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Variants and Pitfalls in Body Imaging; Review Article

CT and MR imaging are often the primary examination considered in the evaluation of patients with a variety of abdominal and pelvic conditions. These exams can be encountered with either incidental irrelevant findings or normal anatomic variants both of which can mimic pathology. In addition, the quality of imaging studies has a direct impact on their proper interpretation and depends on numerous factors. Therefore, optimal protocol and the familiarity of the radiologist with the normal variants and pseudo tumors are essential in the interpretation of such studies. In addition, lack of clinical information such as prior abdominal surgery can be major contributors to misdiagnoses, which can lead to an erroneous management. For CT, these subjects are discussed in the following three categories.

I. Procedural Factors:

To optimize routine CT examinations of the abdomen, several general principles need to be followed. These include optimization of the technical parameters of the CT scanner for a particular clinical indication, achieving optimal contrast enhancement of the targeted solid organs and surrounding structures and adequate distention of the hollow viscera.

The current technology of Spiral (Helical) and multidetector CT (MDCT), allow us in most patients to scan the entire abdomen and pelvis in one or two breath holds often without motion artifact. Thin collimation and a reconstruction interval every 5 mm generally allow adequate CT evaluation. If only axial incremental CT scanning is available, the examination is often optimized by the liberal use of thinner collimation over the area of interest. In MDCT, coronal and sagittal reconstructions will often provide additional diagnostic information and reduce errors and pitfalls.

Administration of oral contrast is essential in CT assessment of the abdomen and pelvis. The amount of contrast, its density, timely administration and proper timing of CT study in relation to the start time of drinking contrast are essential elements in optimal opacification of the GI tract and reduction of the pitfall rate.[1] For evaluation of the pancreas or stomach, using water or gas producing granules prior to CT scanning is often helpful. Inadequate distention or opacification of the hollow viscera can obscure a neoplasm or mimic conditions such as an abscess (Figures 1 and 2).

Intravenous contrast is recommended for CT evaluation of the gastrointestinal tract and it is a requirement for proper assessment of solid abdominal viscera.[2,4] The wall of the hollow viscera if well distended is easily evaluated by performing

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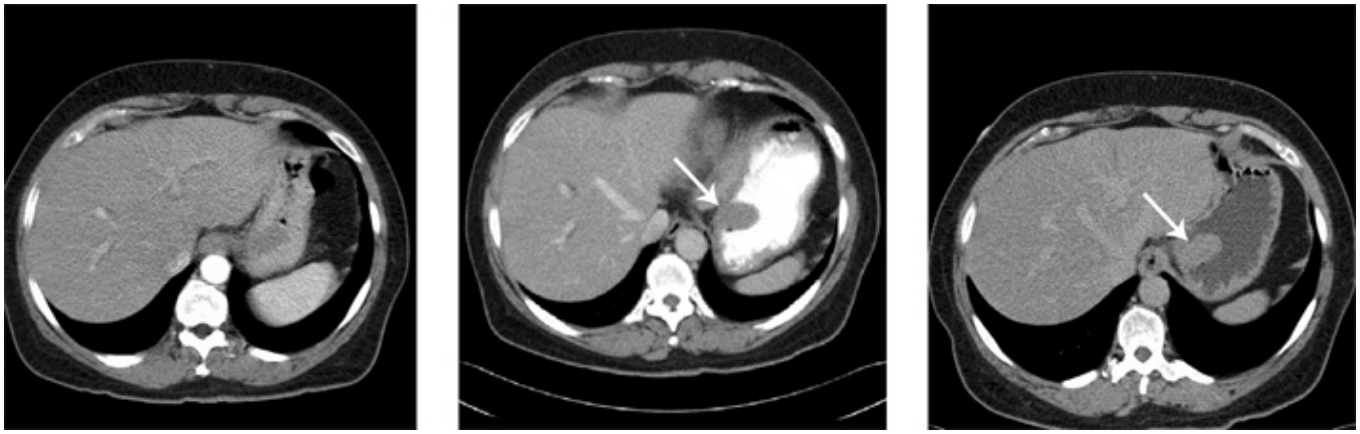

Fig 1. A small stromal tumor in the stomach (GIST) was missed in the initial study. It can be clearly seen in the stomach distended with dilute barium or water.

contrast CT during the late arterial or early portal venous phase. For spiral CT, typically 100-120cc of contrast is injected at a rate of 3-5cc per second and the data is obtained during both arterial and portal venous phases. The arterial phase is generally done at a scan delay of 25-30 second and reflects the enhancement of the solid viscera by their respected arteries. In the liver, this will result in little enhancement as the hepatic artery supplies only 25% of the liver blood. Therefore, there will be a minimal enhancement of the hepatic parenchyma, and the portal and particularly hepatic veins often remain unopacified, which can be a source of diagnostic pitfall. Conversely, hypervascular lesions, which are only seen on the arterial phase, may not be appreciated if only the venous phase is obtained. Hyper-enhanced areas are occasionally encountered in the arterial phase of the liver, referred to as transient hepatic attenuation difference (THAD). This pattern has been described in many conditions that alter the balance of hepatic arterial and portal venous bloodflow to a portion of the liver. These include arterial portal shunts, hypervascular tumors, gallbladder inflammation, hepatic congestion, systemic portal shunts, portal vein thrombosis and superior vena cava obstruction. [1] These intrahepatic areas of attenuation difference may be anatomic and follow a lobar, segmental or subsegmental distribution, or alternatively, in cases such as hepatic congestion, the difference may not follow any obvious anatomic

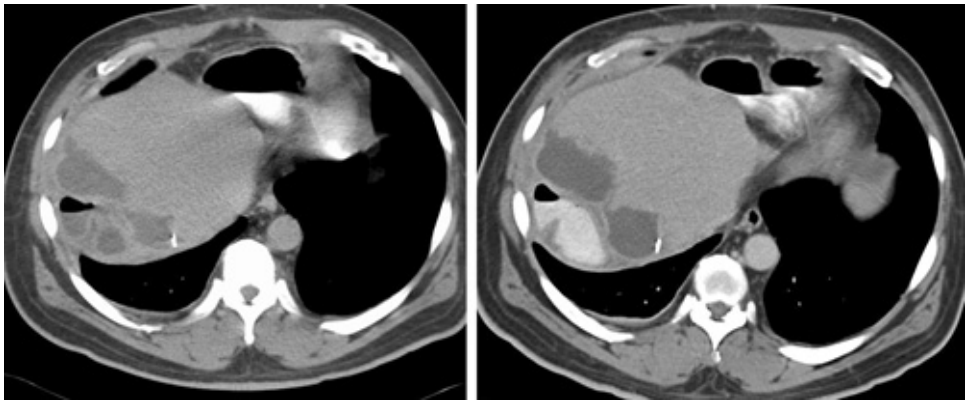

Fig 2. This febrile patient with recent right hepatic lobectomy was thought to have a multiloculated abscess with probable liver involvement. A repeat CT with oral contrast (right) reveals unopacified bowel loops, which mimicked abscess and intrahepatic bilomas.

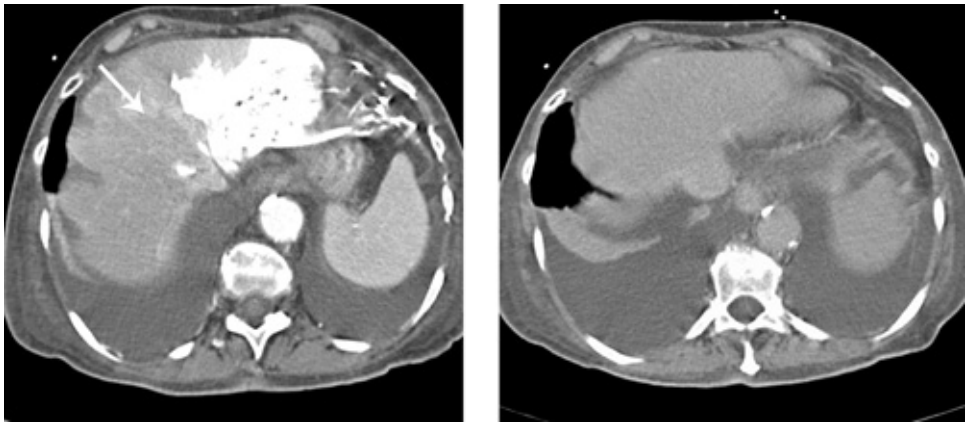

Fig 3. THAD in the left lobe as a result of a patent pericardiopherenic vein. Delayed image (right) does not reveal the enhancing segment.

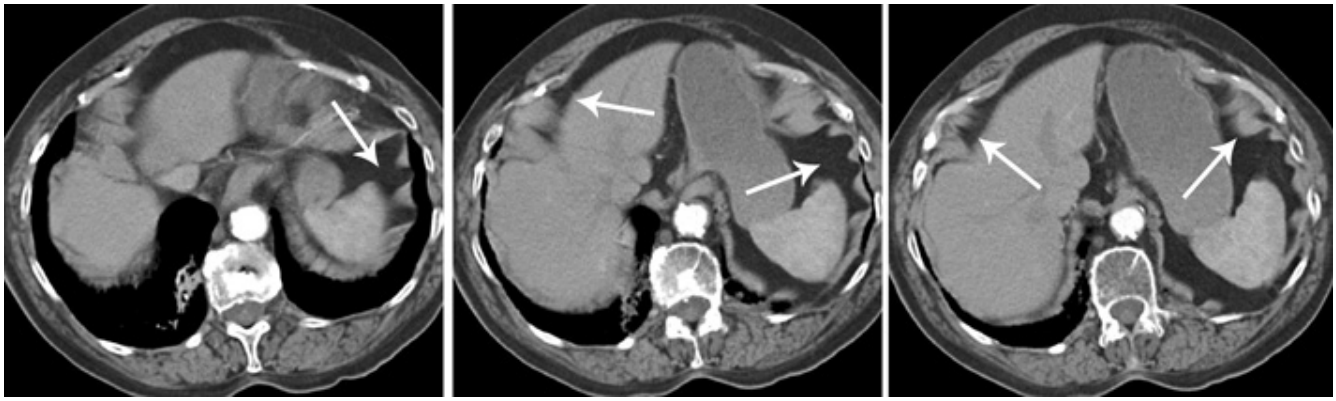

Fig 4. Prominent invagination of muscular fibers of the diaphragm

distribution. Such transient patterns can mimic a hypervascular tumor in the liver (Figure 3).

Rarely, THAD can persist in the portal phase and sometimes the cause remains unknown.

The portal venous phase of hepatic enhancement allows good detection of hypovascular liver tumors and is usually performed using an 80 second scan delay.

Spleen displays heterogeneous enhancement patterns during the arterial phase of contrast enhanced CT and MRI. This is related to variable rates of blood flow to the different histologic components of the spleen. As the terminal arteries transport contrast enhanced blood into the splenic parenchyma, it is first carried into the white pulp before being discharged into the relatively larger volume of red pulp, which is comprised of splenic sinuses and cords. The patterns of heterogeneous enhancement in the spleen have been described as "serpentine", "cord-like", "muddled" or "striped". The term "zebra spleen" has been often applied. By less than two minutes post injection, the normal spleen should demonstrate a homogeneously enhancing pattern.

II. Anatomic Variations:

Diaphragm, liver, spleen, pancreas, kidneys, adrenal glands and the GI tract can have numerous anatomic variants. Such findings on sectional imaging occasionally mimic pathologic conditions.

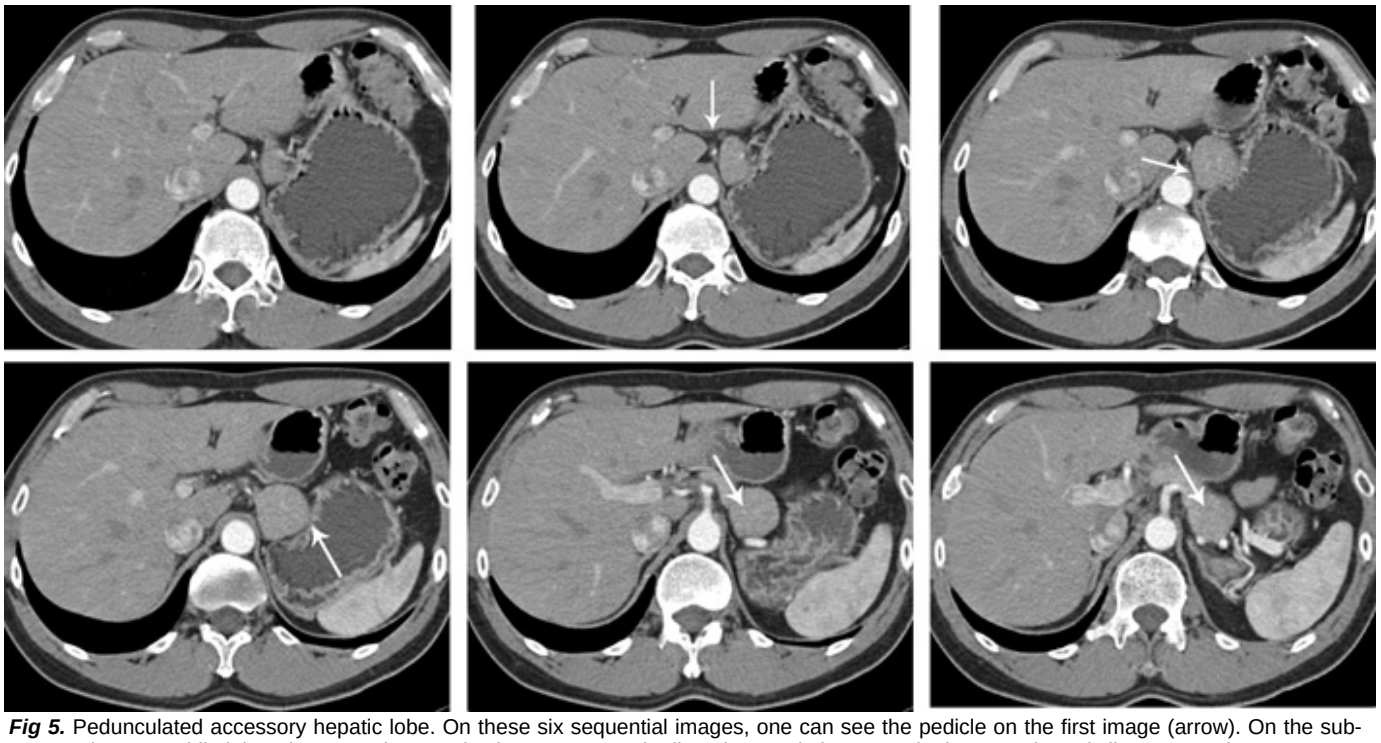

Fig 5. Pedunculated accessory hepatic lobe. On these six sequential images, one can see the pedicle on the first image (arrow). On the subsequent images, while it has the same degree of enhancement as the liver, it can mimic a mass in the gastrohepatic ligament or the pancreas.

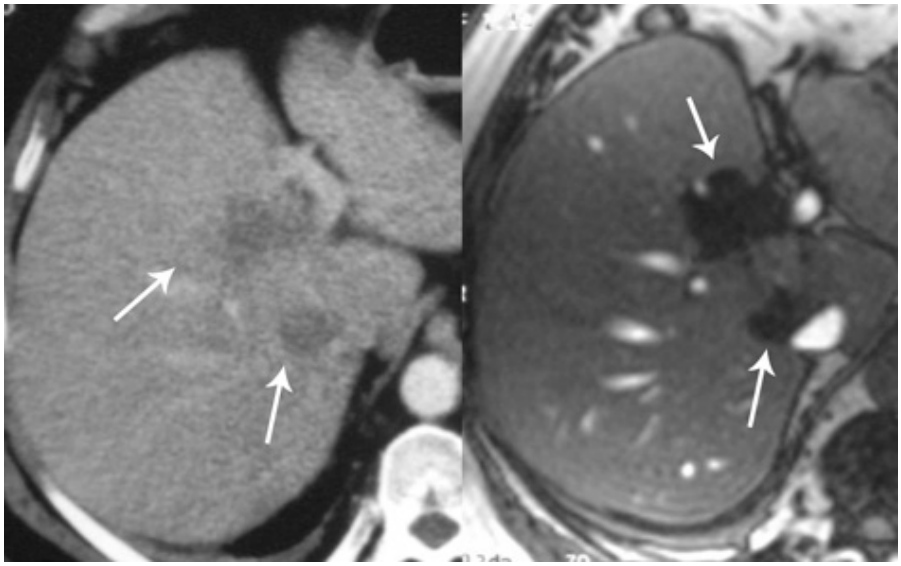

Fig 6. Two focal areas of low attenuation on CT liver CT in a patient with breast carcinoma. Out of phase sequence MR image proves them to represent focal fatty infiltration. Note the normal caliber of a vessel traversing the larger area of low signal.

Muscular fibers of the diaphragm, which are primarily at the peripheral part, may invaginate into the adjacent subdiaphragmatic fat in the upper abdomen and on CT scans or MRI, may be seen as soft tissue nodules (Figure 4). Deeper diaphragmatic invaginations, on the right, can result in accessory liver fissures, which are often seen in the superior aspect of the liver. In the posterior pararenal spaces, the lateral arcuate ligament of the diaphragm may be seen as a soft tissue nodule. These diaphragmatic slips are more common in older persons (nearly 70% frequency in patients older than 70 years, compared with 24% in younger patients) and are more prominent at inspiration or in patients with emphysema. The diaphragmatic crura are ligamentous bands that are tendinous at origin, the right crus is longer and larger and often more lobular than the left one. On axial images of CT or MR, thickened areas of the crura can be mistaken for lymphadenopathy or even an adrenal nodule.

The caudate lobe of the liver may be divided in its inferior part into the medial papillary process and the lateral caudate process. If prominent, the papillary process may appear similar to an enlarged node at the porta hepatis or simulates a mass in the head of the pancreas [1,5] It can extend medially behind the gastric antrum and is separated from the liver on at least oneCT scan in about 20% of the patients. With MDCT, reconstruction of images in different planes will resolve this issue. Pedunculated accessory hepatic lobe is a rare condition and can mimic an enlarged node or a pancreatic mass (Figure 5).

Fatty infiltration of the liver is commonly associated with obesity, diabetes mellitus, Cushing's disease, malnutrition, chronic alcoholic abuse, steroid use or malnutrition related to malignancy or chemotherapy, and intravenous hyperalimentation. Because of differences in perfusion, fatty infiltration of the liver may occasionally appear as regional or focal and should not be mistaken for mass or infarction. Fatty changes, particularly when patchy, perivascular and multifocal can be mistaken for liver metastasis on CT scans. [6] However, presence of an unaltered vascular pattern is a major clue. When focal, in a patient with known malignancy, MRI may occasionally be needed for differentiation from a tumor (Figure 6). In cases of

Fig 7. This 47-year-old woman had a splenectomy due to car accident at the age of 17. She also needed blood transfusion the result of that was hepatitis C, and eventually hepatocellular carcinoma (seen in the middle CT image), 30 years later. Notice multiple implants, which proved to represent splenosis on the nuclear study.

diffuse fatty infiltration, one or several areas of unaffected liver may remain and represent islands of normal hepatic parenchyma called "spared areas".

The spleen has various configurations and positions, and its position depends on the length of the splenorenal ligament. Even with normal lengths, there is some movement to the spleen in supine and prone positions. The length of splenorenal ligament can place the spleen in direct contact, or even dorsal or caudal to the left kidney. An elongated ligament results in "wandering spleen". In addition, "accessory spleen and polysplenia" should not be misdiagnosed as masses. Synchronous and equal enhancement of accessory spleen with the normal spleen is one clue to the diagnosis. Patients with history of traumatic splenic rupture who have had a prior splenectomy are prime subjects to develop intra-abdominal splenosis. This condition results in implantation of splenic tissue on the peritoneal surfaces, which will grow and mimic small nodules or masses. Should the patient develop malignancy at a later age, splenosis shall not be mistaken for metastasis (Figure 7).

Pancreas is traditionally divided into five parts, the uncinate process, head, neck, body and the tail. The first four parts are retroperitoneal while the tail extends into the peritoneum ensheathed in the splenorenal ligament and can have variable configurations. The position of the pancreas is often variable and partly attributed to the increasing laxity in the retroperitoneal connective tissue that accompanies the aging process. Position of the tail also depends on the presence and location of the spleen and the left kidney. Normally, the pancreas has homogeneous density and tapers from its head toward tail, but there are many variations in the contour and density.

Vascular anomalies and normal variants in the retroperitoneum are often related to the inferior vena cava and the left renal vein and may be mistaken for a node on the unenhanced CT. These include transposition or duplication of the IVC and circumaortic or retroaortic left renal veins.

Fat impingement on the IVC can mimic thrombosis. This phenomenon always occurs above the confluence of the hepatic veins and the IVC and a relates to the subdiaphragmatic paraesophageal fat extending laterally and superiorly to impinge on the suprahepatic IVC.

Adrenal glands usually have a linear shape: however, on the left side, the adrenal can have a normal triangular shape (5%) with smooth or concave borders. A gastric diverticulum arising from the gastric cardia, and extending into the left adrenal fossa can mimic an adrenal mass. Oral contrast and scanning in different positions will often clarify the nature of the apparent mass.

III. Postoperative Pitfalls:

Surgery of any type within the abdomen and pelvis may affect the normal orientation of the solid and hollow viscera. This could be due to either organ removal or transplantation or as a result of an erroneously implanted foreign object, implantation of tissue and prosthesis, or creation of ostomies and pouches.

A. Pitfalls as the Result of Organ or Tissue Removal

Surgery may be for removal of solid viscera such as a kidney, part of liver or pelvic organs.

Post nephrectomy pitfalls: As the result of nephrectomy which may be done for renal cell carcinoma, unopacified bowel loops, pancreas, gallbladder, or spleen may occupy the vacant renal fossa mimicking tumor recurrence or simulating an abscess, potentially resulting in unnecessary intervention.

Post hepatic lobectomy pitfalls: Regeneration of the remaining liver by hypertrophy, hyperplasia, or both starts to take place immediately after partial hepatectomy. On CT, this is recognized by progressive enlargement and change in contour for 6 months to 1 year after resection. As a result, the gallbladder is often displaced to unusual locations, mimicking other pathologic conditions.

Post cystectomy pitfalls: Radical cystectomy results in a vacant space, which usually is filled with intestinal loops. Immediate postoperative CT may be obtained to rule out an abscess, and follow-up CT is often requested to rule out any recurrent neoplasm. The use of adequate oral contrast before CT is important in such patients. Ileostomy, particularly when identified with opacified urine, is recognizable on CT: however, a nonopacified continent ileostomy can be mistaken for an abscess or other collections.

Loop Electrosurgical Excision Procedure (LEEP) is a

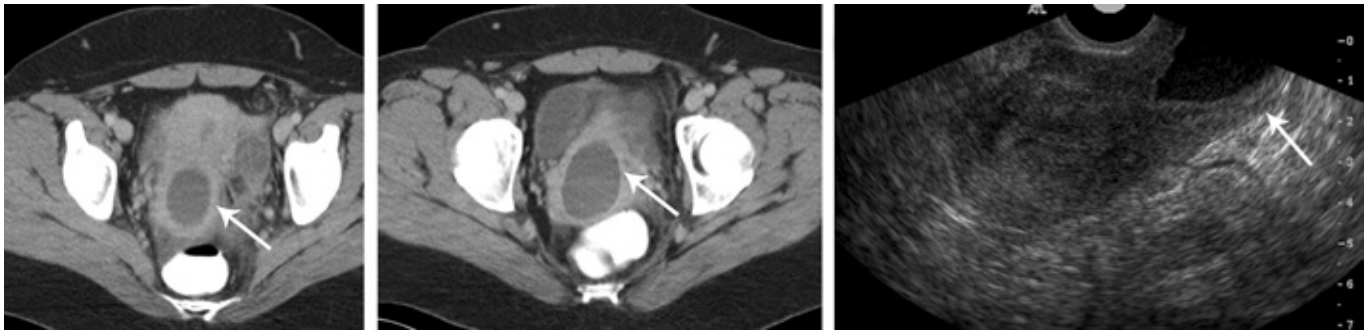

Fig 8. Cervix after LEEP procedure mimicking a cystic lesion. Notice the cystic area on the sagittal transvaginal sonogram.

way to test and treat cervical dysplasia. In some cases, it may be used to treat early stages of cervical cancer. After such procedure, the CT or ultrasound will show the paucity of cervical tissue as a focal cervical canal dilatation mimicking a cystic lesion (Figure 8).

B. Pitfalls as a Result of Abdominoperineal Resection (APR)

After APR for rectal carcinoma, in addition to recurrent tumors, the differential diagnosis of a presacral soft tissue mass should include unopacified bowel loops, relocated pelvic organs such as seminal vesicles or uterus, and postoperative fibrosis. [7,8] Although the recurrent tumor often needs to be proven by biopsy or follow up, recognition of the other conditions is important to prevent an unnecessary intervention (Figure 9).

C. Pitfalls as the Result of Implantation of Tissue and Prosthesis

Whenever postoperative radiation therapy is contemplated in the pelvis, one of the limiting factors in optimizing its effects is the low level of radiation tolerance of the small intestine. [9] Omental fat, synthetic absorbable mesh, or occasionally breast implant have been used during surgery to lift the small bowel out of the radiation field in patients treated for gynecologic or colonic cancers. The omental lid is formed into a pedicle flap, based on either the left or the right gastroepiploic artery, and is usually swung down to the left pericolic gutter to cover the denuded pelvic wall. Such a flap serves both as a vascular bed to absorb the serous drainage and as an x-ray barrier for the bowel loops. Without knowledge of such operations, the radiologist may misinterpret the CT images .[10]

After localized resection of a renal lesion, such as a cyst, stone-filled caliceal diverticulum, or a small renal cell carcinoma, surgeons have used perinephric fat to tamponade the bleeding cut surface of the kidney before closing the renal capsule over the cortical defect. [11] This may also be done in liver cysts (Figure 10). Such fat can be a source of pitfall in the interpretation of postoperative CT or sonogram. Also in removal of large benign liver cyst or hydatid cysts, the surgeon my choose to fill the vacant area with omen-

Fig 9. After APR, two seminal vesicles are displaced inferiorly.

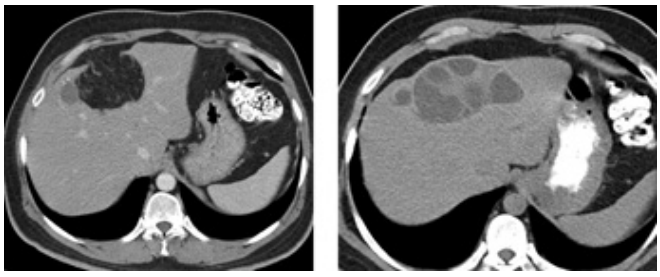

Fig 10. This patient with hydatid cyst of liver (right image) had a cyst removal about a year ago. At the time of operation, the surgeon used omental fat to fill the vacant space in the liver. Notice a small residual cyst on the post-operative CT scan (left image).

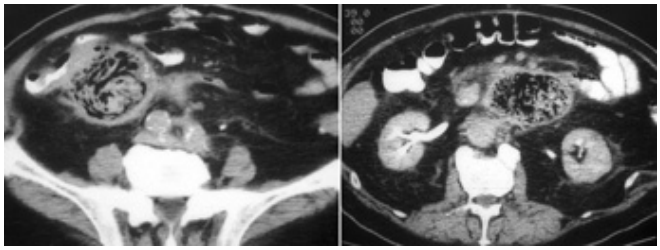

Fig 11. This patient with history of AAA repair was found to have this abnormality extending from LUQ to RLQ. At surgery, a towel was removed,

tal fat.

D. Pitfalls as the Result of Organ Transplantation

The organs commonly transplanted in the abdomen include kidneys, the pancreas, and theliver. Ovaries can be reimplanted for the purpose of protecting them from radiation therapy in the pelvis.

Renal Transplantation: In this condition, the transplanted kidney is easily recognizable. Postoperative complications such as infarctions and abscesses, however, may be difficult to diagnose if proper history is not available.

Pancreatic Transplantation: Such surgery is undertaken in selected patients in an attempt to prevent, arrest, or reverse progression of diabetes complications. A whole or segmental graft may have been obtained from a cadaver, and placed in the pelvis, which may appear as a soft tissue mass on pelvic CT.

Oophoropexy: At the time of radical hysterectomy for early-stage cervical carcinoma, the decision to remove or retain grossly normal ovaries in premenopausal patients involves weighing several competing factors. Ovarian conservation and lateral ovarian transplantation may be used in treating such patients[12]. When pelvic irradiation is planned, the ovaries are mobilized at the time of surgery. Then, with their vascular pedicle, they are transplanted near the peritoneum in each pericolic gutter (oophoropexy) and thus are removed from the radiation field. This information is vital to the radiologist, so that normal ovaries will not be mistaken for an abnormal mass.

E. Pitfalls as the Result of Foreign Objects

Topical hemostatic materials are widely used to control bleeding in abdominal surgery. They are often oxidized regenerated cellulose and are locally absorbed without tissue reaction. [13,14] However, if left behind, they can mimic an abscess on follow-up CT in a febrile postoperative patient (Figure 11). Erroneously, larger material may be left in the abdomen and can mimic an abscess. Generally, the diagnosis of retained surgical foreign bodies continues to be a problem as long as nonabsorbable materials are used. Because cotton sponges are inert, they do not undergo any specific decomposition or biomedical reaction. Pathologically, however, there is either an aseptic fibrinous reaction or an exudative response.

F. Pitfalls as the Result of Recent Procedures, Pouches, and Ostomies

Changes on CT related to operations such as gastroduodenostomy, gastrojejunostomy, pancreaticojejunostomy, ileocolostomy, and other types of anastomoses in the gastrointestinal tract or the biliary system, are less likely sources of pitfalls. In patients who have had the gastrojejunostomy, however, an unopacified duodenal loop can cause confusion in the evaluation of the head of the pancreas for mass lesions. Ileostomies and colostomies, particularly when opacified by oral contrast or renal excretion of intravenous contrast, are easily recognizable on CT. A nonopacified continent ileostomy or the reservoir from ileocystostomy, however, can be mistaken for abscesses or other abnormal fluid collections. [15]

A Puestow Procedure is a surgical procedure performed for chronic pancreatitis .[16] In such patients, the duct within the pancreas becomes dilated and obstructed. During the procedure, the duct is cleared and attached lengthwise to the small intestine. This increases the amount of pancreatic enzymes secreted into the small intestine. CT scan after such procedure can mimic peripancreatic cysts.

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