In fat we trust: abdominal and pelvic fat containing lesions

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Learning objectives

- To value the importance of determining macroscopic and microscopic fat content in different abdominopelvic pathologic processes, in order to improve differential diagnosis.
- To describe how the fat (macroscopic and microscopic) behaves according to the imaging technique used for diagnosis: CT, MRI, ultrasound, or plain film.
- To review the clinical and radiological characteristics of the main abdominopelvic diseases in which fat is the key to diagnosis.

Background

There are various abdominopelvic pathologic processes that can be accurately diagnosed depending on their imaging characteristics. We have focused on fat containing lesions because they are frequently found in routine exams, we can use different imaging techniques to confirm the presence of fat and it lets us classify the lesions as benign or malignant. Frequently the image makes the diagnosis itself.

These lesions represent a broad spectrum of congenital, metabolic, inflammatory, traumatic, degenerative, and neoplastic processes. They can be divided into fat-containing neoplasms, fat-containing nonneoplastic masses, and other abdominopelvic fatty masses. We can also divide them in lesions with predominantly macroscopic fat, like myelolipoma, angiomiolypoma, lipoma, liposarcoma, teratoma, epiploic appendangitis, fat infarction and mesenteric panniculitis; and lesions with predominantly microscopic fat include adrenal adenoma and some teratomas. Fig. 1 on page 6

X-ray:

Fat density, which is between that of soft tissue and that of gas, outlines the contour of solid organs or muscles. In obese patients, fat may not be distinguishable from ascitic fluid on plain abdominal film. The flank stripe, also called the properitoneal fat stripe, is a line of fat next to the muscle of the lateral abdominal wall. The flank stripes are symmetrically concave or slightly convex in obese people located along the side of the abdominal wall. The normal properitoneal fat stripe is in proximity to the gas pattern seen in the ascending or descending colon.

Fat is present in the retroperitoneal space adjacent to the psoas muscle. The psoas muscle shadow may be absent unilaterally or bilaterally as a normal variant or as a result
of inflammation, hemorrhage, or neoplasms of the retroperitoneum. Unilateral convexity of the psoas muscle contour suggests an intramuscular mass or abscess. The quadratus lumborum muscles may be delineated by fat located lateral to the psoas shadow. In the pelvis, the fatty envelope of the obturator internus muscle is seen on the inner aspect of the pelvic inlet. The dome of the urinary bladder may be delineated by fat.

Fat lesions have the same density as these anatomic structures described, x-rays are nonspecific to diagnose fat lesions but may be helpful to experimented radiologists to suggest the presence of them. Fig. 2 on page 6

**US:**

This technique is also nonspecific for fat lesions, they may appear hyperchoic. The best example of typical diagnose of fat lesion made by ultrasonography are renal angiomyolipomas, they appear as hyperechoic limited lesions, located in the renal cortex, without posterior acoustic shadowing. Fig. 3 on page 7

**CT:**

Identification of fat at computed x-ray tomography (CT) is based on x-ray resorption and therefore attenuation. For each picture element (pixel) the attenuation of the radiation is calculated and expressed as Hounsfield units (HU). Water has, by definition, a Hounsfield unit value of 0. Fat and air are always black in CT; bone cortex and high atomic-number contrast media are always white. Fat has lower attenuation than water.

If the proportion of fat within a voxel is large, the corresponding image pixel will be dark, typically measuring less than -20 HU.

Microscopic fat may be difficult to identify reliably as mixing of higher-attenuation water and protein increases the mean CT number. For this reason CT is not as sensitive for detecting microscopic fat as MR imaging. Fig. 4 on page 8

**MRI:**

Fat has short T1 and relatively long T2 relaxation and this is the reason it appears hyperintense on T1-weighted and intermediately intense to hyperintense on T2-weighted fast spin-eco and gradient-echo images. However, these signal intensities are nonspecific, and signal intensity on T1 and T2 weighted images does not allow reliable
Identification of fat. To reliably identify fat, it is necessary to exploit the different resonance frequencies of water and fat protons. Fig. 5 on page 9

As we know, protons are the source of signal intensity in conventional MR imaging. Within a magnetic field (B₀), protons resonate (spin) at a specific frequency (v₀) that is described by the Larmor equation. The magnetic field affecting a proton consists of the externally applied magnetic field (B) and the local magnetic field effects (Bₗₒ𝑐) of adjacent atoms and molecules. Human tissue contains several populations of protons. Two of the most important sources of protons for MR imaging are those associated with free water (H₂O) and those associated with fat (-CH₂-)ₙ. The Bₗₒ𝑐 of free water protons differs from the Bₗₒ𝑐 of fat protons because the influence of adjacent atomic structures is different. Therefore, fat and water protons have different resonance frequencies. At times, fat and water protons are in phase (IP) with each other, and at other times they are 180° of phase (OP).

**Opposed-phase (OP) MR imaging** is a technique used to characterize masses that contain both lipid and water on a cellular level.

When voxel containing fat and water is imaged in phase, signal intensities are additive; when imaged out of phase, signals interfere with each other, this is the reason why we say that these lesions lose signal intensity when they are in out of phase images. Voxels containing either mostly fat or mostly water will not lose signal intensity out of phase. Fig. 6 on page 10

Methods other than OP imaging that allow suppression of signal intensity from fat-containing tissue on MR imaging can be used:

Inversion recovery sequences, such as short inversion time inversion recovery (STIR), use a 180° inversion pulse and a variable inversion time to non-selectively null the signal intensity from fat as well as other tissues that have the same T₁ value as fat. Therefore, STIR should not be used to characterize fat. STIR should also not be used after administration of a paramagnetic contrast agent such as gadolinium chelate, because T₁ tissues accumulating the agent may become similar to the T₁ of fat, resulting in signal reduction of the target tissue and loss of contrast enhancement.

**Frequency-selective fat suppression** is another technique that reduces the signal from lipid-containing voxels by applying a preparatory pulse with an appropriate frequency to saturate fat protons. This technique effectively reduces macroscopic fat signal, such as lipomas and most teratomas. Frequency-selective fat suppression requires a homogeneous external magnetic field.
Each method has certain advantages: OP imaging is excellent for characterizing fat-water mixtures, short inversion time inversion recovery is useful for detection of abnormalities and edema, and frequency-selective fat saturation is often used during gadolinium administration to allow better depiction of enhancement.

Other methods of identifying fat are water-selective spatial spectral techniques, Dixon techniques and MR spectroscopy.

**DIXON**

Different MR strategies have been developed over the years to characterize the independent contributions of water and fat protons to the overall MR signal. Chemical shift imaging techniques exploit the differences in precession velocities of fat and water protons to detect small amounts of intravoxel fat, a hallmark of certain disorders such as hepatic steatosis and adrenal adenomas. These imaging techniques are derived from the principles first described by Dixon. They are based on decomposing fat and water proton signals according to their resonant frequency difference, or chemical shift, to isolate these two components into two separate images. By adding and subtracting the two complex images (images with both magnitude and phase information) from in-phase and opposed phase imaging, selective water and fat images are generated. Thus, instead of being a true fat-suppression technique, the Dixon method is a water-fat separation method.

Further modifications in the Dixon technique—for example, those implemented by Glover and Schneider and Reeder et al.—have been proposed to overcome problems secondary to magnetic field inhomogeneities. Such modifications have resulted in the three-point Dixon method and, ultimately, in the so-called iterative decomposition of water and fat with echo asymmetry and least-squares estimation, or IDEAL, technique. Instead of collecting just two images with opposed fat and water phases, both of these techniques acquire three images, each with a different relative phase between the water and fat signals. These approaches account for both B0 and B1 magnetic field inhomogeneities, thereby facilitating the fat-water separation process. In the IDEAL technique, the echo times of the three images are carefully chosen so that the reconstructed fat-only and water-only images have the maximum possible signal-to-noise ratio (SNR). IDEAL is compatible with essentially any pulse sequence, and it has been combined with a wide variety of clinically relevant sequences, including fast spin echo, steady-state free precession (SSFP), and T1-weighted spoiled gradient-recalled echo (GRE). This flexibility in sequence combination provides fat and water-separated images with any desired contrast, including T2-weighted, T1-weighted, and proton density-weighted images, with motion compensation—that is, respiratory gating—with either 2D or 3D acquisitions and
with the use of contrast media. An additional advantage of IDEAL is that in-phase and opposed-phase images, and fat-only and water-only images, are obtained during a single acquisition. Thus, a single acquisition with IDEAL imaging has the potential to simplify body MRI protocols by replacing separate acquisitions that use fat-saturation and chemical shift techniques. Furthermore, because all data emanate from a single acquisition, the resulting diverse image sets are inherently co-registered. **Fig. 7** on page 11

**Images for this section:**

**Fig. 1**
X-ray diagnose

Properitoneal fat

Mass effect in pelvis with fat and calcium density

Fig. 2
Fig. 3: Renal angiomyolipoma diagnose using US technique.
Fig. 4: Attenuation of different body components (Hounsfield Units)
Fig. 5: Different MRI sequences to diagnose fat lesions.
**Fig. 6:** In phase & Out phase images
Fig. 7: DIXON
Imaging findings OR Procedure details

We are going to describe the main characteristics of the most common fatty lesions seen in imaging studies, especially focused on CT and MR imaging techniques.

Hepatic lesions:

**Fatty Change:** Fatty change in the liver is the result of excessive triglyceride deposition and has many causes including obesity, alcohol abuse, diabetes, exogenous steroids, malnutrition, chemotherapy, and Cushing syndrome. Recognition of diffuse fatty change at CT requires liver attenuation to be 8-10 HU lower than that of the spleen on non-contrast-enhanced images. Fatty change has a variable appearance on CT scans, ranging from a diffusely homogeneous process, to a diffuse pattern with focal sparing, to focal liver involvement. Fig. 10 on page 21 Fig. 11 on page 22

Focal liver sparing in a diffusely involved liver is common adjacent to the gallbladder fossa. Focal fat deposition is common in the medial segment of the left lobe of the liver, adjacent to the falciform ligament. Focal fatty change often has linear borders and usually does not distort the hepatic vascular architecture seen on cross-sectional images. Magnetic resonance (MR) imaging also allows discrimination of focal fatty change and focal liver sparing from true lesions. Focal and regional fat deposition in the liver has a decreased signal intensity on T2-weighted fat suppressed MR images relative to more normal liver parenchyma. This appearance, combined with standard spin-echo sequences, allows for distinction of focal fat deposition or focal liver sparing from most primary and secondary neoplasms. Fig. 12 on page 22 Fig. 13 on page 23

**Hepatic adenoma:** is a benign, encapsulated neoplasm that shows a propensity to frequent hemorrhage and rare malignant change. It most commonly occurs in young women taking oral contraceptives. Other risk factors include type I glycogen storage disease and use of anabolic steroids. Histologically, a hepatocellular adenoma consists of normal-appearing hepatocytes arranged in sheets and cords instead of the usual lobular architecture. The presence of dilated sinusoids with scanty connective tissue support that are fed by prominent arteries predisposes to hemorrhage. The adenoma cells may be filled with glycogen and fat. Intra and intercellular lipid uncommonly manifests as macroscopic fat deposits within the tumor; 35%-77% of adenomas demonstrate steatosis at chemical shift MR imaging. These findings correlate with the variable lipid content of adenomas and the superior contrast resolution and tissue distinction of MR imaging compared with CT. Fig. 14 on page 24

**Hepatocellular Carcinoma:** is the commonest primary hepatic malignant neoplasm that commonly develops in a cirrhotic liver. Small (<1.5 cm) well-differentiated HCCs
are often associated with a diffuse-type fatty change. Larger tumors have patchy fatty metamorphosis. Fatty change can be seen in up to 35% of small HCCs and is associated with a decrease in the number of intratumoral arteries without any difference in intratumoral portal tracts. Fat deposition in HCCs is usually patchy. Macroscopic fat within HCC is well demonstrated on CT scans. HCC with fatty change appears hyperintense on T1-weighted images and demonstrates signal intensity drop on chemical shift images. The hyperintensity of HCC on T1-weighted images is attributed to a number of factors, including hemorrhage, intratumoral deposition of fat, and/or the copper and zinc content of surrounding liver parenchyma. 

**Adrenal Gland lesions:**

**Adrenal Myelolipomas** are uncommon benign tumors composed of mature adipose cells and hematopoietic tissue. Typically, arises in the adrenal gland. Extra-adrenal myelolipoma is rare and is found most commonly in the presacral and other retroperitoneal areas. Usually asymptomatic and discovered incidentally at cross-sectional imaging, myelolipoma occasionally causes discomfort due to compression or hemorrhage.

The CT features are characteristic, lesions usually have a negative Hounsfield unit value owing to macroscopic fat. Because of intermixed hematopoietic tissue, the attenuation is usually higher than that of retroperitoneal fat. High-attenuation regions may be seen due to hemorrhage or calcifications. At MR imaging, the fatty component is usually hyperintense on T1-weighted images and heterogeneously hyperintense on T2-weighted images due to non-uniform and mixture of fat and marrow components. This appearance is nonspecific and may be mimicked by adrenal metastases or primary adrenal cancers. Frequency-selective fat suppression allows the diagnosis of myelolipoma to be confirmed by demonstrating signal loss. Fat-containing malignancies of the adrenal gland are exceedingly rare; thus, adrenal malignancies would not be expected to lose signal on fat-suppressed images. Chemical shift in-phase/opposed-phase imaging may also be diagnostic by demonstrating india ink or etching artifacts between fat- and water-based components. India ink or etching artifacts are produced at boundaries between fat- and water-based tissues. The reason is that the voxels along those boundaries contain both fat and water protons and hence lose signal on opposed-phase relative to in-phase images.

**Adrenal adenoma:** is a common tumor, as the majority of lesions are small and nonfunctional, most adenomas are incidental findings (“adrenal incidentalomas”).

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Page 14 of 48
Hyperfunctional adenomas also occur and are responsible for important endocrine disorders such as Cushing syndrome and Conn syndrome.

At pathologic analysis, both hyperfunctioning and nonfunctional adenomas contain a variable amount of intracytoplasmic fat. Lipid-rich adenomas (approximately 80% of adenomas) are easily identified at both CT and MR imaging. At CT, adrenal adenomas appear as small (<3 cm), well defined homogeneous masses that are typically hypoattenuating relative to the liver. Lipid-poor adenomas are more difficult to diagnose because the CT numbers increase and approach those of soft tissue. Contrast-enhanced imaging with 10-minute-delayed CT scans may be helpful in these cases. By using a threshold of 30 HU, the sensitivity and specificity for delayed contrast-enhanced CT in the characterization of benign disease are 80% and 100%, respectively. A relative percentage washout of more than 50% in the delayed study represents a sensitivity and specificity of 98% and 100%, respectively, for the detection of adenoma. Fig. 17 on page 27 Fig. 18 on page 28

Chemical shift MR imaging is a reasonable second imaging test for further characterization when CT results are indeterminate. Because of the high sensitivity of chemical shift MR imaging to minute amounts of intravoxel fat, MR imaging demonstrates signal intensity loss on opposed-phase images in the majority of adenomas, with a sensitivity of 89% for lesions with an attenuation of 10-30 HU and 100% for lesions with an attenuation of 10-20 HU with a maintained specificity of 100%. Fat suppressed images and STIR techniques have less sensitivity for detecting minute amounts of lipid and are of little if any benefit in lesion characterization. Fig. 19 on page 29

Atypical adenomas may contain calcification, hemorrhage, or necrosis. In addition, adenomas may lack detectable amounts of intracytoplasmic lipid even at chemical shift MR imaging. In these cases, comparison to results of previous studies, short-term imaging follow-up, or biopsy may be necessary.

Renal:

Angiomyolipomas: are renal masses composed of abnormal blood vessels, mature fat, and smooth muscle that may be associated with hemorrhage, necrosis, and dystrophic calcification. CT findings of this tumor reveal the presence of a well-defined heterogeneous renal mass reflecting the amount of fatty, muscular, and vascular tissue within it. The administration of a contrast agent contributes to enhancement of solid areas, which is directly related to the existing vascular structures. Bleeding may disguise the areas of fatty density, consequently presenting difficulties to making the diagnosis. Fig. 20 on page 30

MR imaging allows correct characterization of most angiomyolipomas because of intratumoral fat deposition. The intratumoral fat can be confidently identified by using fat suppression techniques or by demonstrating an india ink or etching artifact at the interface
of the water-based kidney and the fat-containing tumor. MR imaging offers no definite
diagnostic advantage over CT but should be considered in younger patients because
of the absence of ionizing radiation. The most important differential diagnosis for large
exophytic angiomyolipomas is retroperitoneal (perirenal) liposarcoma.

**Renal lipomas:** are unusual benign tumors of the kidney exclusively composed of
adipose tissue. On CT, simple lipomas display fat attenuation and do not enhance after
contrast material administration.

**Renal sinus lipomatosis:** is an excessive accumulation of fat in the renal sinus that may
occur in obese or normal-weight patients. On excretory urography, this fatty tissue may
resemble a peripyelic mass, with compression of calyx structures. On CT, the origin of this
condition can be determined according to its characteristic density. **Fig. 21** on page 31

**Replacement lipomatosis** of the kidney is an advanced type of renal sinus lipomatosis.
This condition occurs with parenchymal atrophy associated with a proliferation of the
renal sinus fat. The presence of both a staghorn calculus and the atrophic renal
parenchyma is easily depicted on CT. The characteristic distribution of fat within the renal
sinus and the perinephric space is suggestive of this process. Replacement lipomatosis
of the kidney should be differentiated from xanthogranulomatous pyelonephritis. **Fig. 22**
on page 32

Other entities less frequently found in the kidney but containing fat density are renal
capsule liposarcomas, Wilms' tumors, and renal cell carcinomas.

**Pancreatic:**

The major histologic finding of pancreatic lipomatosis is the presence of fatty deposits
in the parenchyma, it may occur in obese and diabetic patients with varying levels of
pancreatic insufficiency; and also manifest in patients with cystic fibrosis or diseases
such as Shwachman syndrome and Johanson-Blizzard syndrome. In advanced stages
of pancreatic lipomatosis, the whole parenchyma is replaced by fat, and the pancreatic
duct is identified as a linear density.

**Focal fatty infiltration** of the pancreas refers to a focal region of pancreatic parenchyma that on CT shows normal or lower density compared with that of the
surrounding pancreas. In focal pancreatic infiltration, contrast-enhanced CT reveals low-
attenuation tissue interposed between normal pancreatic parenchyma that can mimic a
hypoattenuating mass (cystic or solid neoplasm). **Fig. 23** on page 33
Intestinal tract lesions:

Findings that may be seen at imaging of the intestinal tract include lipomatous neoplasms such as lipomas or liposarcomas, intussusception containing mesentenic fat, and iatrogenic incorporation of fat that may occur after Nissen fundoplication.

Mural on pedunculated lipomas occur throughout the intestinal tract. They are most common in the colon, followed by the small bowel, stomach, esophagus, and pharynx. Gastrointestinal lipomas are typically circumscribed and have a uniform fat attenuation matrix on CT scans. They have homogeneous signal intensity identical to that of fat with all MR imaging pulse sequences. Thin fibrous septa of low signal intensity on T1- and T2-weighted images may traverse the lesion. Complications of lipomas include intussusception and intestinal bleeding. Fig. 24 on page 34 Fig. 25 on page 35

Liposarcomas of the gastrointestinal tract are rare but should be considered if a prominent associated soft-tissue component can be identified. Two patients with ulcerated benign lipomas with prominent septa on CT scans have also been described; therefore, the association of fat with apparent soft-tissue components is not pathognomonic for a liposarcoma. CT frequently enables identification of fat in the ileocecal valve. An enlarged ileocecal valve due to diffuse lipomatous infiltration on focal lipoma can be readily diagnosed with CT examination.

An intussusception often contains some mesentenic fat attached to the involved segments of bowel. Approximately 80%-90% of intussusceptions in children and 10%-50% of intussusceptions in adults are idiopathic. Identifiable causes include tumors, Meckel diverticula, and previous intestinal surgery.

After gastric fundoplication, iatrogenic incorporation of perigastric fat often allows CT recognition of fat in the resultant postoperative gastroesophageal junction "mass".

Mesenteric and Omentum lesions:

Epiploic Appendagitis: appendices epiploicae are pedunculated adipose structures protruding from the external surface of the colon into the peritoneal cavity, typically measure 1-2 cm thick and 2-5 cm long and extend from the cecum to the rectosigmoid junction. Appendices epiploicae are prone to torsion leading to ischemic or hemorrhagic infarction, due to their limited blood supply, pedunculated shape, and excessive mobility. Infarction results in a focal inflammatory process called epiploic appendagitis. The condition usually manifests as localized abdominal pain in one of the lower quadrants and clinically mimics acute appendicitis or diverticulitis. CT is usually diagnostic,
avoiding unnecessary surgery. Characteristic findings include a paracolonic oval fatty mass representing the infarcted or inflamed appendix epiplioica, a well circumscribed hyperattenuating rim that surrounds the mass and represents the inflamed visceral peritoneal lining, and sometimes a high attenuation central dot representing engorged or thrombosed central vessels or central areas of hemorrhage. Mild local reactive thickening of the adjacent colonic wall is often seen.

**Omental Infarction:** generally, is a rare condition because of the presence of abundant collateral vessels. Nevertheless, the right lateral free edge of the omentum has a more tenuous blood supply than the rest of the omentum; it is hypothesized that this tenuous blood supply renders the right inferior portion of the omentum more vulnerable to infarction. **Primary omental infarction** is often a hemorrhagic infarction resulting from vascular compromise related to the tenuous blood supply to the right edge of the omentum or to kinking of veins, usually those in the right side, deep within the anterior pelvis in the inferior extent of omentum. Some omental infarcts are related to a combination of the reduced arterial and venous blood flow that occurs in hypercoagulable states, congestive heart failure, and vasculitis. Omental infarction has also been reported in marathon runners and is thought to be related to a state of low blood flow to the omentum, a result of physiologic shunting and splanchnic vasoconstriction resulting from elevated levels of epinephrine, norepinephrine, vasopressin, and angiotensin II. **Secondary omental infarction** may occur after a traumatic injury as a result of surgical trauma or inflammation of the omentum. Often, the site of secondary infarction is near the surgical site rather than in the right lower quadrant, the typical location of primary omental infarction. Patients with omental infarction usually present with subacute onset of pain in the right lower quadrant, often with a slightly elevated white blood cell count. Other gastrointestinal symptoms such as vomiting, nausea, and fever are absent. Establishing a preoperative diagnosis of omental infarction is difficult because it often mimics acute appendicitis or cholecystitis. In most cases, the diagnosis is made by the radiologist after cross-sectional imaging has been performed.

Omental infarction demonstrates a variety of imaging appearances at CT. Classically, it appears as a fatty, large (>5 cm) encapsulated mass, with soft-tissue stranding adjacent to the ascending colon. Early or mild infarction may manifest as mild haziness in the fat anterior to the colon. Omental torsion is a rare cause of omental infarction and occurs when a portion of the omentum twists upon itself, leading to vascular compromise. In omental torsion, swirling of the vessels is often visible within the omentum. Although most cases of omental infarction are on the right side, left-sided infarction also may spontaneously occur. Unusual locations of infarction are more commonly seen in the setting of surgical trauma or postsoperative changes that result in altered omental vascular supply and subsequent infarction. Similar to epiploic appendagitis, the adjacent colon is usually spared, although, rarely, the colonic wall may be thickened, a result of direct extension of omental inflammation. At US, may appear as a focal area of echogenic fat that corresponds to the site of focal tenderness.
**Mesenteric Paniculitis** is a rare condition characterized by a nonspecific chronic disorder in the adipose tissue of the intestinal mesentery. It may be a paraneoplastic condition in some patients, although the association with the underlying malignancy is poorly understood. The most characteristic CT findings include superior mesenteric veins surrounded by a well-defined fatty mass, movement of intestinal loops, well-differentiated nodules in the soft tissue smaller than 5 mm in diameter, and mass effect on the adjacent organs. In such cases, the term "misty mesentery" is often applied. This term refers to increased attenuation in the mesentery, but this sign is not specific for mesenteric panniculitis. Any process that infiltrates the mesentery can result in a misty mesentery. Therefore, hemorrhage, edema, or tumor (lymphoma) can have an appearance similar to that of mesenteric panniculitis. 

**Pelvic and gynecological:**

**Ovarian teratomas** are the most common germ cell neoplasms and the most common benign ovarian tumors in women less than 45 years old. Most of them are mature cystic teratomas, also known as dermoid cysts. They are composed of well-differentiated derivations from at least two germ cell layers (ectoderm, mesoderm, or endoderm). Ectodermal tissue (skin derivates and neural tissue) is invariably present. Mesodermal tissue (fat, bone, cartilage, muscle) is present in over 90% of cases, and endodermal tissue (gastrointestinal and bronchial epithelium, thyroid tissue) is seen in the majority. The tumors are bilateral in 10% of cases. Although most mature teratomas are asymptomatic, abdominal pain or other nonspecific symptoms occur in a minority of patients. Important complications are torsion, rupture, and malignant degeneration.

At CT, fat attenuation within a cystic adnexal mass, with or without calcification in the wall, is diagnostic. Fat is reported is 93% of cases, and teeth or other calcifications are reported in 56%. At MR imaging, the sebaceous component has high signal intensity on T1-weighted images, similar to that of retroperitoneal fat. The signal intensity on T2-weighted images is variable, usually approximating that of fat. Frequency-selective fat saturation or chemical shift artifact enables accurate differentiation of teratomas from hemorrhagic lesions. A little percentage of them do not demonstrate a sebum-filled cyst cavity. However, they usually demonstrate evidence of fat in the wall or in the Rokitansky nodule. Immature teratomas contain immature or embryonic tissues at histologic analysis, demonstrate clinically malignant behavior, are much less common (<1% of teratomas), and affect a younger group (during the first 2 decades of life). Solid components usually dominate over small foci of fat, and calcifications tend to be coarse or ill-defined. Recognition of these differential imaging and demographic features permits the correct diagnosis to be suggested. 

Fig. 29 on page 39

Fig. 30 on page 40

Fig. 31 on page 41

Fig. 32 on page 42
Rare fatty adnexal lesions include **ovarian lipomas** and **ovarian lipoleiomyomas**. **Lipomatosus uterine tumors** include pure lipomas, lipoleiomyomas, and fibromyolipomas. Uterine lipoleiomyomas can be associated with more typical leiomyomas.

**Retroperitoneum:**

**Liposarcoma** is a malignant tumor of mesenchymal origin that may arise in any fat-containing region of the body. Liposarcoma is one of the most common primary neoplasms in the retroperitoneum. It rarely arises in the mesentery or peritoneum. Histologically, liposarcomas are classified, in increasing order of malignancy, as well-differentiated, myxoid, pleomorphic, and round cell subtypes. Liposarcomas may contain multiple histologic subtypes within the same lesion. CT and MR imaging appearances vary according to these histologic subtypes. **Well-differentiated liposarcomas** resemble lipomas, with attenuation (CT) and signal intensity (MR imaging) equal to those of fat. Fibrous septa may be thicker, more irregular, or more nodular than those seen in lipoma. These septa have attenuation (CT) and signal intensity (MR imaging) similar to those of muscle and may enhance dramatically on fat-suppressed T1-weighted MR images after administration of a gadolinium chelate. These tumors often recur if only marginally excised but do not metastasize.

**Myxoid liposarcoma** is the most common subtype, accounting for 50% of all liposarcomas. At CT, they often have an inhomogeneous appearance, with CT attenuation values less than that of muscle. Occasionally, fat and soft tissue elements are distributed homogeneously within the lesion, producing fluid attenuation at CT. Consequently, the lesion may appear cystic on nonenhanced CT images and cause diagnostic confusion. At MR imaging, they have signal intensity similar to that of water: low signal intensity on nonenhanced T1-weighted images and high signal intensity on T2-weighted images. Although these lesions may superficially resemble cysts on unenhanced CT and MR images, they are readily differentiated after intravenous administration of contrast material. Slowly progressive, reticular enhancement is characteristic and reveals the solid nature of these tumors. **Pleomorphic and round cell liposarcomas** are heterogeneous, nonfatty tumors. Therefore, it is usually impossible to differentiate them from other sarcomas. Fig. 33 on page 43

**Miscellaneous:**

**Lipoma of the inferior vena cava**, has been presented as a normal variant of perioesophageal fat distribution or as intravascular lipoma. It can be diagnose by ultrasound, CT and MRI, the usual diagnose is made by CT exams made for another reason. In the absence of surgical exploration or autopsy, two distinct processes have
been hypothesized: the first, a normal anatomical variant of pericaval fat distribution; the second, a lipoma within the vessel that could be found in patients with various pathologies, particularly hepatic diseases such as cirrhosis, hepatocellular carcinoma and hepatoma. In reality, there is no direct correlation between the lipoma of the IVC and liver pathology, because these lesions were also identified in patients with a number of unrelated pathologies. Fig. 34 on page 44

Herniations of abdominal and pelvic fat may occur through diaphragmatic and abdominal wall musculature defects, as well as through anatomic vascular or neural canals. The more common diaphragmatic hernias include the anteromedial Morgagni hernia and the posterior Bochdalek hernia. Occasionally, esophageal hernias consist of only intraabdominal fat. The inguinal hernias are by far the most common canal hernias follow by the umbilical hernias. Femoral hernias are more common in females. Less common hernias include spigelian (through the linea semilunaris), lumbar, and perineal. Fig. 35 on page 45

Images for this section:
**Fig. 10:** Lower liver attenuation than spleen.

**Fig. 11:** Focal liver steatosis in chemical shift images.
**Fig. 12:** Focal liver steatosis in chemical shift images.
Fig. 13: US image of geographic liver steatosis
Fig. 14: Phase and opposite phase MR image showing the signal fall in the opposite fase in a liver adenoma.
Fig. 15: Phase and opposite phase MR image showing the signal fall in the opposite fase in a hepatocellular carcinoma.
**Fig. 16:** US, CT and MR images of an adrenal mielolypoma. US: hyperechogenic mass. CT: Hypodense mass. T1FS hypointense, STIR intermedial signal, phase/opposite phase: fall of signal in opposite phase.
Fig. 17: Coronal CT images showing a suprarrenal hypodense mass.
**Fig. 18:** Axial CT images showing a suprarrenal hypodense mass in two different patients.
**Fig. 19:** MR Chemical shift images showing a suprarrenal mass that loses signal in opposite phase images.
Fig. 20: US images in two different patients: hyperechogenic mass in renal cortex.
Fig. 21: Axial CT image showing right renal sinus lipomatosi
Fig. 22: Axial CT image: left replacement lipomatosis of the kidney.
Fig. 23: Axial CT image: fatty infiltration in pancreatic head.
**Fig. 24:** Axial CT image showing a submucosal ileum lipoma. Fluoroscopic study in the same patient.
**Fig. 25:** Axial CT image: duodenal hypodense lesion with fat density: lipoma.
**Fig. 26:** Axial CT images in two different patients, showing an area of fat stranding around an ovoid structure, with fat attenuation (arrow) next to the left colon.
Fig. 27: CT image shows a focal, fatty mass with soft-tissue stranding (arrow) anterior to the colon.
**Fig. 28:** CT image shows a focal, fatty mass with soft-tissue stranding (arrow) anterior to the colon. And 6 months later we see the resolution of the omental infarction.
Fig. 29: CT images showing a solitary well defined mass of inhomogeneous fatty tissue at the root of the jejunal mesentery.
**Fig. 30:** Abdominal x-ray showing a dense teeth like structure in a young woman. NECT of the pelvis shows a fat tissue mass with calcifications.
Fig. 31: Axial and coronal CT images showing a fat pelvic mass. MR images of an ovarian teratoma.
Fig. 32: CT and MR images of an ovarian teratoma.
Fig. 33: Pelvic liposarcoma.
Fig. 34: CT showing a fat tissue density mass inside the inferior vena cava.
Fig. 35: CT showing fat tissue inside an umbilical hernia.
Conclusion

After this review we can conclude that:

- The fat content of various abdominopelvic lesions can help us to come to an adequate differential diagnosis.
- Different imaging techniques can accurately diagnose the macroscopic and microscopic fat content of different lesions.

Images for this section:

Fig. 9
References


Personal Information