Learning objectives

Review the fat-containing lesions of the liver.

Describe the main findings of each one and their significance.

Discuss the role of imaging in the diagnosis and differential in a fat-containing liver lesion.

Background

The group of liver lesions containing fat is wide including benign and malignant. The fat may be present as macroscopic fat or intracellular lipid.

Ultrasound (US) is usually the first approach of liver lesions. The fat usually appears hyperechoic at US and, as the fat attenuates more than normal liver parenchyma, partial acoustic shadowing may occur deep to fat-containing lesions [1]. However hyperechogenicity may be found in non-fat-containing lesions and subsequent characterization with CT, MRI or even biopsy is usually necessary.

Macroscopic fat-containing lesions are usually easily characterized on CT by presenting areas of low attenuation compared with normal liver parenchyma, ranging between -10 and -100 Hounsfield Units [2]. However sometimes the lack of sufficient lipid pixels may prevent adequate characterization. At MRI macroscopic fat demonstrate hyperintensity on T1- and T2-weighted images with signal loss on fat-saturated MR images.

Intracellular lipid containing lesions can be characterized by chemical shift MRI imaging with opposed-phase gradient-echo (GRE) sequences [3]. During the in-phase imaging the signals of water and lipid are additive. In intermediate echo times, lipid and water protons are out of phase leading to phase cancellation effect at a voxel and resulting in signal loss in voxels with water and fat.

Findings and procedure details

Benign liver lesions containing fat are common and include:

Hepatic steatosis, which can be diffuse or focal, is often seen. The typical locations (periligamentous or periportal) and the absence of "mass effect" usually help in
recognizing focal steatosis. (Fig. 1 on page 5) However, multifocal nodular steatosis with patchy focal fat deposition may simulate metastatic disease at US or CT [4]. The use of GRE with in-phase and opposed-phase imaging allows a correct diagnosis. (Fig. 2 on page 6)

**Adenoma** is a benign, encapsulated neoplasm that usually occurs in young women taking oral contraceptives. Type I glycogen storage disease and use of anabolic steroids are also associated with increased risk. Adenomas frequently haemorrhage and rarely become malignant. Hepatocellular adenomas are composed of cords of hepatocytes, which may be filled with glycogen and fat and uncommonly intra and intercellular manifests as macroscopic fat deposits. Although only 7% of adenomas demonstrate lipid deposition in CT, 35-77% of adenomas show steatosis at chemical shift MR imaging [5,6]. (Fig. 3 on page 7) Due to its hypervascular nature it usually present early enhancing during arterial phase and rapid washout in contrast-enhanced MRI [6].

**Focal Nodular Hyperplasia** (FNH) is the second most common benign hepatic lesion often discovered incidentally in young asymptomatic woman. FNH is a well-circumscribed mass consisting of hepatocytes containing bile ducts and mononuclear inflammatory cells and exhibits benign behaviour. Typically presents at MRI as a isointense or nearly isointense on T1- and T2-weighted images with a intense enhancement in the arterial phase and rapid washout [7]. A central scar bright on T2 and delayed contrast enhancement is characteristic. The presence of fat is extremely rare and is usually patchy in distribution [8]. (Fig. 4 on page 8) Intratumoral steatosis, better demonstrated at MR imaging, may exist and can be associated to diffuse hepatic steatosis.

**Lipomas** of the liver are extremely uncommon and are constituted by mature adipose tissue. They appear as homogeneous hyperechoic well circumscribed lesions at US and present characteristics of a fatty lesion at CT and MRI. (Fig. 5 on page 10)

**Angiomyolipoma** (AML) is a benign mesenchymal tumor composed of varying proportions of smooth muscle cells, thick-walled blood vessels and mature adipose tissue. They are frequent in kidneys but rare in liver and may occur as a solitary mass or associated with tuberous sclerosis [9]. (Fig. 6 on page 12, Fig. 7 on page 12) AMLs can be histologically categorized into mixes, lipomatous, myomatous and angiomatous types [10]. AML typically demonstrate the fat component and prominent central vessels. AML presents as a hypodense lesion on unenhanced CT, usually with areas of macroscopic fat with attenuation values less than -20HU. The appearance at MR imaging is variable depending on the proportion of Intratumoral fat. AML show early intense contrast enhancement that peaks later than that of a hepatocellular carcinoma (HCC) [11].
**PEComa** is a mesenchymal tumor composed of histologically and immunohistochemically distinctive perivascular epithelioid cells and some have malignant behavior. PEComas often resemble AML or HCC, not only in terms of imaging features but histological as well. Imaging characteristics are variable but well-demarcated margins and hyperintensity on T2-weighted images and strong enhancement are common. [12] The nodules may show variable fat component usually identified on chemical shift sequences. *(Fig. 8 on page 13)*

**Cystic Teratomas** of the liver is an extremely rare entity. The majority of the denominated "hepatic teratomas" are intraperitoneal or retroperitoneal teratomas with liver "invasion". These encapsulated tumors arise from pluripotential cells and usually have components derived from all three germ layers. The cystic mass often contains fat, hair and calcifications. The presence of fat, fluid and calcification in a mass virtually indicates teratoma [13].

**Adrenal Rest Tumor** (ART) is an ectopic collection of adrenocortical cells in an extra-adrenal site. Hepatic ART are similar to adrenocortical tumors and the presence of fat is the most characteristic feature. At imaging they are typically subcapsular demonstrating macroscopic fat and hypervascurarity [14].

**Pseudolipoma of the Glisson Capsule**, also known as hepatic pseudolipoma, refers to an encapsulated lesion containing degenerated fat that is enveloped by liver capsule. A detached colonic epiploic appendix may be the origin of this lesion that may become attached to the liver capsule. It appears as a well-circumscribed nodule on the liver surface with a center of fatty attenuation. *(Fig. 9 on page 15)*

**Focal Fat adjacent to intrahepatic Inferior Vena Cava** can be occasionally seen and is described as a normal variant. Is more frequent in patients with chronic liver disease and can mimic a fat-containing liver lesion [15]. *(Fig. 10 on page 15)*

**Xanthomatous Lesions in Langerhans Cell Histiocytosis** (LCH) in the liver are uncommon. The liver lesions associated with LCH are usually seen in patients with extensive LCH and characteristically located in the periportal region. Four stages have been described: proliferative, granulomatous, xanthomatous and fibrous [16]. Xanthomatous lesions have low attenuation at CT and display characteristics of fat at MR imaging. *(Fig. 11 on page 16)*

Malignant fat-containing liver lesions include:
**Hepatocellular Carcinoma** (HCC) is the most common primary hepatic malignant lesion and usually develops in a cirrhotic liver. Fatty metamorphosis was found in up to 17% of HCCs, usually diffuse-type in small lesions and patchy in larger tumors [17]. Macroscopic fat within HCC is well demonstrated on CT. At MR imaging the fatty areas appear hyperintense on T1-weighted images and demonstrates loss of signal on chemical shift images. However hyperintensity on T1-weighted images may be due to other factors as haemorrhage, glycogen content, clear cell formation and excessive copper/zinc accumulation [18]. (Fig. 12 on page 17, Fig. 13 on page 19)

**Liposarcoma** is an uncommon malignant tumor accounting for 15% of all sarcomas. Metastatic spread of retroperitoneal and extremity liposarcomas is common, but liver is involved in only 10% of cases [19]. The majority of hepatic liposarcomas are metastatic although cases of primary hepatic liposarcomas have been reported [20].

**Hepatic Metastases** are common but usually do not contain fat. Rare examples of metastases with focal fat exist.

**Images for this section:**
**Fig. 1** Focal hepatic steatosis (a) Axial in-phase T1-weighted MR image shows peripheral high-signal-intensity areas in left hepatic lobe (arrows). Also notice a focal nodular periligamentous hiper-intense area (circle). (b) Axial opposed-phase T1-weighted MR image shows a decrease in the signal intensity of the two high-signal-intensity areas, indicating the presence of fat. (c) Axial portal phase CT image showing low density areas in the referred location due to the presence of fat.
Fig. 2 Diffuse nodular hepatic steatosis (a) Ultrasound image. Heterogeneous liver parenchyma with multiple nodular hyperechogenic areas. (b,c) Axial in- and opposed phase T1-weighted MR image shows multiple hyperintense nodules scattered in the liver parenchyma, demonstrating decrease in the signal intensity in the opposed-phase image, indicating the presence of fat.
Fig. 3 Hepatic adenoma (36y female) (a) Axial in-phase T1-weighted MR image shows a large adenoma in the left liver lobe with intermediate peripheral sign and a central hemorrhagic area, hypointense with a hyperintense rim (arrows). (b) Axial opposed-phase T1-weighted MR image shows a decrease in the signal intensity of the peripheral area, indicating the presence of fat. (c,d) Axial arterial and portal phase MR images showing early enhancing and rapid washout, common in adenomas.
Fig. 4 Focal nodular hyperplasia (FNH). (a,b) Axial in and opposed-phase T1-weighted GRE images shows a patchy peripheral focus of high signal intensity (arrow) that decrease in the opposed-phase which represents a focal fat deposit. (c) Axial T2 weighted fat-sat image shows the high-signal-intensity central scar. (d) Axial delayed phase T1-weighted MR image shows central scar late enhancement.
Fig. 4
Fig. 5  Hepatic lipoma (a,b) Axial T1-wheighted GRE sequence in- and opposed-phase. A hyperintense nodule is identified in the left liver lobe presenting signal loss in the opposed-phase with ink artifact, suggesting the presence of macroscopic fat. (c) AxialT1 fat-suppressed contrast enhanced MRI shows low signal indicating the presence of macroscopic fat and no enhancement. (d) Axial unenhanced CT of a different patient. A lipoma presents as well-circumscribed nodule with fat attenuation values is present in the right liver lobe.
**Fig. 6**  Hepatic angiomyolipomas (AML) in a patient with known tuberous sclerosis (a) Ultrasound (US) image. A hyperechogenic and heterogeneous liver nodular lesion is found. (b) Coronal reformatted contrast enhanced CT image demonstrating a well-circumscribed nodular lesion presenting a fatty attenuation area indicating the presence of macroscopic fat. (c) Axial contrast enhanced CT in a different patient. Hepatic heterogeneous mass with areas of fat attenuation in a patient with known tuberous sclerosis.
Fig. 7 Hepatic lipomatous angiomyolipoma. (a, b) Axial in-phase and opposed-phase T1-weighted GRE images shows a peripheral high-signal-intensity nodule (arrow) that markedly decrease signal intensity in opposed-phase image. (c) Axial T1-weighted fat-saturated image. The nodule shows low signal intensity. (d) Axial portal phase CT image shows a low density peripheral nodule due to the presence of fat. In all images notice the concomitant presence of bilateral renal angiomyolipomas in a patient with known tuberous sclerosis.
Fig.8 Biopsy proven hepatic PEComa. (a,b) Axial in-phase and opposed-phase T1-weighted GRE images show an heterogeneous well-circumscribed nodule with high-signal-intensity focus (arrow) that decrease signal intensity in opposed-phase image. Notice the “india ink artifact” representing areas of macroscopic fat. (c) Axial T1 weighted with fat-sat image shows decreased signal intensity. (d) Axial arterial phase T1-weighted MR subtraction image shows early enhancement, common in PEComas.
**Fig. 9** Pseudolipoma of the Glisson capsule. *(a)* Axial contrast enhanced CT. A well-circumscribed nodule with attenuation values of fat is identified in the surface of the left liver lobe. *(b)* Axial unenhanced CT shows a similar nodule in the posterior surface of the right liver lobe.
**Fig. 10** Focal fat adjacent to the Inferior Vena Cava. (a,b) Axial and coronal reformatted contrast enhanced CT images. A well-circumscribed nodule with attenuation values of fat is identified near the intrahepatic Inferior Vena Cava. A hepatic hemangioma is partially seen in the left image.

**Fig. 10**

**Fig. 11** Biopsy proven liver involvement of Langerhans Cell Histiocytosis (LCH) (a) Axial non-enhanced CT image. Multiple hypodense hepatic lesions are identified, one of each presenting area of fatty attenuation (circle) indicating xanthomatous type lesion. (b) Axial chest unenhanced CT (lung window) in the same patient. Notice the multiple nodules, with some presenting cavitation, compatible with lung involvement of LCH.
Fig. 12 Histology proven hepatocellular carcinoma (HCC). (a,b) Axial in and opposed-phase T1-weighted GRE images. High-signal-intensity nodular lesion that shows decrease in the signal intensity in opposed-phased image. Notice the diffuse decrease in the signal of the hepatic parenchyma, secondary to diffuse steatosis. (c) Axial arterial phase T1-weighted MR image subtraction shows early enhancement. (d) Coronal portal phase T1-weighted MR image demonstrating “wash out” and a persistent rim enhancement (capsule).
**Fig. 13** Histology proven hepatocellular carcinoma (HCC). **(a,b)** Axial in and opposed-phase T1-weighted GRE images. Heterogeneous lesion in the periphery of the right liver lobe, with focal areas of signal-intensity loss in the opposed-phase, indicating patchy fat metamorphosis. **(c,d)** Axial arterial and portal phase T1-weighted MR image subtraction shows early enhancement and washout compatible with HCC.
Conclusion

Fat-containing liver lesions include a heterogeneous group of tumors with variable histologic, imaging findings and prognostic. The identification of fat in a lesion is important to the diagnosis. The characteristics of the fat component along with the other imaging features help in narrowing the differential diagnosis. Although CT and US can sometimes show the presence of fat, MRI is the most specific and useful technique in demonstrating both microscopic and macroscopic fat.

Personal information

References


