Hepatic MR Imaging Techniques, Optimization, and Artifacts

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KEYWORDS

• Hepatic MRI protocol • Hepatic MRI sequence optimization • Minimizing hepatic MRI artifacts
• Extracellular space contrast agents • Hepatocyte-specific contrast agents
• Postgadolinium pulse sequences • Diffusion-weighted imaging • Parallel imaging techniques

KEY POINTS

- The foundation for hepatic magnetic resonance imaging (MRI) includes T1-weighted images (including chemical shift imaging), T2-weighted images, fat suppression, and in most cases, contrast-enhanced images. Complementary techniques include balanced steady-state free precession and diffusion-weighted imaging.
- To maximize the clinical utility of hepatic MRI exams, each pulse sequence must be optimized while minimizing artifacts that interfere with interpretation.
- An understanding of the different types of gadolinium-based contrast agents (GBCAs) and the most important characteristics of each agent is needed to improve the diagnostic yield of the hepatic MRI exam.
- T1-weighted fat-suppressed gradient echo (GRE) sequences must be properly timed to account for the type of GBCA used while adjusting imaging parameters to maximize image quality.
- Most pulse sequences can be effectively performed after administering gadolinium. Exceptions include dual GRE sequences, single-shot fast-spin echo heavily T2-weighted sequences, high-resolution 3-dimensional MR cholangiopancreatography sequences obtained after gadoxetate disodium administration, and short TI inversion recovery sequences obtained after administration of extracellular space contrast agents.

INTRODUCTION

Compared with other hepatic imaging modalities including ultrasonography, contrast-enhanced ultrasonography, computed tomography (CT), and positron emission tomography-CT, magnetic resonance imaging (MRI) offers more comprehensive evaluation of the liver, establishing in many cases an accurate tissue diagnosis. To fully harness the power of MRI, the techniques must be optimized

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while minimizing artifacts interfering with interpretation. The foundation for hepatic MRI includes T1-weighted images (including chemical shift imaging), T2-weighted images, fat suppression, and in most cases, contrast-enhanced images. Complementary imaging sequences include balanced steady state free precession (BSSFP) and diffusion weighted imaging (DWI). Pregadolinium and postgadolinium fat-suppressed T1-weighted 3D gradient echo (GRE) sequences are generally the workhorse of the examination and must be properly timed to account for the type of gadolinium based contrast agent (GBCA) while adjusting imaging parameters to maximize image quality. Finally, certain pulse sequences can be performed after gadolinium administration to improve examination efficiency while maximizing the diversity of pulse sequences.

This article describes a basic 1.5-T hepatic MRI protocol, strategies for optimizing pulse sequences while managing artifacts, the proper timing of postgadolinium 3D GRE sequences, and an effective order of performing pulse sequences with the goal of creating an efficient and high-quality hepatic MRI examination. The authors have implemented this general approach on Philips (Philips Medical Systems, Best, Netherlands), Siemens (Siemens Medical Solutions, Erlangen, Germany) and General Electric (GE Medical Systems, Milwaukee, Wisconsin, USA) clinical scanners.

THE BASIC HEPATIC MR IMAGING EXAMINATION

In clinical practice, the typical hepatic MR imaging examination (**Table 1**) includes comprehensive imaging of other abdominal viscera, although generally, the MR imaging protocol is optimized for evaluation of the liver. For gadolinium-enhanced studies, intravenous gadolinium should be administered as early as possible during the examination. Then, if the examination is prematurely terminated for any reason, gadolinium-enhanced images, which are often the most important sequences for lesion characterization, will have already been completed. This protocol is achievable because most sequences, except dual GRE (in and out of phase) sequences, single shot fast spin echo (SSFSE) heavily T2-weighted sequences, high-resolution 3D MR cholangiopancreatography (MRCP) sequences obtained after gadoxetate disodium administration, and short TI inversion recovery (STIR) sequences obtained after administration of extracellular space contrast agents (ECSAs), are not adversely affected by gadolinium and can be performed after gadolinium administration. A torso phased array coil should be used for all sequences, including localizer images.

INDIVIDUAL PULSE SEQUENCES

Localizer Images

Clinical utility

This series is used to confirm positioning of the torso coil by ensuring that the entire liver and other tissues of interest are included within the sensitive volume of the coil. Sagittal images are useful for determining the anteroposterior dimensions of the abdomen to localize subsequent axial images and help determine if a rectangular phase field of view can be used. Although T1-weighted images are commonly used for localizer images, a T2-weighted SSFSE sequence or T2/T1-weighted BSSFP sequence can be more clinically useful. The latter can be implemented as a rapid motion-insensitive 3-plane comprehensive initial survey.

The sagittal and/or coronal images obtained in a localizer sequence are useful for evaluating the spine to exclude compression fractures and to localize findings noted in the axial plane. A BSSFP localizer series is useful to evaluate vascular anatomy and patency (discussed below).

Technique/Optimization

The localizer series is usually a rapid sequence with a moderately large field of view obtained in 3 planes (ie, axial, sagittal, and coronal) or just the coronal plane. There are often significant gaps between slices to ensure adequate coverage in minimal time, but the authors recommend increasing the utility of these images by using a slice thickness of 6 mm or less and a gap between slices of 1 mm or less. A comprehensive 3-plane BSSFP survey of the entire abdomen can be completed in about 2 minutes during quiet breathing.

Artifacts

Large gaps between each slice, and variable breathing or breath-hold, cause misregistration artifact. Artifacts for SSFSE T2-weighted and BSSFP sequences are discussed below.

SSFSE Heavily T2-Weighted Images

Clinical utility

This fluid-sensitive series is useful for demonstrating cysts, fluid collections, or edema. For cystic lesions, this sequence provides superior visualization of papillary projections or septations compared with CT. In general, the vast majority of liver lesions with hyperintensity approaching cerebrospinal fluid on heavily T2-weighted images are benign (cysts or hemangiomas) and largely contain free water, whereas solid lesions lacking free water and generally composed of water bound to macromolecules are usually not well seen on this sequence.[1] This fact is in contrast to moderately T2-weighted images (discussed below)