Magnetic resonance imaging of hepatic neoplasms

MARK T. DIMARCANGELO, DO

Excellent diagnostic images of the liver can now be obtained with magnetic resonance imaging (MRI) because of new imaging techniques. The flow void phenomenon allows excellent anatomic detail of the liver. Morphologic features, comparson of tumor signal to normal parenchymal signal, and tumor behavior in various pulse sequences help to define liver tumors. The MRI characteristics of primary hepatomas, cavernous hemangiomas, hepatic cysts, liver adenomas, and focal nodular hyperplasia are among the hepatic lesions described. In most instances, MRI helps in differential considerations and in some cases will provide a specific diagnosis.

(Key words: Liver diseases, liver neoplasms, magnetic resonance imaging, diagnostic imaging, radiology)

The scope of clinical radiologic practice has increased exponentially over the past two decades. Radiologists have been transmuted from mere film interpreters and purveyors of barium to elite diagnosticians, imaging specialists, and interventionalists. Ultratechnologic advances have played the leading role in the whirlwind evolution of diagnostic radiology. One of the most recently developed, and perhaps the most intriguing of the high-technology modalities to emerge on the scene, is magnetic resonance imaging (MRI).

Magnetic resonance imaging has received high acclaim and wide acceptance by radiologists as well as the medical community at large. When compared with its clinical predecessor, computed tomography (CT), MRI has multiple advantages including the following: multiplanar imaging; no ionizing radiation; excellent contrast resolution of the soft tissue structures; lack of dependency on intravenous iodinated contrast agents with their attendant adverse effects; and the acquisition of important physiochemical data. The present disadvantages of MRI when compared with CT are the following: prolonged scanning time; artifacts secondary to physiologic motion; diminished detectability of calcium; inducement of claustrophobia; and problems arising from implanted metallic devices.

The purpose of this article is to acquaint the nonradiologist clinician with the implementation of MRI in the diagnosis of hepatic diseases, specifically those presenting as space-occupying lesions. The use of MRI in liver disorders has lagged behind other applications such as brain, spine, and musculoskeletal diseases predominantly because of technical glitches stemming from physiologic motion including respirations, cardiovascular pulsations, and peristalsis.[1] These involuntary processes act synergistically to reduce the magnetic resonance signal and increase noise levels, which consequently degrade the computer-generated images. Fortunately, newer imaging techniques

Dr DiMarcangelo is attending radiologist, Department of Diagnostic Radiology and Nuclear Medicine, Cooper Hospital/University Medical Center, and clinical assistant professor of radiology, Robert Wood Johnson Medical School, University of Medicine and Dentistry of New Jersey, Camden.

Reprint requests to Mark T. DiMarcangelo, DO, MSc, Department of Diagnostic Radiology and Nuclear Medicine, One Cooper Plaza, Camden, NJ 08103.

have been devised to improve the signal-to-noise ratios of upper abdominal MRI scans. By manipulating various imaging parameters, excellent diagnostic images of the liver may be obtained.

Liver anatomy

Excellent anatomic detail of the liver is rendered by MRI particularly because of the flow void phenomenon. The dynamic movement of plasma within the vascular lumina makes the scanner unable to detect any signal, so the vessels appear dark on the obtained images (*Figures 1* and *2*). A detailed discussion of the physical principles of MRI is beyond the scope of this paper, but if the reader desires such, the medical literature is replete with information on this topic.[2] The signal void phenomenon allows the portal and hepatic veins to be visualized without the administration of intravenous contrast media. The hepatic veins are usually three in number and course within the intersegmental fissures; that is, the right hepatic vein defines the right intersegmental fissure, the left hepatic vein delineates the left intersegmental fissure, and the middle hepatic vein runs within the interlobar fissure demarcating the right and left hepatic lobes proper. The portal veins, as well as the hepatic arteries and biliary radicles, branch intrasegmentally. These three structures are known as the portal triad. Thus, the right portal vein branches within the anterior and posterior segments of the right hepatic lobe, and the left portal vein divides within the medial and lateral segments of the left hepatic lobe. The bile ducts and small hepatic arteries are not demonstrated discretely on MRI in the healthy patient.

Magnetic resonance imaging delineation of hepatic segments is an important consideration in assessing the location and the extent of neoplastic disease and aids the surgeon who is planning lesion resection, such as subtotal hepatectomy. Normal hepatic parenchyma is homogeneous in signal intensity, and the liver is smooth in contour. Mass effect, pathologic alteration of liver tissue, contour irregularities, perihepatic fluid collections, vascular abnormalities, biliary disease, and other abnormalities may be depicted on MRI. The extent of tumor involvement and extrahepatic lesions can be surveyed in detail because of the multiplanar capability of MRI.

Imaging of hepatic lesions

Magnetic resonance imaging has a high degree of sensitivity in the detection of parenchymal masses. In fact, recent study has indicated that MRI is more sensitive than contrast-enhanced CT in detecting metastatic diseases, which are the most common malignant neoplasms involving the liver.[3] In some tumors, MRI examination can allow a specific diagnosis to be made or may suggest certain differential diagnostic considerations. Factors that are required to characterize liver tumors include morphologic features, comparison of tumor signal to normal parenchymal signal, and the behavior of the tumor in various pulse sequences (for example, T1 and T2 spin-echo pulse sequences). Areas of increased water content (that is, edema, cystic entities, and necrosis) appear hypointense on T1-weighted pulse sequences and hyperintense on T2-weighted pulse sequences. Other biochemical changes within tumors, such as hemorrhage, melanin, scarring, and iron, can be suggested on T1- and T2-weighted images.

Hepatic metastases in most cases are multiple, are found in both lobes, and are present in both the intraparenchymal and subcapsular locations. Metastatic lesions are usually hypointense on T1-weighting and hyperintense on T2-weighting with respect to the surrounding normal parenchymal intensity. Metastatic foci are not as intense as cerebrospinal fluid or bile within the gallbladder lumen on T2-weighted scans in the vast majority of cases (*Figure 3*). Metastases like other neoplasms have this appearance primarily because of extracellular water and peritumoral edema. Among a wide variety of primary tumors, the three most common to metastasize to the liver are bronchogenic, colonic, and breast adenocarcinomas.

In certain rare instances, metastases may have intensities similar to bile or cerebrospinal fluid. Such intensities are due to one or more of the following circumstances: (1) subacute or chronic hemorrhage; (2) necrosis; or

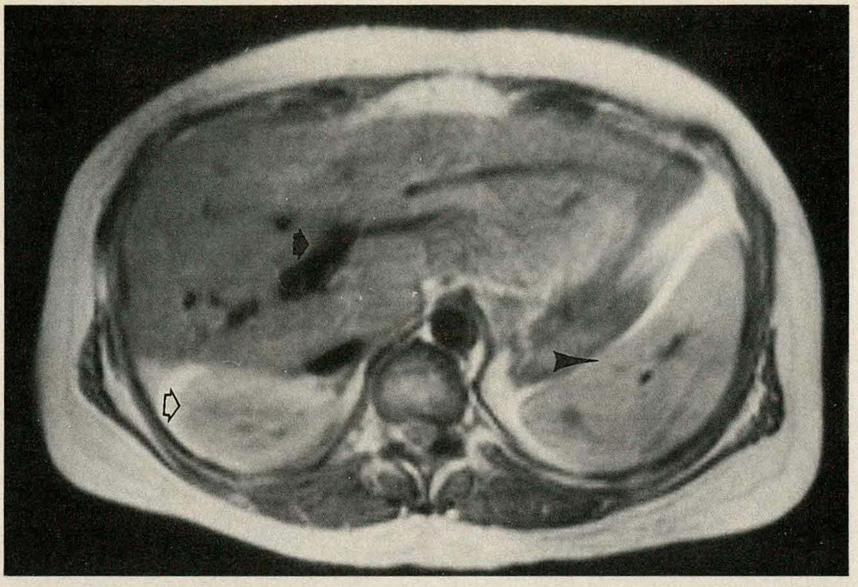

Figure 1. *Axial T1-weighted scan of upper part of abdomen. Signal void is seen within a hepatic vessel (*arrow*).* Open arrow *indicates right kidney;* arrowhead *indicates spleen.*

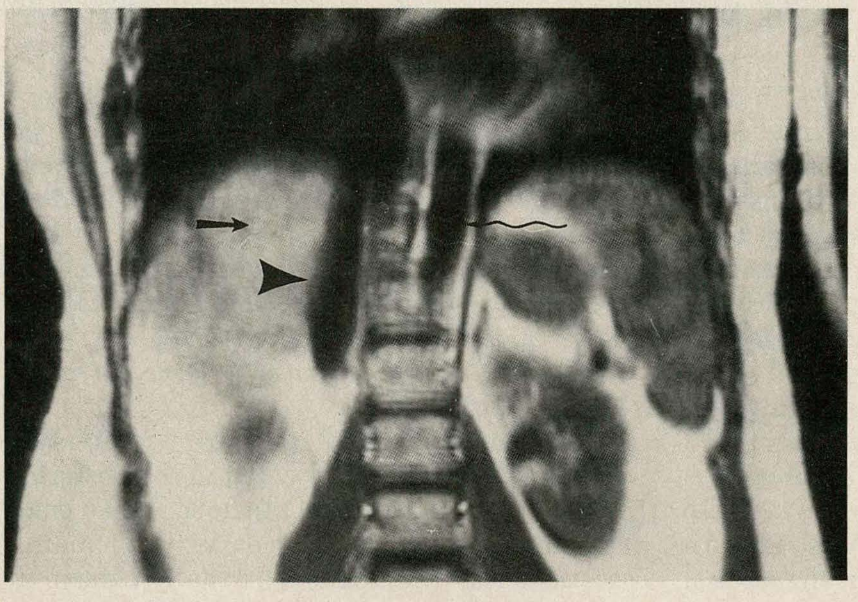

Figure 2. *Coronal T1-weighted image through lower portion of chest and upper part of abdomen. Lungs appear dark because air does not produce a signal.* Arrow *indicates liver. Abdominal vessels (*arrowhead, *inferior vena cava;* wavy arrow, *aorta) are well visualized secondary to signal void phenomenon.*

(3) highly vascular components.[3] In such cases, differentiation from other entities such as hemangiomas and cysts is rather difficult. Delineation of lesion signal intensity will be discussed further in regard to hepatic cavernous hemangiomas.

In many instances, metastases have an intense outer ring and a less intense inner core particularly evident on T2-weighted scans. These are dubbed "target lesions," and it is believed that the hyperintense outer aspect is based on a halo of edema surrounding the metastatic focus. Unfortunately, this is a nonspecific finding and can be visualized in other entities including abscesses. Small metastatic lesions may be difficult to resolve in the presence of intrahepatic ductal ectasia.

Primary hepatomas, the most common of the primary liver neoplasms, may be unifocal, multifocal, or diffusely infiltrating. Primary hepatocellular carcinoma is more prevalent on the African and Asian continents where hepatitis is ubiquitous. Hepatomas are most commonly associated with alcoholic liver disease in the United States. On T1-weighting, approximately 40% of hepatomas show a hypointense rim or pseudocapsule, suggesting that the histologic grade is low and that they may be more

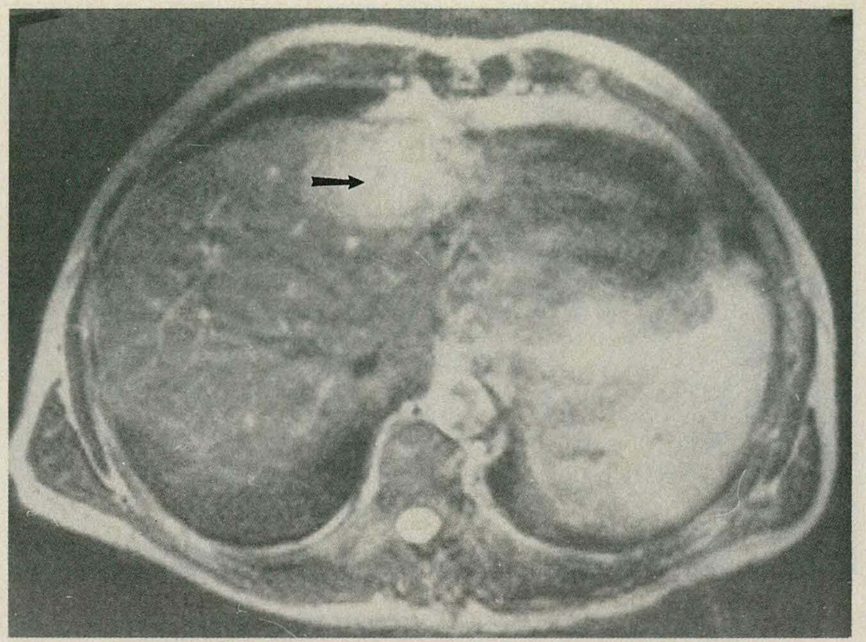

Figure 3. *Axial T2-weighted image demonstrates relatively hyperintense lesion in left hepatic lobe, consistent with metastatic disease.*

easily excised (*Figure 4*).[4] A certain number of these lesions are somewhat hyperintense on T1-weighted sequences, most likely because of increased lipid concentration.[4] Hepatomas are the only known solid neoplasms of the liver that have this MRI appearance. The following MRI morphologic and signal characteristics aid in the differential diagnosis of hepatomas: (1) presence of a thin pseudocapsule; (2) existence of satellite lesions; and (3) tumor involvement of the hepatic venous system. In the majority of cases, hepatomas are isointense or hypointense on T1-weighting and are invariably hyperintense on T2-weighting. Most hepatomas demonstrate evidence of central necrosis.

Cavernous hemangiomas are the most frequently occurring benign liver masses; they are present in 7% to 20% of the general population.[5] Because of their prevalence, hemangiomas must be differentiated from malignancy in oncology patients. Ultrasonography, dynamic CT, and technetium-labeled red blood cell single photon emission CT imaging are helpful for identifying hemangiomas, although these diagnostic modalities fall quite short of 100% specificity. Magnetic resonance imaging can increase the accuracy rate of hemangioma detection if certain criteria are satisfied.[6]

Histologically, cavernous hemangiomas are abnormally dilated vascular networks that allow very slow percolation of blood, which does not result in the signal void phenomenon. The "classic" cavernous hemangioma would portray the following findings on MRI: (1) lobulated, smooth contour; (2) homogeneity of signal on both T1- and T2-weighted scans; (3) very high signal intensity on T2-weighted images; and (4) increasing hyperintensity as the T2-weighting is accelerated, referred to as the "light bulb" sign.[5]

Cavernous hemangiomas are usually solitary and typically are located in the posterior segment of the right hepatic lobe. When compared with solid hepatic neoplasms (including metastases), hemangiomas usually behave in a unique fashion on MRI. On T1-weighting, they are more hypointense than solid lesions. On T2-weighting, they have hyperintensity that rivals the appearance of cerebrospinal fluid and of bile (*Figure 5*). Only a few solid neoplasms, chiefly metastatic endocrine tumors and certain sarcomas, appear similar to cavernous hemangiomas on MRI. If hemangiomas are greater than 6 cm in diameter, they are usually heterogeneous in signal intensity because of underlying thrombosis or fibrosis (or both). Despite early optimism, MRI does not always provide the radiologist with a clear-cut diagnosis and, in such cases, percutaneous needle biopsy cannot be avoided. Biopsy of a

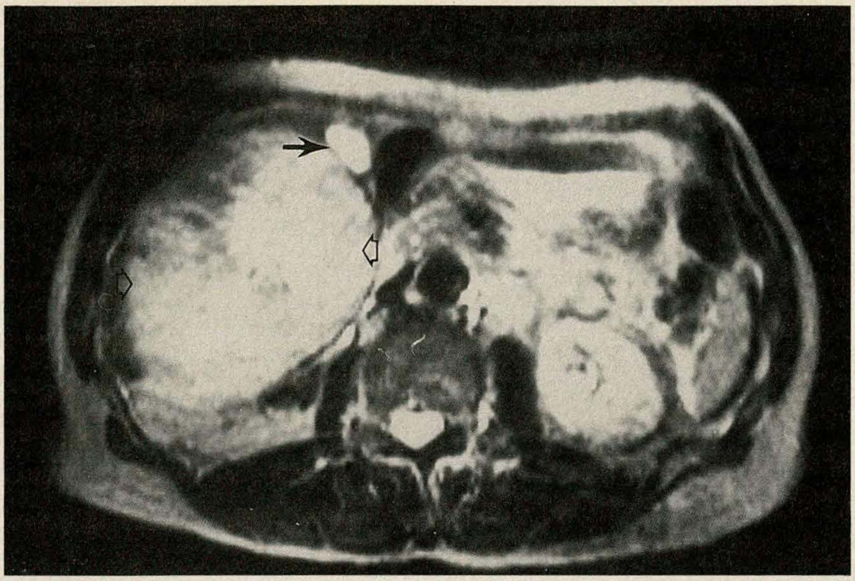

Figure 4. *Axial T2-weighted scan demonstrates large lesion with hypointense rim comprising most of hepatic volume, representing hepatoma (*open arrows*).* Arrow *indicates gallbladder.*

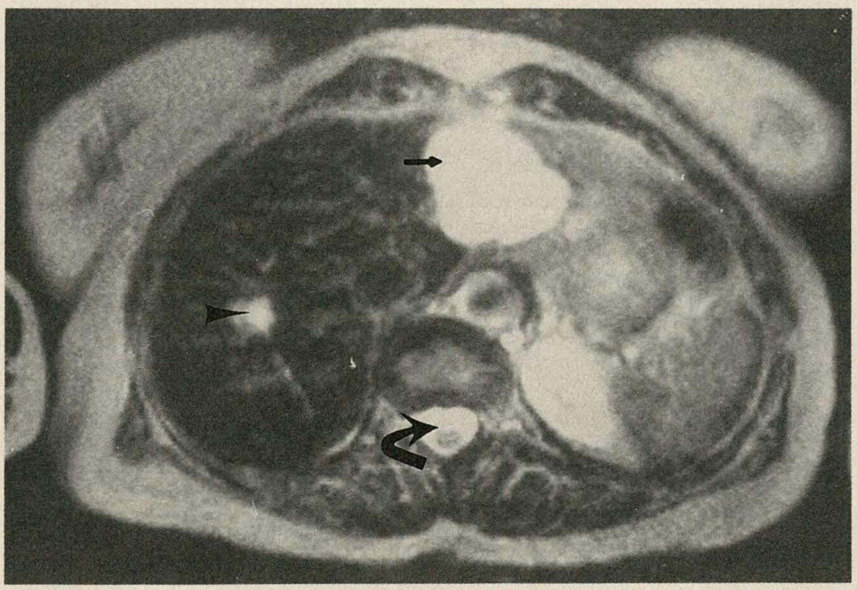

Figure 5. *Axial T2-weighted image demonstrating large hemangioma in left hepatic lobe (*straight arrow*) and smaller hemangioma in right hepatic lobe (*arrowhead*). These lesions have signal similar to that of cerebrospinal fluid in subarachnoid space (*curved arrow*).*

cavernous hemangioma is not without an attendant risk of hemorrhage.

Simple hepatic cysts, which have characteristic findings on ultrasonography and CT, are usually indistinguishable from hemangioma on MRI with regard to their signal intensities. On T1-weighted scans, they are more hypointense than solid lesions, and on T2-weighted scans, they are brighter than solid lesions, with intensity similar to that of cerebrospinal fluid. Cysts are best diagnosed with ultrasonography and, in most cases, patients who undergo MRI of the liver have had ultrasonography or CT (or both). Complex hepatic cysts may be difficult to diagnose on MRI and are best evaluated by ultrasonography, which allows differentiation between cysts and solid tumors. Cysts may be complicated by hemorrhage or infection. Also, small, simple cysts may be hard to resolve on MRI because of respiration-related volume averaging and artifacts.

Hepatic adenomas tend to occur in premenopausal women who have a history of oral contraceptive usage. Adenomas are hypervascular and usually are clinically dormant unless there is hemorrhage. Spontaneous hemorrhage will incite right upper quadrant pain. Adenomas are rarely multifocal and are typically well encapsulated. If they are hemorrhagic, they will appear hyperintense on T1-weighted images. On T2-weighted images, these lesions are hyperintense with a thin hypointense rim. One may detect central areas of hypointensity within these masses due either to central scar formation or to vascular flow void.

Focal nodular hyperplasia is a benign disorder of the liver that more often affects women than men. It is characterized by a centrally positioned scar, which is usually of a stellate or spoke-wheel configuration. In many instances, focal nodular hyperplasia is isointense with the remainder of the liver parenchyma. These lesions are diagnosed by the recognition of mass effect on the vasculature. The identification of a central scar does not always indicate the existence of focal nodular hyperplasia because other lesions are associated with cicatricial reaction. These lesions include adenomas, hemangiomas, hepatomas, abscesses, cirrhosis, and fibrolamellar carcinoma.

Lymphomatous involvement of the liver may have either a diffuse or a focal pattern. The focal pattern is characterized by fairly well-circumscribed masses that have a nonspecific appearance. Diffuse liver involvement may not show any definite abnormality on MRI because such lymphoma microscopically invades the periportal tissues.

Hemangioendotheliomas, liver lesions that are seen in the neonatal period, are a cause of high-output congestive heart failure because of arteriovenous shunting. On MRI, these masses are well delineated, lobular, and demonstrate signal void because of the aberrant vasculature. Hepatoblastomas are the most common primary liver tumors in newborn infants. Hepatoblastomas demonstrate lobular contours and hemorrhage.

Comment

Magnetic resonance imaging is a useful adjunct in clinical diagnosis of space-occupying lesions of the liver. In certain instances, specific diagnoses may be elicited, and in most cases the differential considerations can be narrowed to a select few. It is conceivable that further refinements in the MRI system in the future will increase the sensitivity and specificity of this modality in hepatologic diagnosis.

References

1. Mattrey R, Trambert M, Edelman RR: MR imaging of the upper abdomen and adrenal glands, in Edelman RR, Hesselink JR (eds): *Clinical Magnetic Resonance Imaging*. Philadelphia, Pa, WB Saunders Co, 1990, pp 845-898.
2. Fisher MR, Wall SD, Hricak H, et al: Hepatic vascular anatomy on MRI. *AJR* 1985;144:739-746.
3. Ferrucci JT, Freeny PC, Stark DD, et al: Advances in hepatobiliary radiology. *Radiology* 1988;168:319-338.
4. Itoh K, Nishimura K, Togashi K: Hepatocellular carcinoma: MR imaging. *Radiology* 1987;164:21-25.
5. Weissleder R, Stark DD: *MRI Atlas of the Abdomen*. London, UK, Martin Dunitz Ltd, 1989, pp 25-99.
6. Ferrucci JT: MR imaging of the liver. *AJR* 1986;147:1103-1116.