

Fig. 1.8 Segmental anatomy of the liver.

If a hepatobiliary contrast medium is used to differentiate hepatocellular tumors (focal nodular hyperplasia, well-differentiated hepatocellular carcinoma), additional delayed images should be obtained no earlier than 2 h after contrast injection.

MRI Appearance of Normal Anatomy

The normal liver is of uniform signal intensity, which is higher than that of the spleen on T1w images and lower on T2w images. Hepatic vessels appear dark on T1w images due to flow-related signal loss (see **Fig. 1.2**). They are also dark on T2w images unless gradient moment nulling (flow compensation) is used, in which case intrahepatic vessels are bright. The branches of the portal vein and intrahepatic veins serve to identify the liver segments (**Fig. 1.8**). Differentiation of the liver from other structures in the upper abdomen is usually straightforward.

MRI Appearance of Pathologic Entities

Most benign and malignant liver tumors are hypointense on T1w images and hyperintense on T2w images. Cysts, hemangiomas, and metastases from neuroendocrine tumors are visualized with high contrast, as are intratumoral necrosis and abscesses. The vast majority of other liver metastases and cholangiocarcinoma (CCA) are less conspicuous on both T1w and T2w images. Liver tumors that are isointense or nearly isointense to normal liver parenchyma are focal nodular hyperplasia (FNH) as well as an occasional adenoma or hepatocellular carcinoma (HCC) (**Table 1.4**). T1w sequences contribute little to lesion characterization, except for cysts, which are clearly identified as sharply demarcated lesions of very low signal intensity on T1w images. In all other cases, characterization of focal liver lesions is primarily based on T2w sequences, which enable good evaluation of tumor margins and internal structures. Use of different T2 weightings, including images generated from late echoes, allows fur-

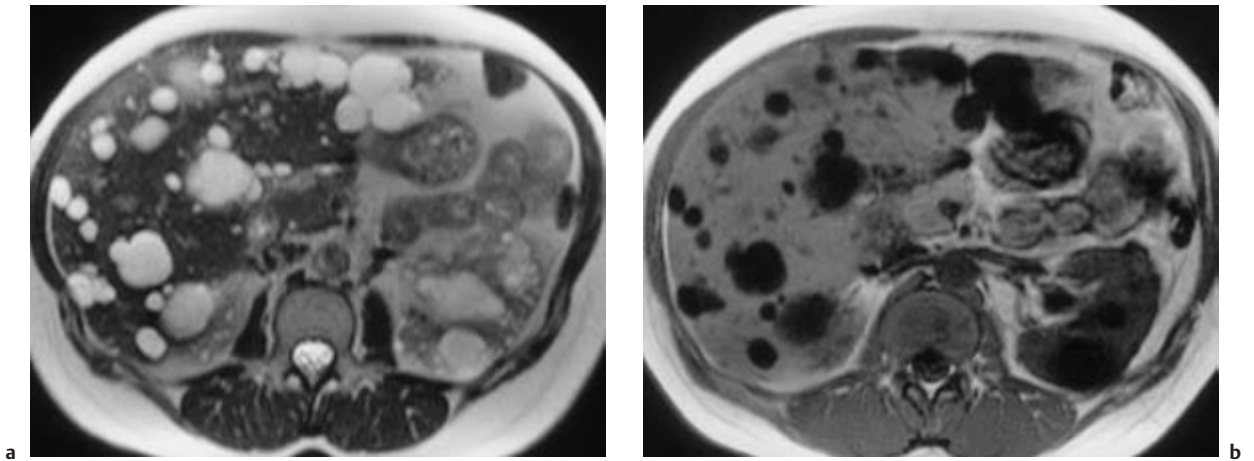


Fig. 1.9a, b Multiple liver cysts in a patient with autosomal dominant polycystic kidney disease (1.5 T). **a** Single-shot T2w TSE image. **b** T1w GRE image. Both images were acquired during breath-hold.

The liver cysts are depicted as homogeneous lesions of very high SI on the T2w image and very low SI on the T1w image. Also seen are multiple cysts in both kidneys.

Table 1.4 Signal intensities of different liver lesions relative to liver tissue on unenhanced images. Note: opposed-phase signal intensities (T1w OP) for patients without hepatic steatosis

	T1w IP	T1w OP	T2w
Benign tumors			
Cysts	↓↓↓	↓↓↓	↑↑↑
Hemangioma	↓↓↓	↓↓↓	↑↑↑
FNH	0-(↓)	0-(↓)	0-(↑)
Adenoma	↓-↑↑	↓↓-↑↑	0-↑
Malignant tumors			
Metastases			
• Melanotic melanoma	↑-↑↑	↑-↑↑	↑-↓
• Neuroendocrine tumors	↓↓	↓↓	↑-↑↑↑
• Other primaries	↓↓	↓↓	↑-↑↑
HCC	↓↓	↓↓	0-↑
CCA	↓↓	↓↓	↑-↑↑

Table 1.5 List of typically hypervascular liver tumors

Benign liver tumors	
FNH	
Adenoma	
Malignant liver tumors	
HCC	
Metastases	
•	Renal cell carcinoma
•	Breast cancer (may also be hypovascular)
•	Neuroendocrine tumors (e. g., carcinoid, insulinoma)
•	Melanoma
•	Sarcoma

ther characterization and improves accuracy in differentiating cysts and hemangiomas from solid liver tumors. Intralesional hemorrhage and fatty components as well as melanotic liver metastases from malignant melanoma exhibit atypical signal behavior with hyperintensity on both T1w and T2w images. Additional information for characterizing focal liver lesions is provided by dynamic contrast-enhanced MRI, which enables the important differentiation of hypervascular and hypovascular lesions and reveals some typical enhancement patterns such as the progressive centripetal enhancement characteristic of liver hemangioma (**Table 1.5**).

Below we describe the MR appearance of the most important benign and malignant focal liver lesions on unenhanced images and dynamic contrast-enhanced imaging with nonspecific Gd-based contrast media. A separate section illustrates the use of tissue-specific MR contrast media for selected tumor entities.

Benign Focal Liver Lesions

Cyst

Because they contain water, cysts have long T1 and T2 relaxation times, resulting in very low signal intensity on T1w images and uniform high signal intensity on T2w images. A liver cyst is usually sharply demarcated from the surrounding tissue but may appear blurred due to partial volume effects if the plane of section is tangential to it (**Fig. 1.9**). In cases where cysts and hemangiomas cannot be differentiated because of similar T2 signal intensities, a T1w sequence or dynamic imaging will help distinguish the two (**Fig. 1.10**).

MRI clearly differentiates the cyst fluid from the solid wall and septa in echinococcal cysts, while the characteristic curvilinear calcifications (eggshell calcifications) are far better revealed with CT.

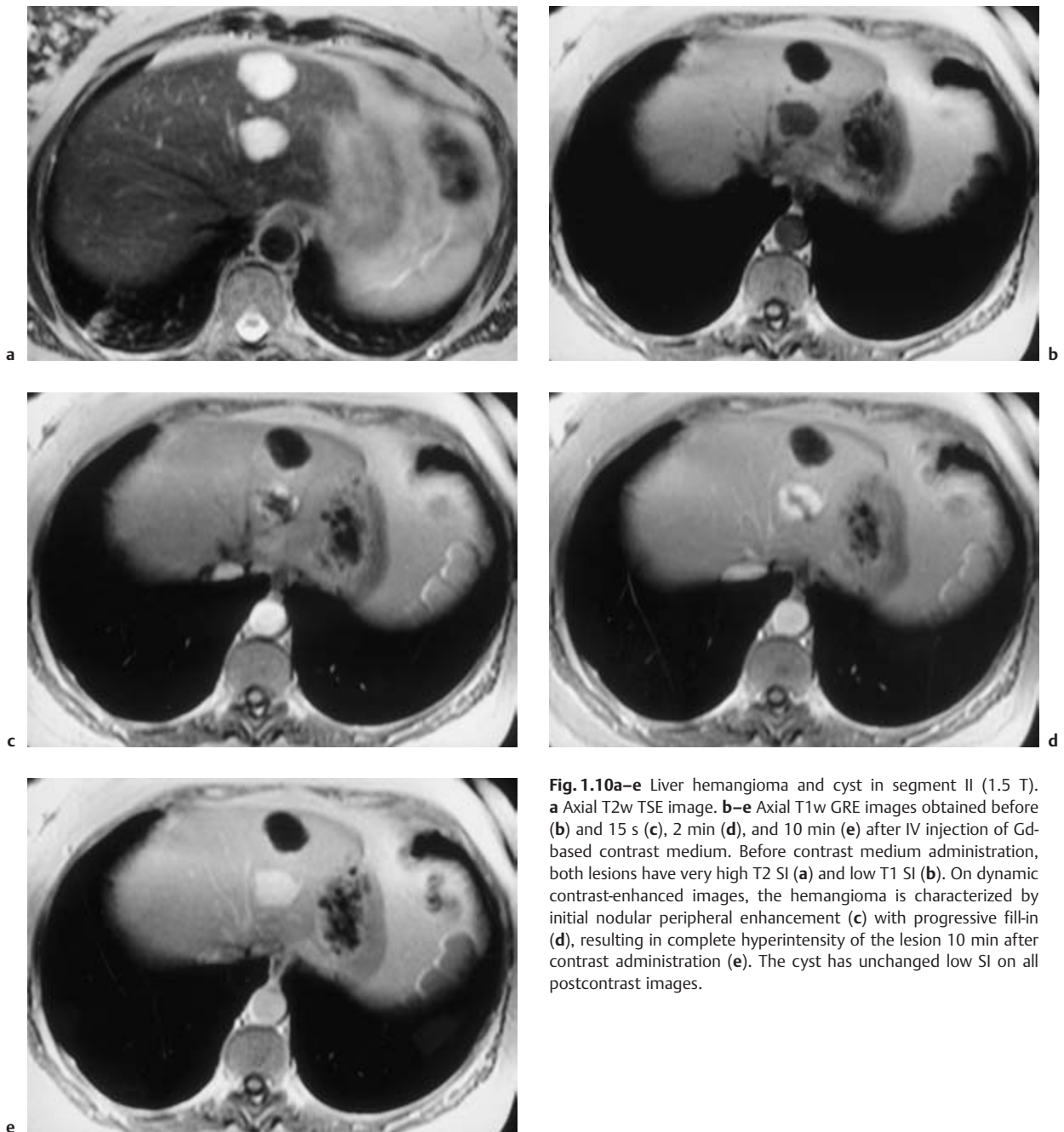


Fig. 1.10a–e Liver hemangioma and cyst in segment II (1.5 T). **a** Axial T2w TSE image. **b–e** Axial T1w GRE images obtained before (**b**) and 15 s (**c**), 2 min (**d**), and 10 min (**e**) after IV injection of Gd-based contrast medium. Before contrast medium administration, both lesions have very high T2 SI (**a**) and low T1 SI (**b**). On dynamic contrast-enhanced images, the hemangioma is characterized by initial nodular peripheral enhancement (**c**) with progressive fill-in (**d**), resulting in complete hyperintensity of the lesion 10 min after contrast administration (**e**). The cyst has unchanged low SI on all postcontrast images.

Hemangioma

Hemangiomas are the most common benign hepatic tumors. They are incidentally detected in ca. 5% of patients undergoing abdominal imaging for other reasons. Hemangiomas are mesenchymal tumors characterized by densely packed, dilated vessels with an endothelial lining. Regressive changes such as scars and central hyalinization may be present in large hemangiomas. Although they have no malignant potential, hemangiomas may pose a diagnostic challenge because they must be differentiated

from liver metastases. This is especially important in patients with multiple hemangiomas (up to 35% of cases).

Hemangiomas are well-circumscribed masses of uniform signal intensity on T1w and T2w images and may occasionally be lobular. They are moderately hypointense on T1w images and clearly distinct from cysts, which have very low T1 signal intensity, while distinguishing them from other solid liver tumors is more difficult. On T2w images, on the other hand, hemangiomas are of high signal intensity and therefore at times resemble cysts