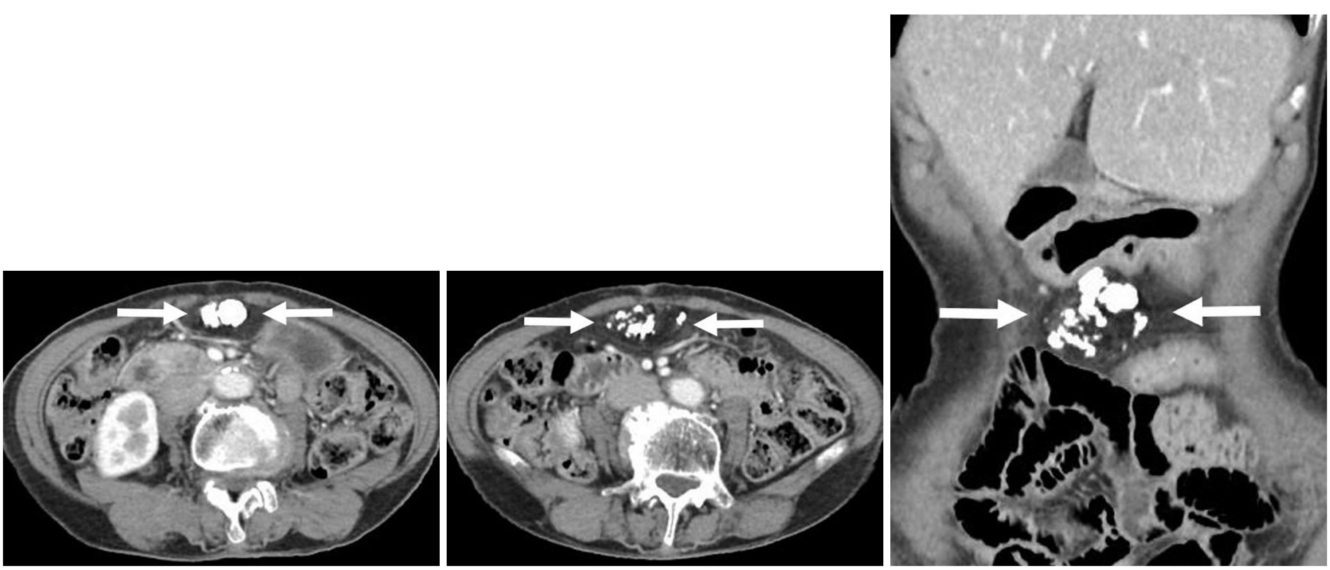

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Fig. 4. A 53-year-old man with heterotopic omental ossification after low anterior resection for rectal cancer 2 months ago.
A, B. Axial CT scans show ossified mass like lesion (arrows) in the greater omentum just beneath the incision skin line.
C. Coronal reformatted image shows ossified lesion (arrows) along the greater omentum.

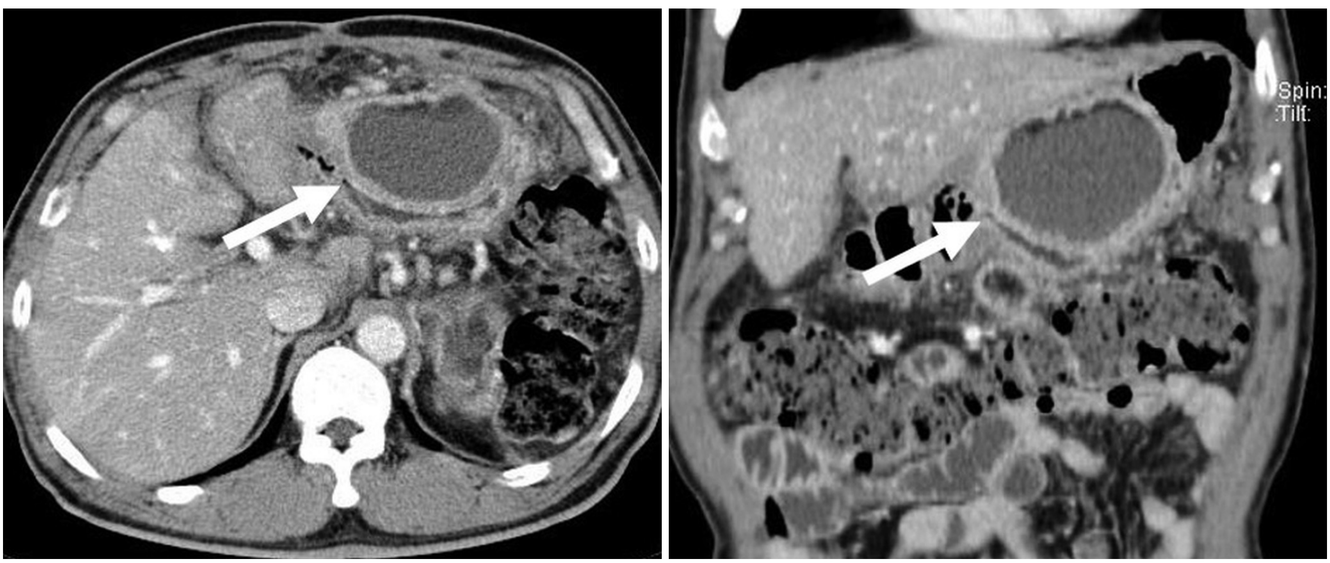
ed as the differentiation of immature multipotent mesenchymal cells into osteoblasts or chondroblasts as a reaction to a variety of stimuli, including trauma, burns, prolonged immobilization, infection, prior surgery, and neoplasia (16, 17). Heterotopic omental ossification is usually associated with laparotomy and colectomy (18). Ossification rapidly (mean, 1–2 weeks) develops postoperatively (15).

CT helps to confirm the diagnosis and shows ossification in the omentum, especially along the incision site (Fig. 4). The ossification in the omentum and mesentery can occasionally be extensive. Bone scanning with Tc 99m pyrophosphate is useful for early diagnosis before calcification or ossification is observed on a plain radiograph (17, 19).

INFLAMMATORY OMENTAL LESION

Omental Abscess

Postoperative omental abscess is usually associated with peritonitis caused by contamination or bowel spillage during surgery or by leakage from the stump or anastomosis site in the postop-



A B

Fig. 5. Postoperative omental abscess in a 59-year-old man who underwent total pancreatectomy and splenectomy for intraductal papillary neoplasm of the pancreas.
A. Postoperative CT scan obtained 5 months after surgery shows loculated fluid density lesion with thick enhancing wall (arrow) in the greater omentum. The stomach is compressed by the abscess.
B. Coronal reformatted image reveals abscess cavity (arrow) in the greater omentum.

A B C

Fig. 6. Gossypiboma in a 53-year-old woman who underwent total abdominal hysterectomy for cervical cancer 3 months ago.
A. Non-contrast CT scan shows large cystic mass with high density of wavy appearance (arrows) and mottled air bubbles (arrowheads) in the greater omentum.
B, C. Arterial **(B)** and portal **(C)** phase of contrast-enhanced CT scans reveal thick capsular enhancement of the lesion (arrows).

erative period (20). Omental infarction can also progress to omental abscess (11, 21).

The CT findings of omental abscess are similar to those of an abscess in other sites. CT reveals a well-defined fluid-density lesion with a peripheral enhanced wall (Fig. 5). Additionally, an inflammatory infiltrative process surrounding the omental abscess is seen as omental haziness and soft tissue stranding in the greater omentum. Occasionally, the abscess can demonstrate gas bubbles or air-fluid levels in gas-forming infections.

Foreign Body Granuloma (Gossypiboma)

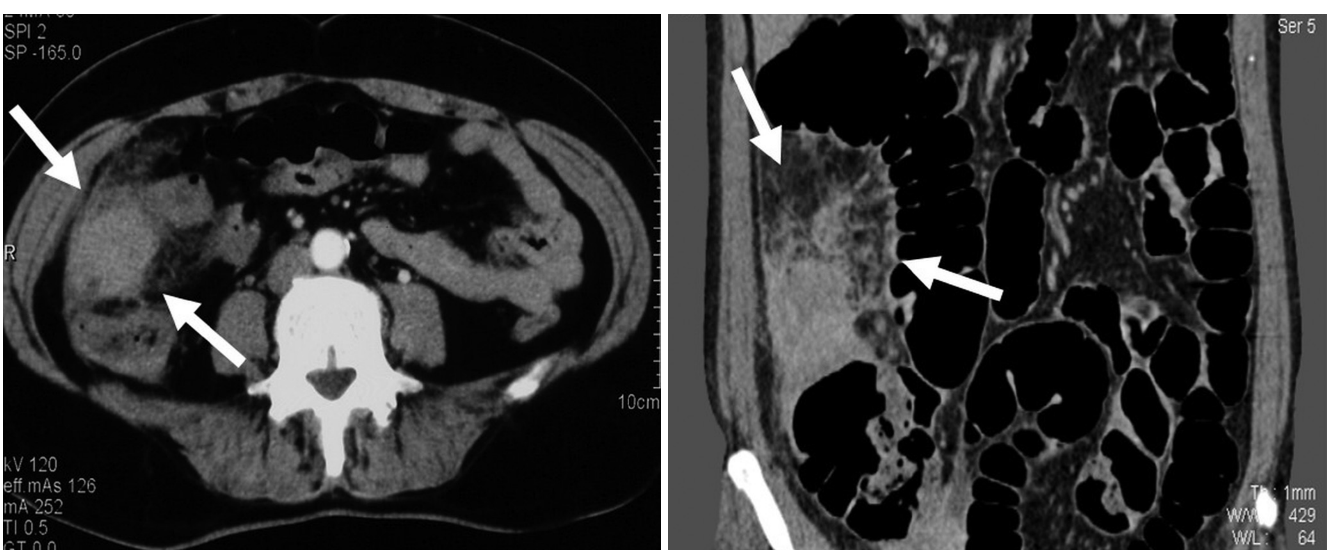
Foreign body granuloma develops from retention of surgical foreign bodies that are left behind in the body cavity during surgery. Various surgical foreign bodies can cause foreign body granuloma. Of these, laparotomy sponges are the most commonly reported surgically retained foreign body, or gossypiboma (22). Although they can be present in any cavity, gossypibomas are most frequently discovered in the intra-abdominal cavity (23). Omental involvement is rare.

Pathologically, inert foreign bodies, such as surgical sponges, can cause two types of foreign body reaction (24). One is an aseptic fibrous response that leads to adhesions and encapsulation, resulting in granuloma formation. Another is an exudative response that induces abscess formation with or without secondary bacterial invasion, which results in various fistulas (23, 24). The clinical presentations of gossypiboma are broad, ranging from none to fatal, and can manifest from the immediate postoperative period to decades after surgery (23, 25, 26).

CT is the imaging modality of choice for gossypiboma. The most characteristic CT finding is a whorl-like spongiform heterogeneous hypodense mass containing air bubbles and a thick peripheral high-density wall that is further highlighted on contrast-enhanced imaging (Fig. 6) (23, 24). The mass might contain wavy, striped, high-density areas that represent the sponge itself (27). A long-lasting gossypiboma shows a calcified reticulate rind sign that may be ascribed to long-standing deposition of calcification along the network architecture of a surgical swab (28).

Omental Panniculitis

Intra-abdominal panniculitis is a rare idiopathic disease that is characterized by fat necrosis, chronic inflammation, and fibrosis of intra-abdominal adipose tissue. Although there is no definite cause of intra-abdominal panniculitis, it is often associated with many medical conditions and diseases, such as abdominal surgery, trauma, drugs, infection, autoimmune disease, or malignancy (29). Of these, malignancy and abdominal surgery are suggested to trigger the development of intra-abdominal panniculitis (29, 30).



A B

Fig. 7. A 50-year-old woman with omental panniculitis after radical total gastrectomy for gastric cancer.
A. Contrast-enhanced CT scan obtained 3 years after operation shows soft tissue density mass like lesion (arrows) in the right side of the greater omentum.
B. Coronal reformatted CT image reveals well-defined mass like lesion with surrounding fatty infiltration (arrows) in the greater omentum. It was pathologically confirmed to omental panniculitis by right hemicolectomy.

Intra-abdominal panniculitis mainly involves the small bowel mesentery, especially at its root, and occasionally the mesocolon. It rarely involves the peripancreatic area, retroperitoneum, pelvis, and omentum (29). In particular, isolated omental involvement is extremely rare. Currently, only 5 cases of isolated omental panniculitis are reported in the literature (31-35).

The characteristic CT findings of intra-abdominal panniculitis are widely known: slightly increased fat density with a regional mass effect, soft tissue nodules, fat-ring sign (fat density preservation around vessels and nodules), and tumoral pseudocapsule (hyperattenuating pseudocapsule surrounding fat) (29, 31). The fat-ring sign and tumoral pseudocapsule are very specific for the diagnosis of intra-abdominal panniculitis (29, 36, 37). Isolated omental panniculitis shows varying CT features, ranging from mild infiltration to a soft tissue density mass (Fig. 7). CT can also reveal a fat-ring sign and tumoral pseudocapsule, similar to features of intra-abdominal panniculitis in other sites (31-35).

Pancreatitis-Related Omental Lesion

The incidence of acute postoperative pancreatitis is relatively lower than other well-recognized postoperative complications. However, it is associated with a high mortality rate (38). Acute postoperative pancreatitis is mainly related with surgical injury of the pancreas that can occur during gastrectomy, such as stomach adhesion to the pancreas and pancreatic parenchymal injury from electrocauterization, traction, compromised microcirculation, and direct injury to the pancreatic duct (39, 40). In addition, it is related to extended lymph node dissection and distal pancreatectomy or splenectomy in cases of invasion by gastric carcinoma (39, 41).

Omental involvement in pancreatitis is rare. It can occur when extravasated pancreatic enzymes dissect the transverse mesocolon and spread along the omentum, which are characteristic sites involved in severe pancreatitis (9, 42).

CT findings of postoperative pancreatitis-related omental lesion include underlying acute pancreatitis, such as segmental or diffuse enlargement of the pancreas, and extension of inflammatory infiltration, and fluid collections into the transverse mesocolon and omentum (Fig. 8). In the Atlanta classification, these omental fluid collections are classified into four types according to necrosis and elapsed time: 1) acute peripancreatic fluid collection (within 4 weeks, without necrosis); 2) pseudocyst (encapsulated collection after 4 weeks, without necrosis); 3) acute necrotic collection (within 4 weeks); and 4) walled-off necrosis (encapsulated collection after 4 weeks, with necrosis) (43). It is important to localize the origin of the inflammatory process to distinguish between secondary inflammatory changes and primary omental diseases (44).

VASCULAR OMENTAL LESION

Omental Infarction

The greater omentum is a vascular-rich structure that has numerous small vessels with abundant collaterals. Therefore, omental infarction is generally uncommon. However, compromised omental vascularization from various causes can induce segmen-

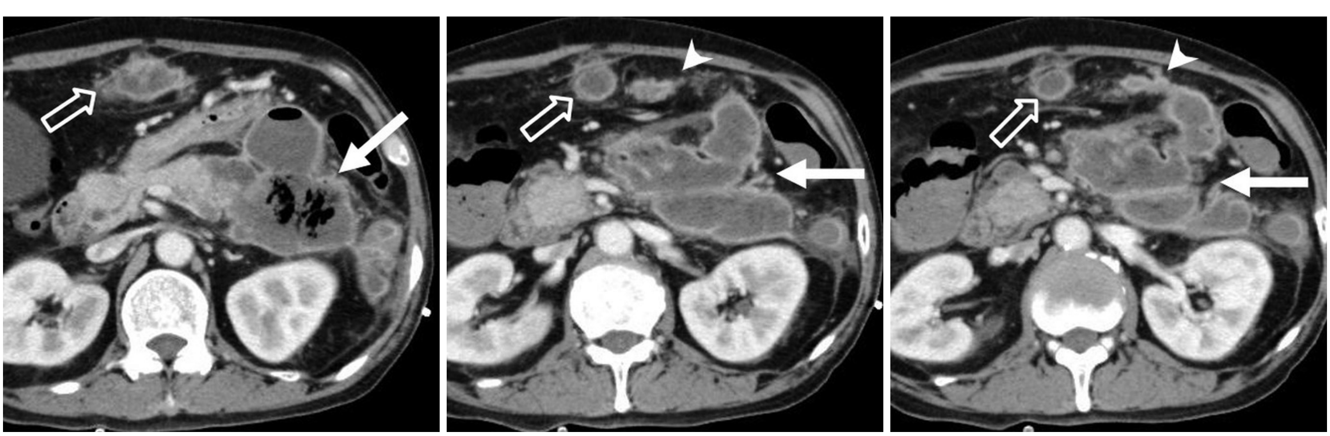


Fig. 8. A 60-year-old man with omental lesion related to pancreatitis who underwent distal pancreatectomy and splenectomy for splenic lymphoma. Contrast-enhanced CT scans obtained 1 month after operation show well defined, encapsulated fluid collection with air bubbles in peripancreatic area (arrows). According to Atlanta classification, these findings are suggestive of walled-off necrosis. Continuity (arrowheads) between omental lesion (blank arrows) and peripancreatic walled-off necrosis is observed.

tal omental infarction, which clinically manifests as localized abdominal pain, nausea, vomiting, anorexia, diarrhea, and fever. According to the classification proposed by Leitner et al. (45), omental infarction might be primary or secondary and occur with or without torsion. Primary omental infarction, with or without torsion, is related with congenital anatomic variations, mostly in obese patients (45-47). Secondary omental infarction with torsion might be caused by pathological foci of omentum such as cysts, inflammation, masses, or scars (47, 48). Omental infarction without torsion might be secondary to a predisposing condition, such as cardiovascular disease, trauma, heavy meals, and surgery (11).

Postoperative omental infarction can be caused by torsion due to adhesion or a surgical scar and by direct cutting of omental vessels during the operation (49-51). In an omentum-preserving operation, the greater omentum is partially divided, leaving the distal omentum attached to the transverse colon. The right and middle omental arteries, including the gastroepiploic artery, are cut while the omentum is partially divided (Fig. 9). Therefore, although the omentum is a vascular-rich structure, infarction can occur in the omentum during the postoperative follow-up period (52).

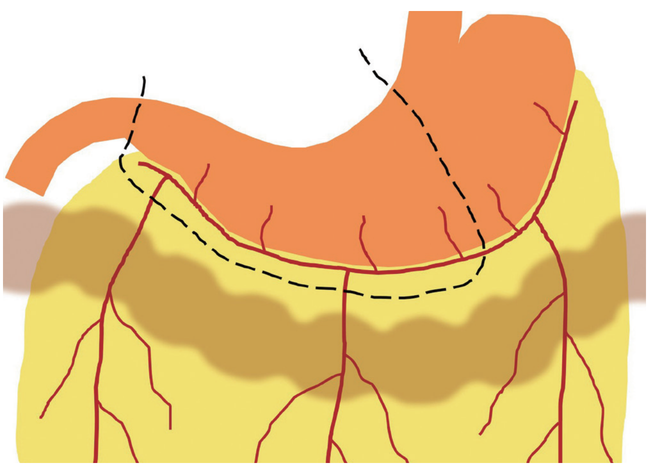
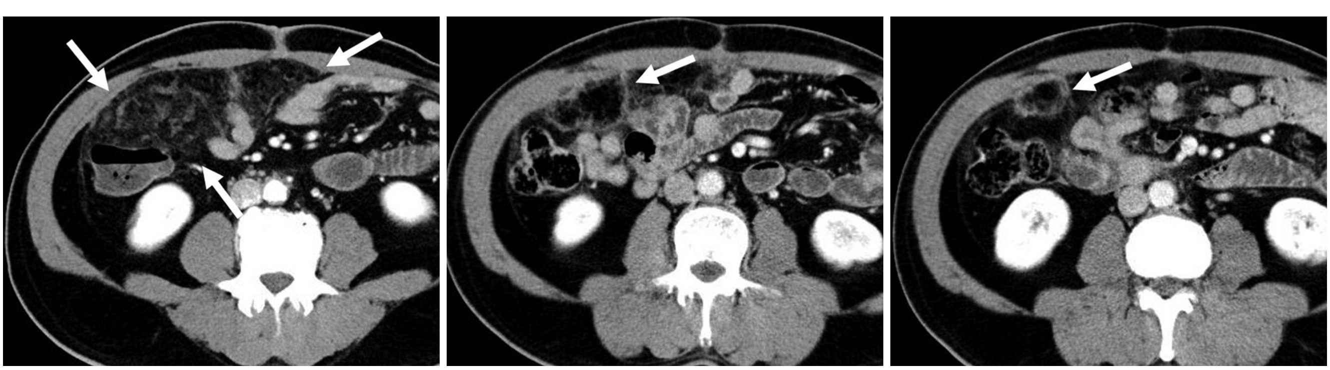


Fig. 9. Schematic figure of the omentum-preserving gastrectomy. Dotted line indicates the incision line of the greater omentum during omentum preserving operation.

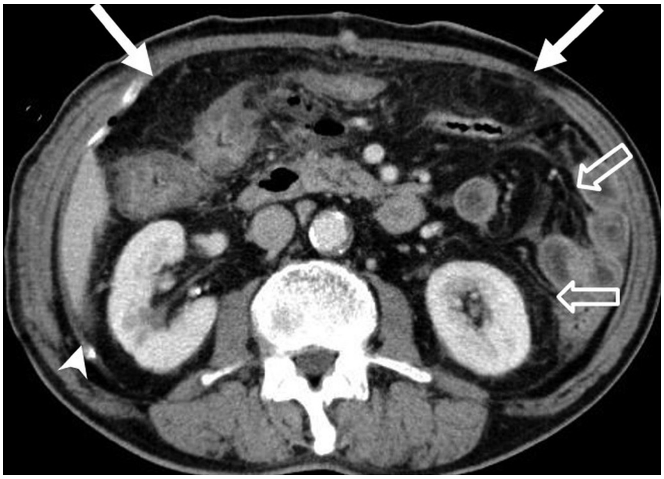
The CT findings of omental infarction progress from an ill-defined, heterogeneous fat density lesion in the early stage (< 15 days) to a well-defined, smaller lesion with a hyperdense rim (> 30 days) (47). The appearance of postoperative omental infarction on CT can be classified into four types: type 1 (ill-defined, heterogeneous, fat density lesion); type 2 (well-defined fat density lesion with rim enhancement); type 3 (well-defined heterogeneous lesion with a fat component); and type 4 (well-defined heterogeneous lesion without a fat component) (52). The initial CT appearance of postoperative omental infarction presents as a type 1 lesion, which can progress to types 2 and 3 (Fig. 10). All infarctions become smaller and better defined with evolution on follow-up CT.

Omental infarction may not contain fat components in the late stage (type 4). Therefore, the radiological differentiation between a type 4 omental infarction and omental metastasis can be difficult. In such a case, review of the previous CT images can be helpful in differentiating omental infarction from omental metastasis (52).



A B C

Fig. 10. A 55-year-old woman with omental infarction who underwent subtotal gastrectomy for gastric cancer.
A. Contrast-enhanced CT scan obtained 2 months after operation shows ill-defined area of increased density (arrows) in the greater omentum.
B, C. Follow-up CT images at 6 months **(B)** and 24 months **(C)** show smaller, fat density lesion with rim enhancement (arrows). The CT appearance of omental infarction was changed from type 1 to type 2 omental infarction.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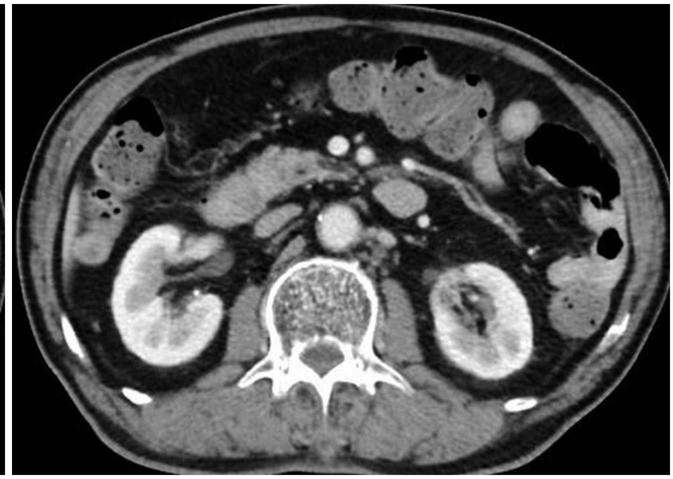
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Fig. 11. Postoperative omental edema in a 80-year-old man with underlying liver cirrhosis after subtotal gastrectomy for gastric cancer.
A. Contrast-enhanced CT scan obtained 10 days after surgery shows diffuse haziness and streaky increased fatty strands at the greater omentum (arrows), small bowel mesentery and retroperitoneum (blank arrows). Ascites is also noted in right subhepatic space (arrowhead).
B. Follow-up CT scan after 6 months shows complete resolution of omental edema with improvement of underlying liver cirrhosis. The edema of small bowel mesentery and retroperitoneum was also resolved.

OMENTAL LESION BY SYSTEMIC CAUSES

Omental Edema Related with a Systemic Condition

Postoperative omental edema can be related to a preoperative systemic condition including liver cirrhosis with portal hypertension, hypoalbuminemia, nephrosis, heart failure, tricuspid disease, and constrictive pericarditis (42). Of these, liver cirrhosis with portal hypertension is one of the most common causes of omental edema (53, 54). When omental edema is secondary to a systemic disease, it is usually combined with mesenteric, retroperitoneal, generalized subcutaneous edema and ascites (42). In patients with liver cirrhosis, omental edema occurs in combination with mesenteric edema, and neither omental nor retroperitoneal edema occurs in the absence of mesenteric edema (55).

The CT findings of omental edema are similar to those of mesenteric edema. They vary from a mild, focal, and infiltrative haze to more diffuse and mass-like appearances, similar to features on CT of other pathologic conditions of the omentum (Fig. 11) (53, 55). With severe systemic conditions that cause omental edema, ascites, subcutaneous edema, and pleural effusion can also occur (42, 55).

On follow-up CT, complete resolution of the omental edema can be observed with improvement in the underlying systemic condition.

CONCLUSION

A variety of benign lesions of the greater omentum can be observed in patients who undergo surgery for an intra-abdominal malignancy. These can be traumatic (contusion, hematoma, heterotopic omental ossification), inflammatory (abscess, foreign body granuloma, panniculitis, omental lesion associated with pancreatitis), vascular (infarction), or systemic in origin. Varying CT findings of these lesions can be challenging for radiologists on follow-up CT. An awareness of the CT features and evolutional changes in these benign omental lesions can help ensure a correct diagnosis and avoid a misdiagnosis.

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복부 암종 수술 후 대망에서 발생한 양성 병변의 전산화단층촬영 소견

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대망은 복강 내 가장 큰 복막 주름으로 복강 내 여러 질환의 진행에 경계 및 통로 역할을 한다. 대망에서 발생하는 질환들은 비특이적이며 중복되는 전산화단층촬영 소견을 나타내는 경우들이 흔히 있다. 특히 복부 암종 수술 후 외상, 염증, 허혈 혹은 전신 질환에 의해 다양한 양성 병변들이 대망에서 발생할 수 있는데 이는 영상의학과 의사들에게 혼란을 야기할 수 있다. 본 종설에서는 복부 암종 수술 후 발생할 수 있는 다양한 양성 대망 병변들의 전산화단층촬영 소견을 기술하고자 한다.

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