MR Imaging of Benign Focal Liver Lesions

Jonathan R. Cogley, MD[a], Frank H. Miller, MD[b,*]

KEYWORDS

• Liver • Hepatic MR imaging • Diffusion-weighted imaging • Hemangioma
• Focal nodular hyperplasia (FNH) • Hepatic adenoma • Liver abscess • Biliary cystadenoma

KEY POINTS

- Magnetic resonance (MR) imaging is helpful for definitive characterization of various solid and cystic hepatic lesions.
- MR imaging also provides important information about the background liver parenchyma, biliary tree, and hepatic vasculature.
- Diffusion-weighted imaging in the liver can be particularly helpful for detection of otherwise subtle lesions and for the diagnosis of pyogenic abscesses.
- Diffusion-weighted imaging alone cannot differentiate between solid benign hepatocellular lesions and malignant lesions, as both can exhibit restricted diffusion with overlap between their respective apparent diffusion coefficient values.
- Hepatocyte-specific contrast agents are helpful for the differentiation of focal nodular hyperplasia and hepatocellular adenoma, two lesions with overlapping imaging features and patient populations, but with potential management implications depending on the diagnosis.

INTRODUCTION

Focal liver lesions are increasingly encountered during routine imaging studies because of advances in technology and more widespread use of imaging. The great majority of lesions are benign in patients with noncirrhotic livers; however, many are indeterminate at the time of initial discovery. Definitive characterization by magnetic resonance (MR) imaging may alleviate patient anxiety, drastically alter management in someone undergoing staging for malignancy, and help avoid unnecessary biopsy or costly follow-up imaging.

MR imaging offers important advantages over computed tomography (CT), such as the lack of ionizing radiation and improved soft tissue contrast. The American College of Radiology Appropriateness Criteria[1] assigns the highest rating to MR imaging without and with contrast for characterization of indeterminate liver lesions, regardless of whether the patient is otherwise healthy, has liver disease, or has a known extrahepatic malignancy. This review presents a standardized approach to liver MR imaging while detailing common and less common benign focal liver lesions and their imaging characteristics.

MR IMAGING TECHNIQUE

Protocol

The goal of a dedicated liver MR imaging is to fully assess any focal lesions and provide valuable information about the background liver parenchyma, biliary system, and vasculature. This is

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[a] Section of Body Imaging, Department of Radiology, Northwestern Memorial Hospital, Northwestern University Feinberg School of Medicine, 676 North Saint Clair Street, Suite 800, Chicago, IL 60611, USA; [b] Department of Radiology, Northwestern University Feinberg School of Medicine, Northwestern Memorial Hospital, 676 North Saint Clair Street, Suite 800, Chicago, IL 60611, USA
* Corresponding author.
E-mail address: fmiller@northwestern.edu

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accomplished by using a wide range of fluid-sensitive and anatomic pulse sequences, including dynamic contrast-enhanced images that allow for improved lesion detection and characterization (Table 1). Enhancement depends on both the nature of the lesion and timing of imaging with respect to the contrast bolus.[2] Images are routinely obtained during hepatic arterial, portal venous, and equilibrium (equal distribution of contrast among the intravascular and extravascular extracellular compartments) phases. Magnetic resonance cholangiopancreatography (MRCP) images can be obtained to better evaluate the biliary tree. Patient cooperation with breath-holding instructions is required to achieve high-quality images.

Contrast Agents

Gadolinium contrast agents have strong paramagnetic effects that shorten predominately the T1 relaxation times of tissues, leading to increased signal intensity (enhancement) on T1-weighted images.[3] The 2 main categories of contrast agents used for liver MR imaging are (1) extracellular and (2) hepatocyte-specific. Extracellular contrast agents are more widely used, providing information on the pattern and degree of enhancement analogous to iodinated contrast agents for CT. After intravenous injection, they circulate the vascular system and are distributed into extracellular spaces before undergoing renal excretion. Hepatocyte-specific contrast agents provide this extracellular dynamic information plus unique additional delayed phase information. On delayed images, tumors of hepatocellular origin with functioning hepatocytes and biliary excretion take up and retain hepatocyte-specific contrast to some degree, whereas other lesions generally do not. This allows for better characterization of focal liver lesions and potentially increases the detection of small lesions that would otherwise be missed.[2]

Table 1
Example of comprehensive liver MR imaging protocol

Protocol Step	Sequence
Precontrast images	T2-weighted single-shot fast SE T1-weighted in and opposed phase GRE Diffusion-weighted imaging T2-weighted FS fast SE 3D T1-weighted FS spoiled GRE T2-weighted MRCP (optional)
Postcontrast images	Dynamic 3D T1-weighted FS spoiled GRE (in hepatic arterial, portal venous, and equilibrium phases) Delayed hepatocyte phase (if applicable)

Abbreviations: FS, fat-suppressed; GRE, gradient echo; MRCP, MR cholangiopancreatography; SE, spin echo; 3D, three-dimensional.

Hepatocyte-specific contrast agents currently approved for clinical use by the Food and Drug Administration are gadobenate dimeglumine (MultiHance; Bracco Diagnostics Inc, Princeton, NJ) and gadoxetate disodium (Eovist; Bayer HealthCare, Wayne, NJ; marketed as Primovist in Europe). In a patient with normal liver and renal function, gadoxetate disodium has a much greater percentage of biliary excretion (50%) than gadobenate dimeglumine (3%–5%).[4] Therefore, more intense liver enhancement and earlier hepatocyte-phase imaging is achieved with gadoxetate disodium (usually within 20 minutes) than gadobenate dimeglumine (usually performed after 60–90-minute delay).[2,3] T2-weighted and diffusion-weighted images can be obtained after injection of gadoxetate disodium to improve time efficiency.

The FDA-approved, manufacturer-recommended dose of gadoxetate disodium (0.025 mmol/kg) is only one-fourth that of gadobenate dimeglumine and extracellular contrast agents (0.1 mmol/kg), resulting in a relatively weaker T1 shortening effect.[2] A smaller volume of contrast (prefilled 10-mL syringe) is typically administered. If injected at a rate of 2 mL/s, it may take less time to deliver the contrast bolus than it does to complete a single high-quality data acquisition.[4] Consequently, it can be challenging to capture peak arterial phase enhancement. Shortened scanning times or reduced injection rates of 1 mL/s have been proposed to overcome this temporal mismatch.[4] Additional methods to avoid missing peak arterial phase include using a bolus timing technique, such as automated bolus detection algorithm or fluoroscopic triggering, or obtaining multiple consecutive arterial phase data sets with higher temporal but lower spatial resolution.[4,5]

Diffusion-Weighted Imaging

Diffusion-weighted imaging (DWI), a technique that derives image contrast from differences in random motion of water molecules, has become a standard part of abdominal MR imaging protocols in recent years. The underlying principle is that different biologic tissues exhibit varying levels of restricted water diffusion, dependent on such factors as tissue cellularity and cell membrane integrity.[6] The ability to depict areas of high