Diagn Interv Radiol 2006; 12:129-135

Focal liver lesions evaluated by MR imaging

Yasemin Bilgili, Zeynep Fırat, Ertan Pamuklar, Birsen Ünal, William Hyslop, Hedrick Rivero, Richard C. Semelka

ABSTRACT
Magnetic resonance signal intensity of focal liver lesions is the result of their histological and cytological features. Therefore, analysis of lesion signal intensity and enhancement patterns obtained with magnetic resonance imaging is essential for the differential diagnosis of focal liver lesions. In this article, we review the magnetic resonance imaging features of the most common focal liver lesions.

Key words: • *liver neoplasms* • *magnetic resonance imaging*

From the Department of Radiology (Y.B. ✉ *mykaradeniz@hotmail.com*, B.Ü.), Kırıkkale University School of Medicine, Kırıkkale, Turkey; and Department of Radiology (Z.F., E.P., W.H., H.R., R.C.S.), University of North Carolina, Chapel Hill, ABD.

Received 8 February 2005; revision requested 11 May 2005; revision received 26 July 2005; accepted 26 July 2005.

Magnetic resonance (MR) imaging findings of focal liver lesions depend on their histological and cytological features. Careful assessment of the enhancement properties of dynamic images obtained before and after administration of intravenous contrast material (IVCM) is valuable in the characterization of the mass (1).

Cyst

Cysts are most often detected incidentally and are grouped as acquired or congenital (2). Acquired cysts are thought to be retention cysts secondary to biliary tract derivatives (3). It is typical for simple cysts to appear as hypointense on T1-weighted (T1W) images, hypointense on T2-weighted (T1W) images, and enhanced, even in the late stages after IVCM administration (Figure 1 a-c).

Ciliated hepatic foregut cyst

Ciliated hepatic foregut cysts are usually seen in anterosuperior localization in the intersegmental area (4). Although they typically appear as hypointense in T1W images and hypointense in T2W images, high signal intensity in T1W images suggests high protein content. Ovarian cancer metastases should be included in the differential diagnosis since they may appear as lesions causing lobulation in the liver contours, though they show wall enhancement (Figure 2).

Angiomyolipoma

Angiomyolipoma is a rare mesenchymal tumor that is generally seen as solitary, which contains lipid, smooth muscle, and vessels (1, 5). Because of the lipid content it is hyperintense in T1W images, and signal loss in out-of-phase images has an importance in the diagnosis. However, it is also reported that 1/3 of angiomyolipomas were found to have less than 10% lipid content (6). Because of the lipid content, in the differential diagnosis, adenoma or hepatocellular carcinoma (HCC) with fatty metamorphosis should be included (Figure 3).

Biliary hamartoma

Biliary hamartomas are frequently seen as multiple lesions 0.5-1.5 cm in diameter located in the subcapsular region (7, 8). They appear as hypointense in T1W images, hyperintense in T2W images, and show peripheral, thin, ring-like enhancement after IVCM administration in the arterial and venous phases. A suppressed liver and inflammation around the lesion are thought to be responsible for the perilesional enhancement. The features of hamartomas (generally smaller than 1 cm, thin, ring-like enhancement, lack of enhancement close to the center, and high fluid content) should be considered in the differential diagnosis of metastases (Figure 4).

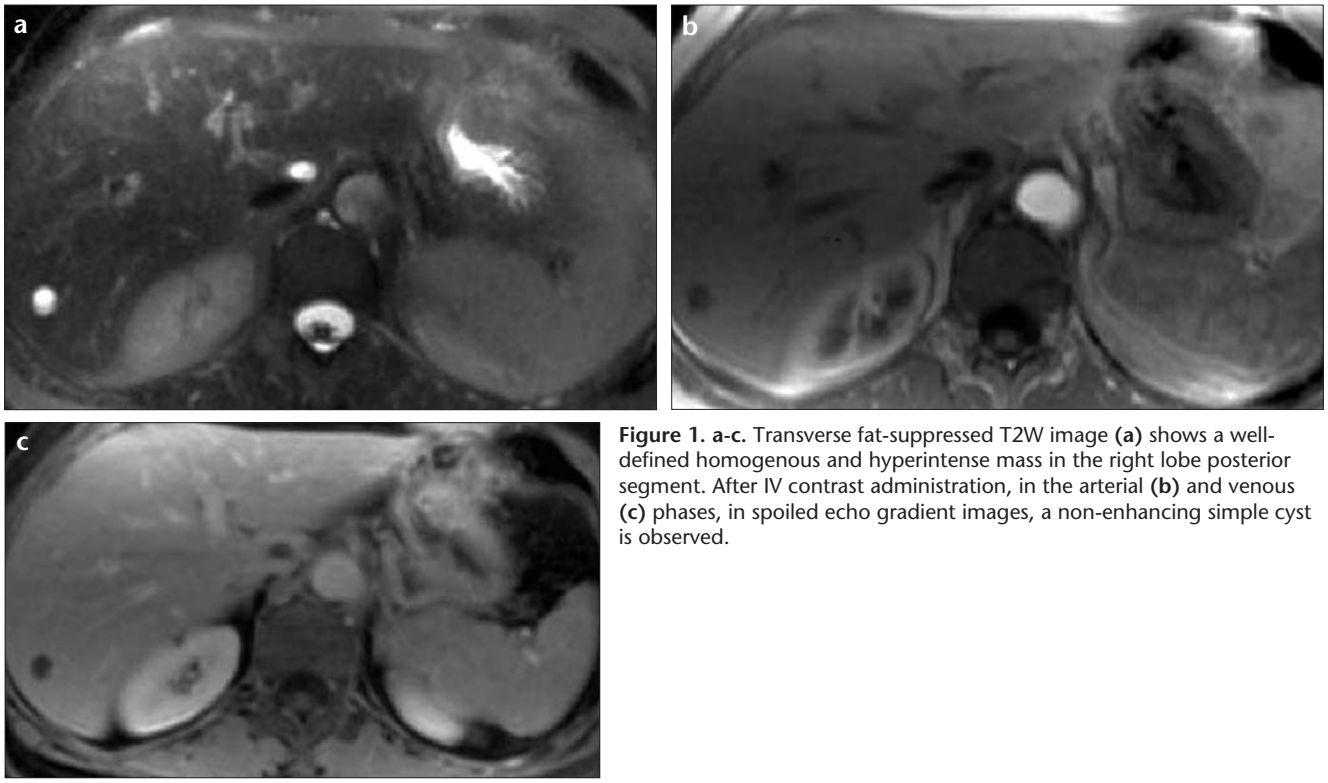

Figure 1. a-c. Transverse fat-suppressed T2W image **(a)** shows a well-defined homogenous and hyperintense mass in the right lobe posterior segment. After IV contrast administration, in the arterial **(b)** and venous **(c)** phases, in spoiled echo gradient images, a non-enhancing simple cyst is observed.

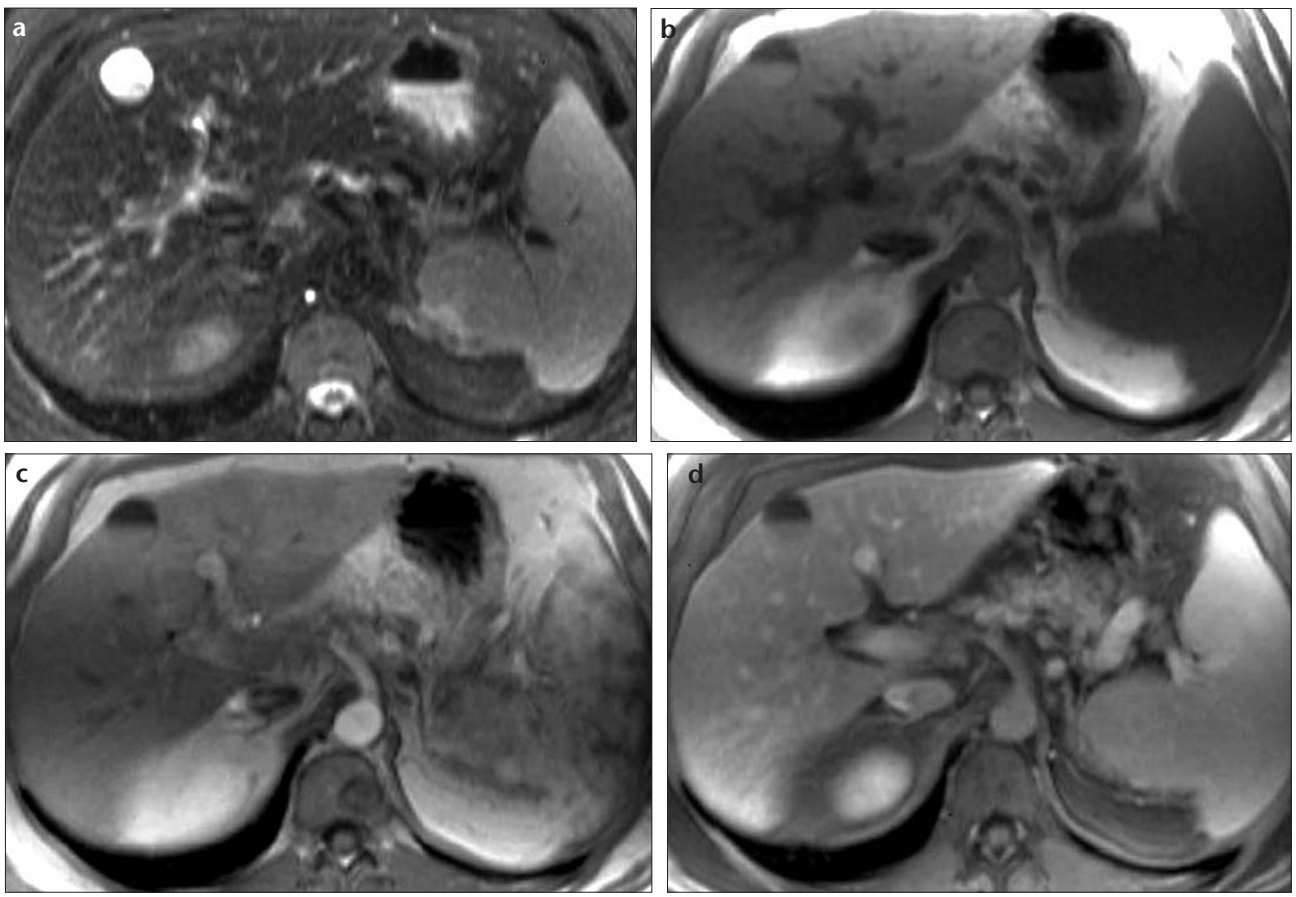

Figure 2. a-d. Transverse fat-suppressed T2W image **(a)** shows hyperintense lesion with high protein content levels in the intersegmental region. The lesion appears to be hypointense on transverse T1W image **(b)** and after IV contrast administration, in the arterial **(c)** and venous **(d)** phases, a ciliated hepatic foregut cyst that does not show significant enhancement in the wall and cyst content is observed (with the permission of Dr. Semelka).

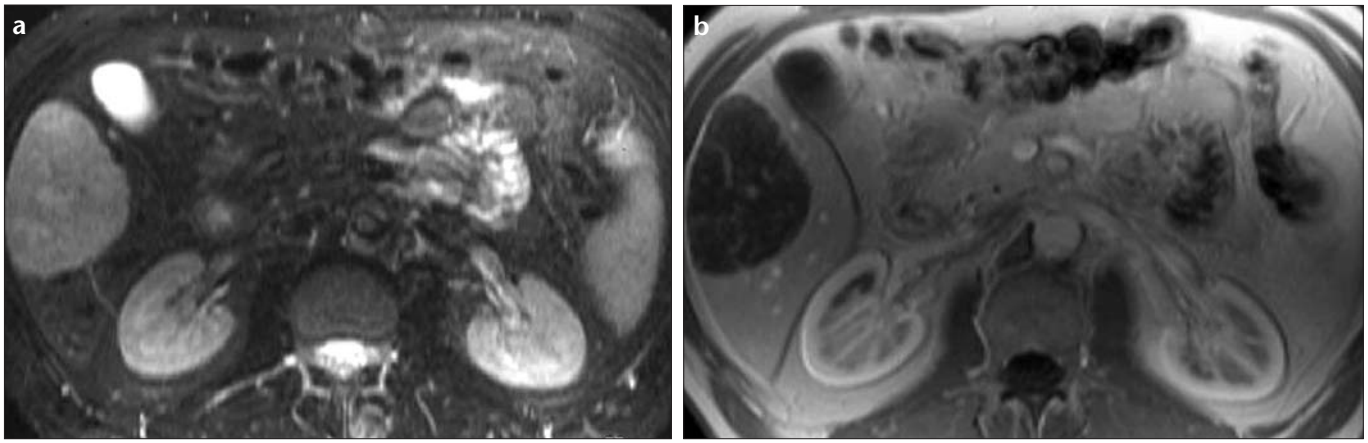

Figure 3. a, b. Transverse fat-saturated T2W image **(a)** shows an angioma with low vessel content that did not show significant signal loss and after IV contrast administration **(b),** wash-out in the 90th second is seen (with the permission of Dr. Semelka).

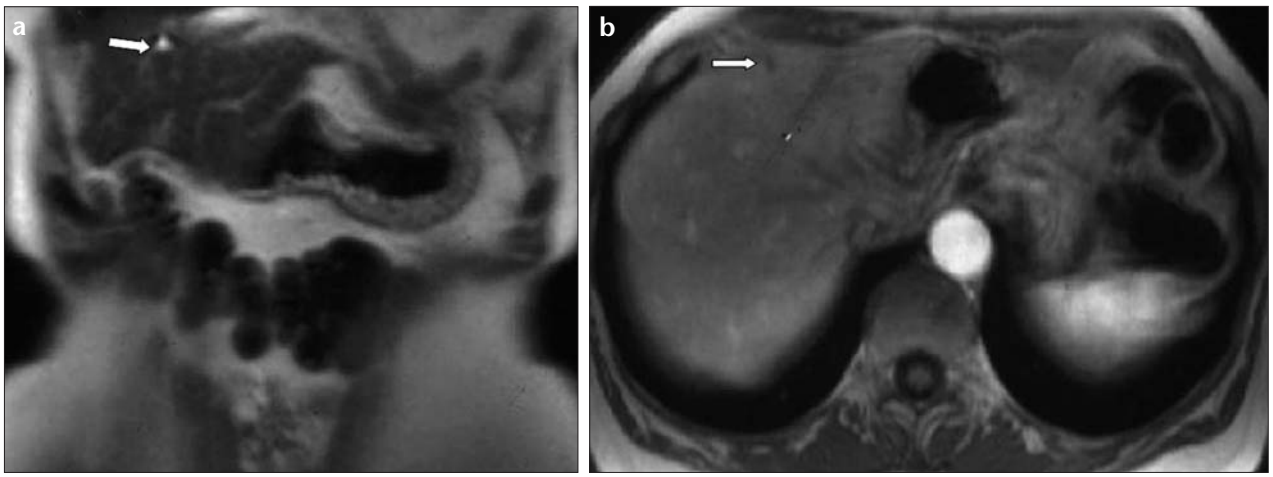

Figure 4. a, b. Coronal T2W image **(a)** shows a solitary subcapsular hyperintense hamartoma *(arrow)*. Following IV contrast administration, hypointense, peripheral, ring-like enhancement on T1W transverse image in the arterial phase **(b)** is observed *(arrow)*.

Hemangioma

Hemangiomas are the most common benign tumor of the liver and are mostly of the cavernous type. The prevalence of hemangiomas is 7-20% in autopsy series (1, 5). Hemangiomas may increase in size during pregnancy, secondary to estrogens; however, an increase in size should raise suspicion since they are known as stable lesions. Secondary to a high fluid content, they are observed as hypointense in T1W images and hyperintense in T2W images. Three types of contrast enhancement patterns are present in dynamic examinations: early homogenous enhancement and persistence of enhancement in the late phase (type 1); peripheral nodular enhancement, centripedal dynamic uniform enhancement (type 2); peripheral nodular enhancement, centripedal dynamic enhancement, and non-enhancing central scar tissue in the late phase (type 3). Following IVCM administration, peripheral, ring-like enhancing nodules, which do not persist in the arterial phase, centripedal enhancement that is maximal in 90th minute, an internal ring, which is prominent only in this phase, undulating nodular contour in the internal part of the ring, and heterogeneous or persistent enhancement without wash-out are important in the diagnosis of hemangiomas (8, 9) (Figure 5, 6).

Ring-like enhancement that is more evident 1 minute after IVCM is administered, wash-out of the contrast material, which causes a heterogeneous appearance, and observation of a uniform, thick ring are valuable in the differential diagnosis with hypervascular metastases (9). In addition, while small hemangiomas are hyperintense in T2W images, half of the metastases are hyperintense and the other half are isointense.

Focal nodular hyperplasia (FNH)

In 1995, an international study group classified FNH as a regenerative lesion in contrast to adenomas, which are classified as neoplastic lesions. They are a hyperplastic response secondary to preexisting vascular malformation (10, 11).

FNH is the second most common tumor, which accounts for 8% of primary hepatic tumors (12). They are hypo- or isointense on T1W images (94-100%) and mildly hyper- or isointense on T2W images (94-100%) (12). Central scar tissue in FNH (hyperintense in T2W images, hypointense in T1W images, and enhancement in the late phase after IVCM administration) is reported in 10-49% of cases. After IVCM is administered, rapid enhancement in the early arterial phase and washout in the late phase is observed, and central scar tissue shows late enhancement

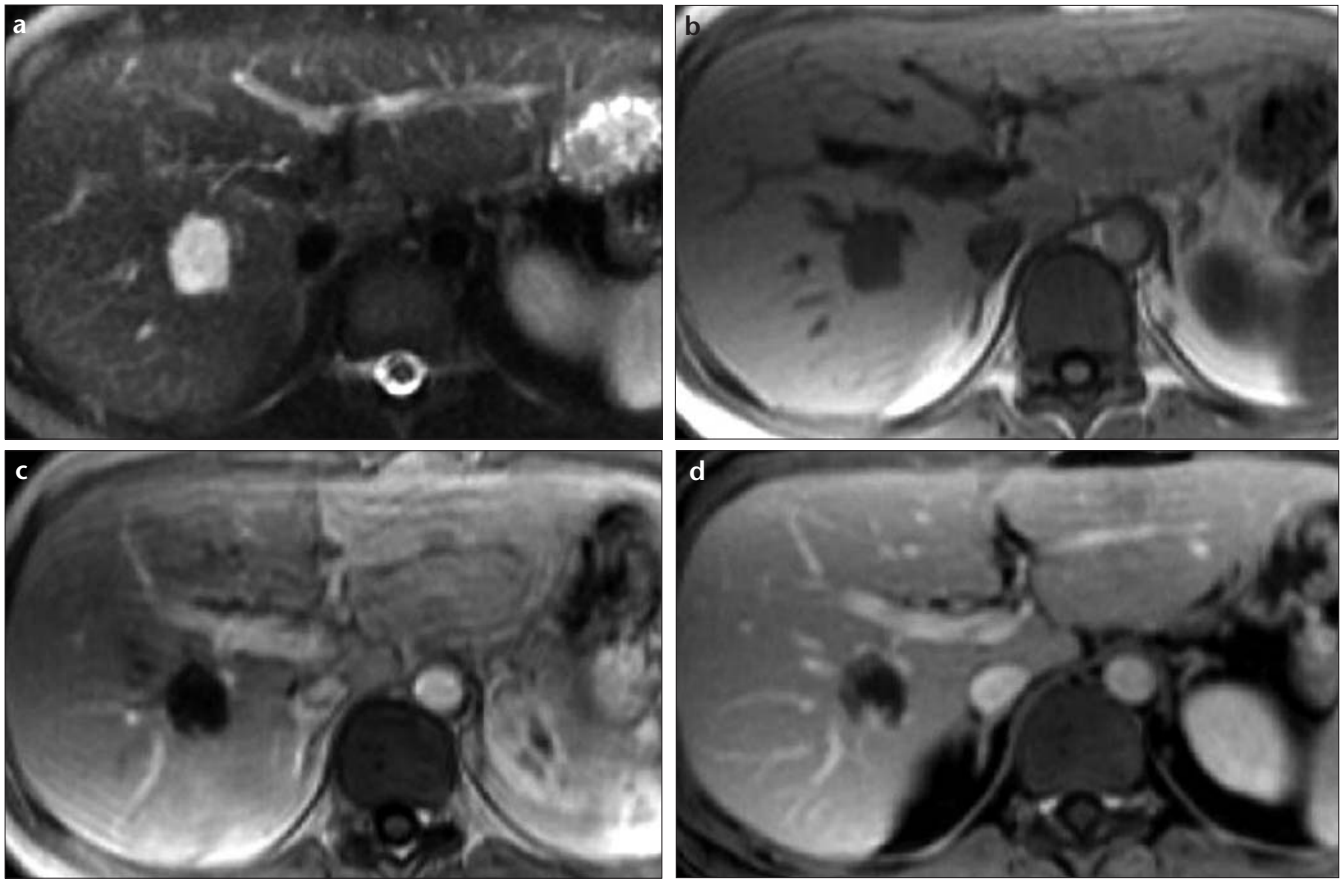

Figure 5. **a-d.** Transverse fat-suppressed T2W image **(a)** shows hyperintense hemangioma. On transverse T1W image **(b)** hypointensity is noted, and after IV contrast administration, in the arterial phase, spoiled echo gradient images reveal progressively and peripherally nodular enhancement pattern in arterial **(c)** and venous **(d)** phase.

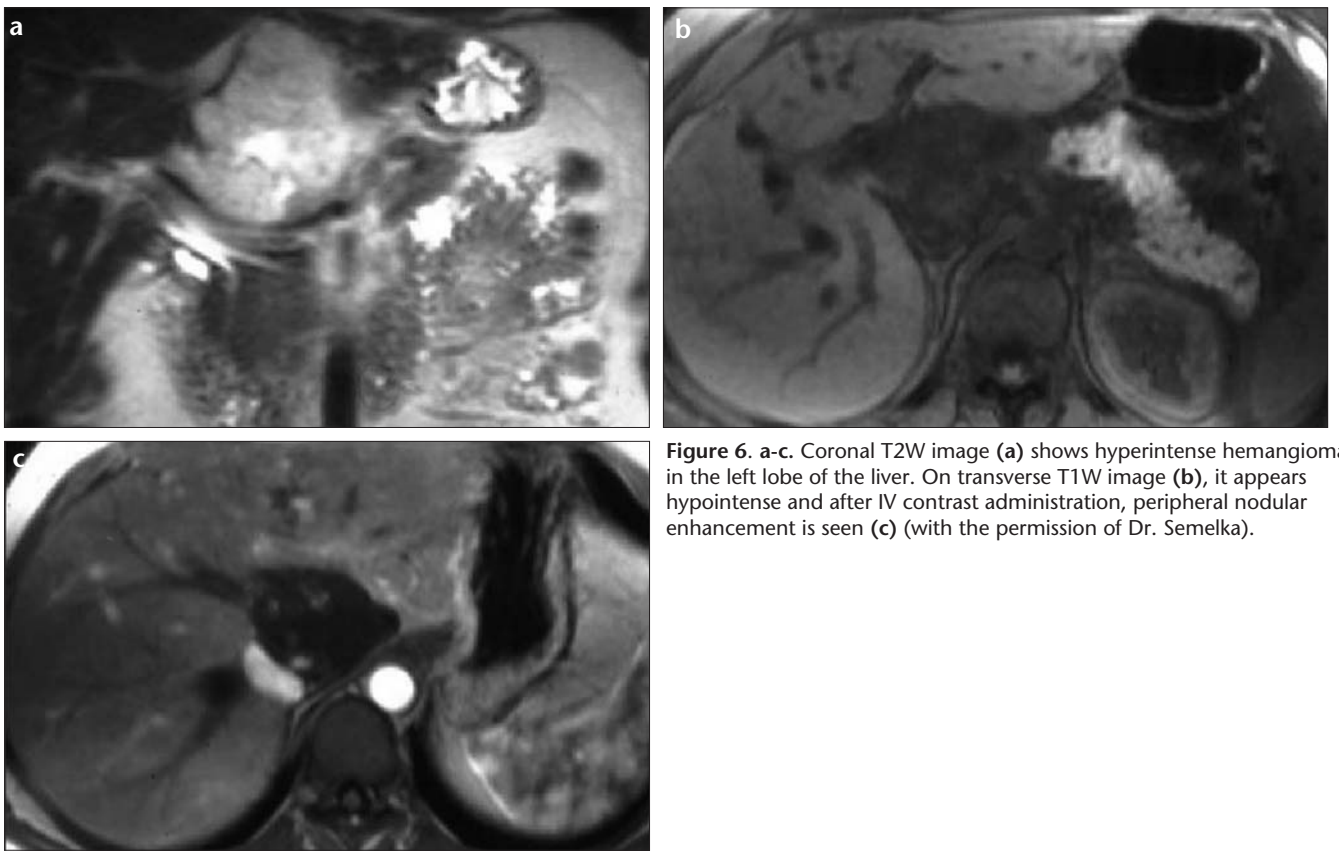

Figure 6. **a-c.** Coronal T2W image **(a)** shows hyperintense hemangioma in the left lobe of the liver. On transverse T1W image **(b)**, it appears hypointense and after IV contrast administration, peripheral nodular enhancement is seen **(c)** (with the permission of Dr. Semelka).

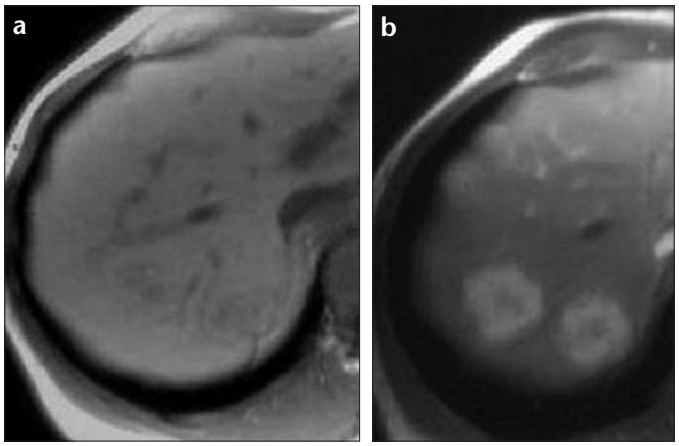

Figure 7. **a, b.** Transverse T1W image **(a)** shows two focal nodular hyperplasias, which are minimally hypointense. After IV contrast administration, in the arterial phase **(b)**, they show significant enhancement but no enhancement is observed in the central scar tissue.

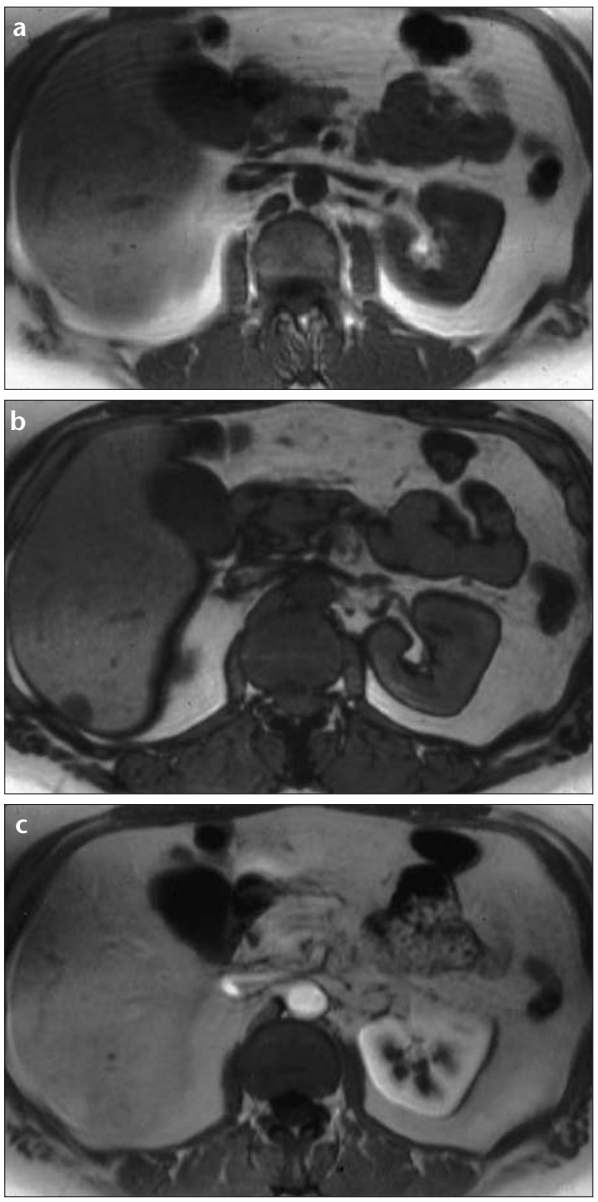

Figure 8. **a-c.** Transverse T1W image **(a)** shows adenoma as isointense to the surrounding parenchyma. It shows signal loss in out-of-phase images **(b)** and intensely enhances in the spoiled echo gradient images **(c)** after IV contrast administration.

(Figure 7). Central scar tissue, which is observed in giant hemangiomas, is larger and more intense. It is more homogenous in T2W images and shows peripheral nodular enhancement. Scar tissue observed in HCC, secondary to necrosis and calcification, shows low signal intensity in T1W and T2W images and does not show significant enhancement after IVCM administration.

Hepatocellular adenoma

The prevalence of hepatocellular adenomas, which are a rare liver tumor (3-4/100, 000) has increased, secondary to underlying metabolic disorders, and administration of both oral contraceptives and androgen steroids (13, 14). Necrosis and hemorrhage are common causes of pain. Diagnosis is important because of the risk of hemorrhage, and although rare, the possibility of malignant transformation. High signal intensity observed in T1W images is secondary to the high lipid and glycogen content (1, 5). Following IVCM administration, intense enhancement in the early arterial phase and fading in the late phase is typical. However, in cases of hepatic adenomatosis there may be heterogeneous enhancement (15). Differential diagnosis of adenoma and FNH is important to the choice treatment approaches. Adenoma is a true neoplasm consisting of normal or atypical hepatocytes, without Kupffer's cells or biliary ducts. There is no central scar and it enhances in a lesser intensity compared to FNH (16) (Figure 8).

Hepatocellular carcinoma (HCC)

The most common abdominal malignancy in the world is hepatocellular carcinoma (17 -19). Although HCC is frequently observed as hypointense in T1W images it may appear as hyper- or isointense because of hemorrhage and copper, glycogen, and high protein content (20). HCC is frequently observed as hyperintense in T2W images. However, well-differentiated HCCs are reported to be hypo- or isointense in T2W images. The intensity in T2W images is reported to be related to the grading of malignancy, and high-grade HCCs are reported to be more hyperintense (21).

After IVCM is administered, prominent enhancement in the arterial phase and heterogeneous washout in

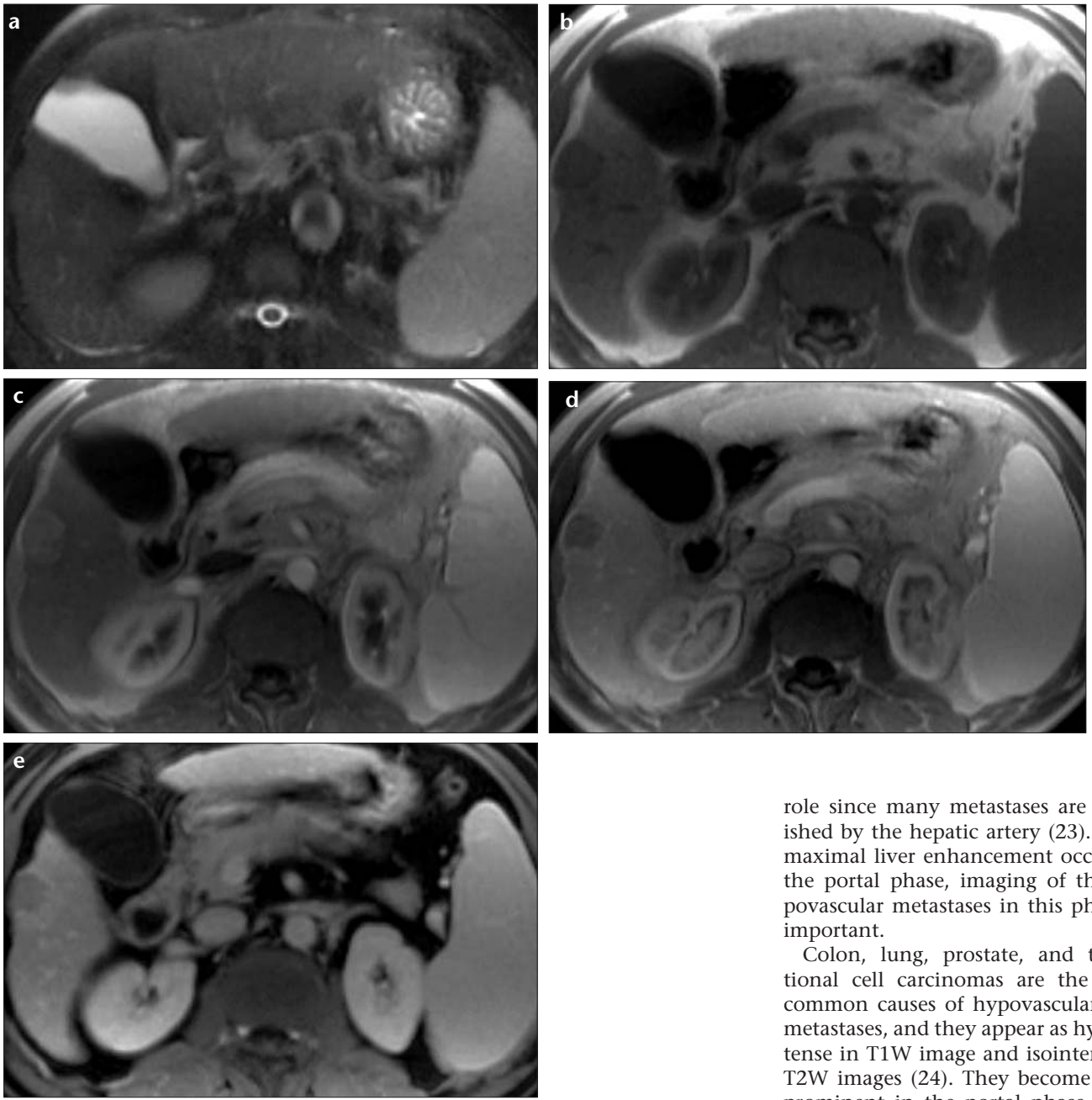

Figure 9. **a-e.** Transverse fat-suppressed T2W image **(a)** shows minimally hyperintense subcapsular hepatocellular carcinoma. Transverse T1W image **(b)** reveals the hypointense nature of the lesion. It intensely enhances after IV contrast administration in the arterial phase spoiled echo gradient image **(c)** and in the portal **(d)** and late venous phase **(e)** images, progressive capsular enhancement and central wash-out are seen (with the permission of Dr. Semelka).

the portal phase has a significant role in the diagnosis of HCC. For a diagnosis of HCC, the following are important: the lesion must be larger than 3 cm; hyperintense appearance in T2W images; intense enhancement in the arterial dominant phase; late washout; presence of capsule; the tendency to invade the portal and hepatic veins; rapid growth (22) (Figure 9).

Metastasis

The liver is the organ most frequently affected by metastasis following the lymph nodes (most frequently affected organ) because of dual blood flow, humoral factors maintaining cell growth, and the discontinuous structure of the hepatic sinusoids, which are related to the extracellular space of Disse. The hepatic arterial phase has an important role since many metastases are nourished by the hepatic artery (23). Since maximal liver enhancement occurs in the portal phase, imaging of the hypovascular metastases in this phase is important.

Colon, lung, prostate, and transitional cell carcinomas are the most common causes of hypovascular liver metastases, and they appear as hypointense in T1W image and isointense in T2W images (24). They become more prominent in the portal phase when maximal liver enhancement occurs. Because of their sensitivity to gadolinium-based contrast materials, it should be taken into consideration that peripheral enhancement may also be detected in hypovascular metastases. Rarely, hypovascular metastases have high fluid content and may mimic hepatic cysts. While in late post-contrast images the borders of metastases lose their clarity and become smaller because of peripheral enhancement, these changes are not observed in the cysts (24).

Hypervascular metastases like islet cell tumors, breast carcinoma, carcinoid and melanoma, thyroid cancer,

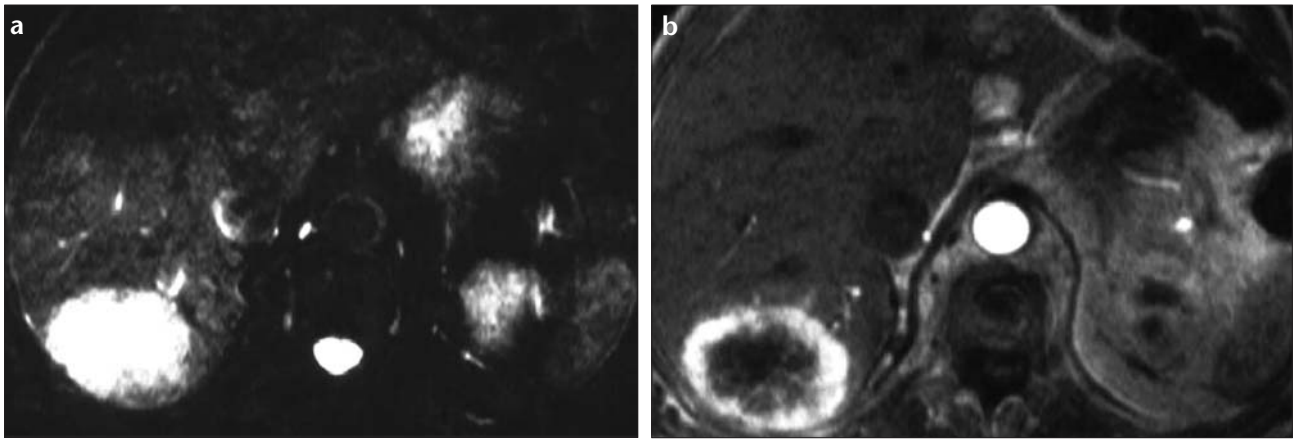

Figure 10. a, b. Transverse fat-supressed T2W image **(a)** shows hyperintense metastatic mass due to renal cell carcinoma. Following IV contrast, lesion demonstrates intense enhancement at the periphery **(b)**.

and renal cell carcinoma enhance in the hepatic arterial phase (24) (Figure 10).

References

1. Bartolozzi C, Cioni D, Donati F, Lencioni R. Focal liver lesions: MR imaging-pathologic correlation. Eur Radiol 2001; 11:1374-1388.
2. Semelka RC, Braga L, Pedro MS. Liver. In: Semelka RC, ed. Abdominal and Pelvic MRI. New York: Wiley-Liss, 2002.
3. Rossai J. Ackermen's Surgical Pathology. 8th ed. Vol 1. St Louis: Mosby, 1995.
4. Hogemann D, Flemming P, Kreipe H, Galanski M. Correlation of MRI and CT findings with histopathology in hepatic angiomyolipoma. Eur Radiol 2001; 11:1389-1395.
5. Tsui WM, Colombari R, Portmann BC, et al. Hepatic angiomyolipoma: a clinicopathologic study of 30 cases and delineation of unusual morphologic variants. Am J Surg Pathol 1999; 23:34-48.
6. Semelka RC, Hussain SM, Marcos HB, Woosley JT. Biliary hamartomas: solitary and multiple lesions shown on current MR techniques including gadolinium enhancement. J Magn Reson Imaging 1999; 10:196-201.
7. Thommesen N. Biliary hamartomas (von Meyenburg complexes) in liver needle biopsies. Acta Pathol Microbiol Scand 1978; 86:93-99.
8. Semelka RC, Sofka CM. Hepatic hemangiomas Magn Reson Imaging Clin N Am 1997; 5:241-253.
9. Semelka RC, Brown ED, Ascher SM, et al. Hepatic hemangiomas: a multi-institutional study of appearance on T2-weighted and serial gadolinium-enhanced gradient-echo MR images. Radiology 1994; 192:401-406.
10. International Working Party. Terminology of nodular hepatocellular lesions. Hepatology 1995; 22:983-993.
11. Kerlin P, Davis GL, McGill DB, et al. Hepatic adenoma and focal nodular hyperplasia: clinical, pathologic, and radiologic features. Gastroenterology 1983; 84:994-1002.
12. Mortelé KJ, Praet M, Van Vlierberghe H, Kunnen M, Ros PR. CT and MR imaging findings in focal nodular hyperplasia of the liver: radiologic-pathologic correlation. AJR Am J Roentgenol 2000; 175:687-692.
13. Shortell CK, Schwartz SI. Hepatic adenoma and focal nodular hyperplasia. Surg Gynecol Obstet 1991; 173:426-431.
14. Bader TR, Braga L, Semelka RC. Exophytic benign tumors of the liver: appearance on MRI. Magn Reson Imaging 2001; 19:623-628.
15. Ruppert-Kohlmayr AJ, Uggowitzer MM, Kugler C, Zebedin D, Schaffler G, Ruppert GS. Focal nodular hyperplasia and hepatocellular adenoma of the liver: differentiation with multiphasic helical CT. AJR Am J Roentgenol 2001; 176:1493-1498.
16. Baron RL, Peterson MS. From the RSNA refresher courses: screening the cirrhotic liver for hepatocellular carcinoma with CT and MR imaging: opportunities and pitfalls. Radiographics 2001; 21:117-132.
17. Kadoya M, Matsui O, Takashima T. Hepatocellular carcinoma: correlation of MR imaging and histopathologic findings. Radiology 1992; 183:819-825.
18. Hussain SM, Zondervan PE, Zermans JN, et al. Benign versus malignant hepatic nodules: MR imaging findings with pathologic correlation. Radiographics 2002; 22:1023-1036.
19. Ward J, Robinson PJ. How to detect hepatocellular carcinoma in cirrhosis. Eur Radiol 2002; 12:2258-2272.
20. Ebara M, Fukuda H, Kojima Y . Small hepatocellular carcinoma: relationship of signal intensity to histopathologic findings and metal content of the tumor and surrounding hepatic parenchyma. Radiology 1999; 210:81-88.
21. Tsai TJ, Chau GY, Lui WY, et al. Clinical significance of microscopic tumor venous invasion in patients with resectable hepatocellular carcinoma. Surgery 2000; 127:603-608.
22. Nonomura A, Mizukami Y, Muraoka K, Yajima M, Oda K. Angiomyolipoma of the liver with pleomorphic histological features. Histopathology 1994 ; 24:279-281.
23. Oliver JH 3rd, Baron RL, Federle MP, Jones BC, Sheng R. Hypervascular liver metastases: do unenhanced and hepatic arterial phase CT images affect tumor detection? Radiology 1997; 205:709-715.
24. Pedro MS, Semelka RC, Braga L. MR imaging of hepatic metastases. Magn Reson Imaging Clin N Am 2002; 10:15-29.