Revisiting Liver Imaging with VIBE

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Introduction

Volume Interpolated Breath-hold Examination (VIBE) [1] offers three-dimensional multiphase image acquisition before and following contrast administration on a breath-hold time scale. The dynamic behavior of liver lesions and structures during the precontrast, arterial, portal venous, early equilibrium and 5-minute-delayed equilibrium phases of enhancement allows more accurate characterization than static pre- and postcontrast analysis. VIBE is specifically designed for this task, and is a central pulse sequence in the MR evaluation of the liver.
However, routine clinical constraints present significant challenges in the acquisition of optimal diagnostic images. Delicate diagnostic decisions require fine image detail and appropriate anatomic coverage, but very ill patients preclude extended breath-holding, limiting matrix size and resolution. Short acquisition times are thus critical for both patient comfort and diagnostic success. The VIBE sequence can overcome these challenges and maintain image quality despite clinical realities.
The VIBE protocol we use at Mallinckrodt Institute of Radiology/ Washington University School of Medicine in St. Louis provides the flexibility to ensure robust, high quality images in diverse clinical situations, on both open bore imaging systems such as the Siemens 1.5 Tesla MAGNETOM Espree and standard bore systems such as the 1.5 Tesla MAGNETOM Symphony, A Tim System.

Method

Patients were scanned with a standard liver protocol on an open 70 cm bore diameter 1.5 Tesla MAGNETOM Espree system, or a standard 60 cm bore 1.5 Tesla MAGNETOM Symphony, A Tim system with Quantum gradient system. Imaging was performed with the standard 6-channel Body Matrix coil of the Total imaging matrix (Tim). In addition to dynamic pre- and postcontrast VIBE, the liver imaging protocol included in-phase/opposed-phase T1 gradient echo, T2 HASTE, multiple breath-hold T2 STIR Turbo Spin Echo, and diffusion-weighted imaging (*syngo* DWI).
Dynamic pre- and postcontrast enhanced VIBE was acquired with a variety of sequence parameter combinations.

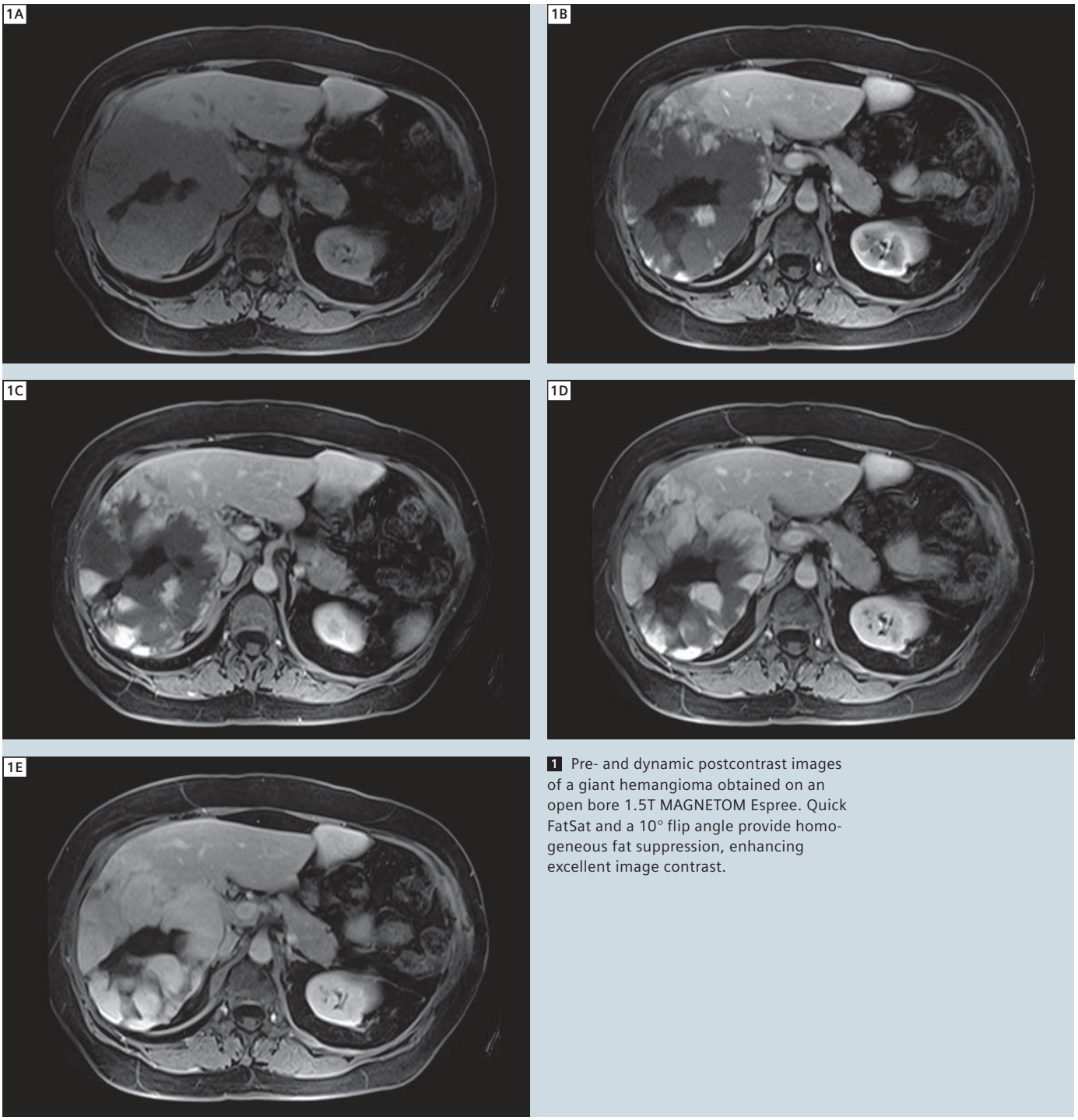
These included 256 or 320 base resolutions,
TE = 1.9–2.4 msec,
TR = 4.3–5.0 msec,
FOV = 300–380 mm,
phase FOV = 80–90%,
partition thickness = 3–4 mm,
slices per slab = 56–72,
slice resolution = 64–67%,
flip angle = 10°–12°,
symmetric or reversed asymmetric echo*,
slice and phase partial Fourier = 6/8 or 7/8,
bandwidth = 360–490 Hz/pixel,
and iPAT parallel imaging with acceleration factor = 2.
Quick FatSat was used for fat suppression.

Clinical cases

The following cases demonstrate the advances and high quality images available with the above parameters on the product and works-in-progress* VIBE sequences.

Case 1

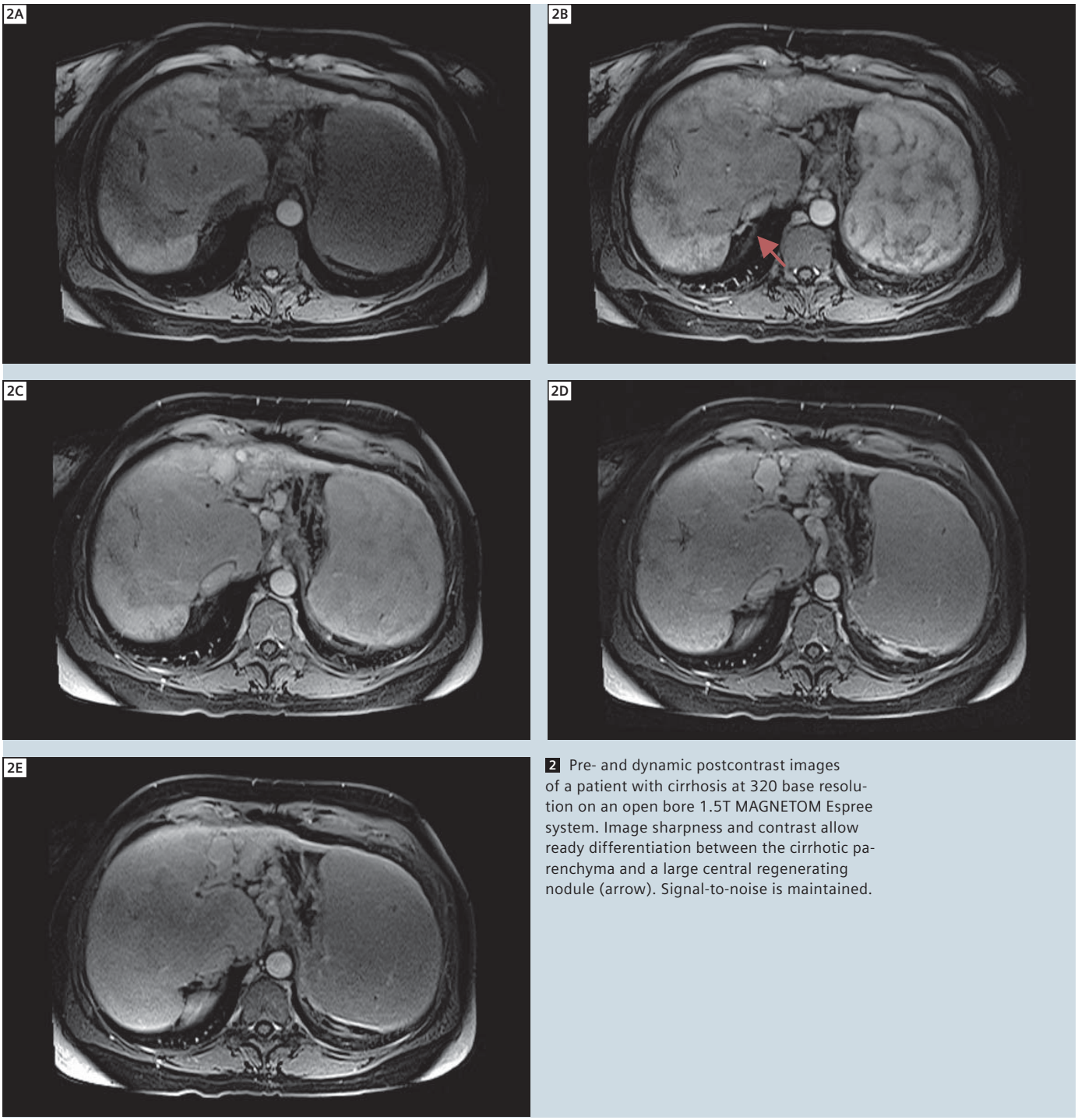
This 59-year-old female was evaluated for a liver lesion with VIBE using a reduced 10° flip angle and Quick FatSat. Figure 1 demonstrates a T1 hypointense mass with progressive discontinuous centripetal enhancement characteristic of a giant cavernous hemangioma [2]. The central non-enhancing portion of the lesion likely represents a fluid cavity in the setting of degeneration. Excellent tissue contrast provides superb evaluation of lesion behavior pre- and post-contrast. Homogeneous fat suppression further enhances image contrast. These images were acquired at 256 base resolution with a bandwidth of 490 Hz/pixel, FOV of 350 mm, partition thickness of 4 mm, and symmetric echo with TE/TR of 1.9/4.3 msec, respectively.



1 Pre- and dynamic postcontrast images of a giant hemangioma obtained on an open bore 1.5T MAGNETOM Espree. Quick FatSat and a 10° flip angle provide homogeneous fat suppression, enhancing excellent image contrast.

Case 2

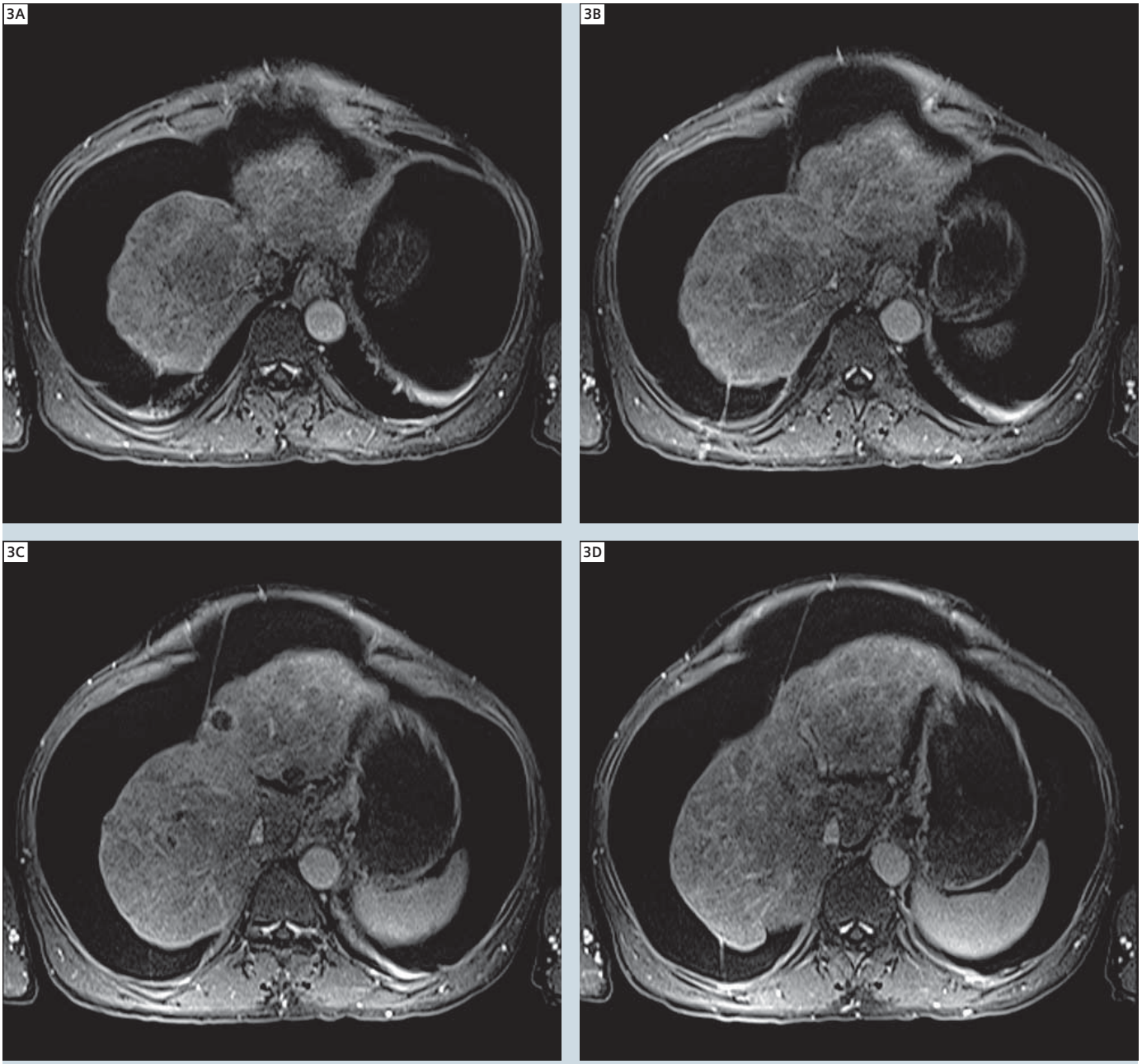
This 44-year-old female with cirrhosis was evaluated with VIBE with an increased base resolution of 320 (Fig. 2). High quality images are required to define the somewhat subtle differences in parenchymal signal and architecture between the background cirrhotic parenchyma and the large central regenerating nodule [3] that might otherwise have been mistaken for a mass. Improvement in resolution is apparent, and signal-to-noise and tissue contrast are maintained. This acquisition required a standard 22 second breathhold. In addition to 320 base resolution, these images were acquired with a bandwidth of 390 Hz/pixel, FOV of 350 mm, flip angle of 10°, partition thickness of 3.5 mm, Quick FatSat and symmetric echo with TE/TR of 2.4/5.0 msec, respectively.



2 Pre- and dynamic postcontrast images of a patient with cirrhosis at 320 base resolution on an open bore 1.5T MAGNETOM Espree system. Image sharpness and contrast allow ready differentiation between the cirrhotic parenchyma and a large central regenerating nodule (arrow). Signal-to-noise is maintained.

Case 3

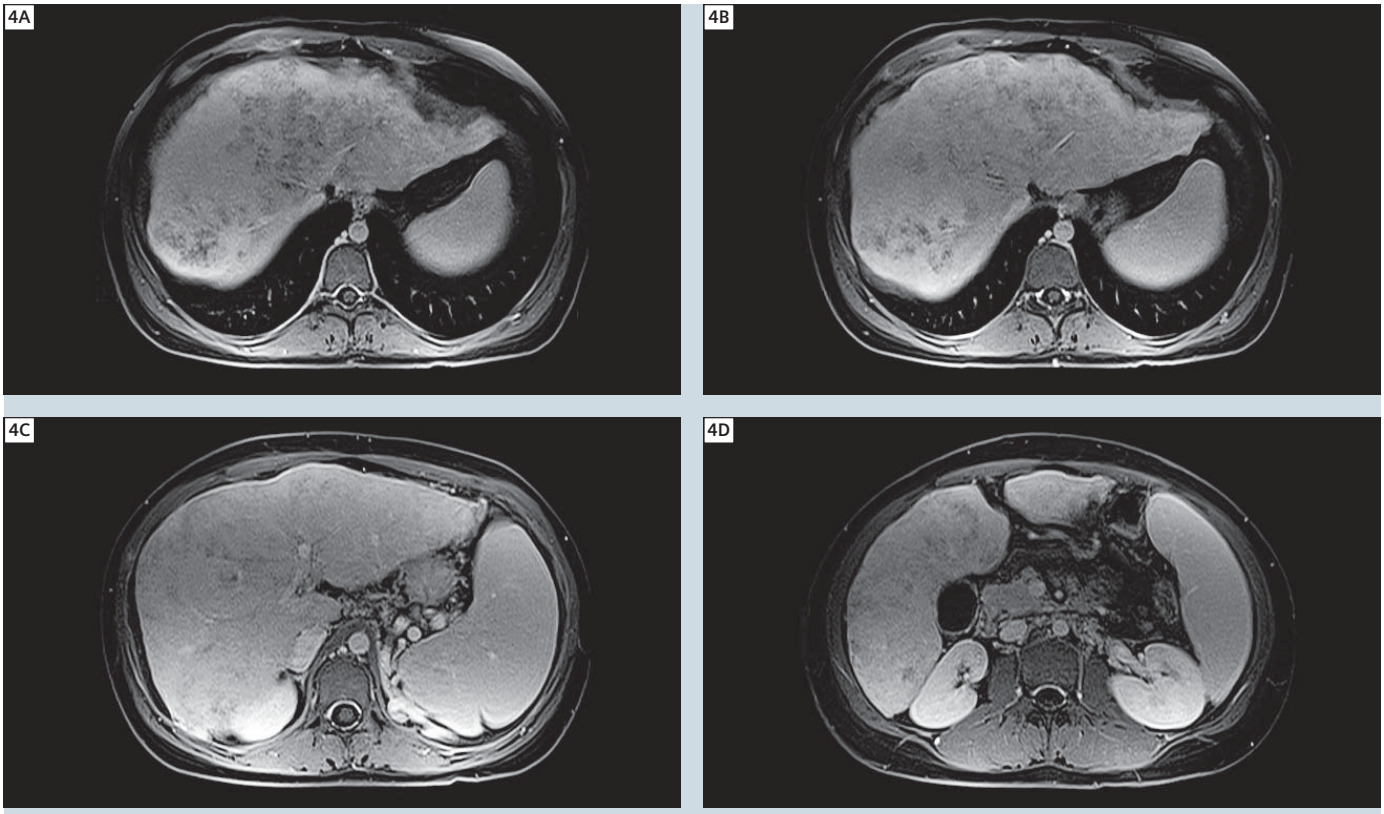
This 50-year-old male with cirrhosis was evaluated with VIBE at 320 base resolution and reversed asymmetric echo acquisition* (Fig. 3). Despite acquisition in the delayed phase of enhancement, excellent contrast and resolution allow the demonstration of numerous enhancing fibrotic bands throughout the cirrhotic parenchyma. The two hypointense foci within the left lobe represent large siderotic nodules [4]. Reversed asymmetric echo acquisition*, allowing shorter TR, and 7/8 partial phase Fourier result in an acquisition time of 16 seconds, sufficient for successful breath holding in this ill patient. In addition to 320 base resolution, reversed asymmetric echo*, and 7/8 partial phase Fourier, these images were acquired with a bandwidth of 360 Hz/pixel, flip angle of 10°, FOV of 320 mm, partition thickness of 3 mm, 64 slices per slab, Quick FatSat and opposed phase TE.



3 Postcontrast delayed equilibrium images of a patient with cirrhosis at 320 base resolution on a 1.5T MAGNETOM Symphony, A TIM system. 7/8 phase partial Fourier and reversed asymmetric echo* shorten acquisition time to 16 seconds. Excellent sharpness and contrast are maintained.

Case 4

This 18-year-old female was evaluated with VIBE with enhanced 320 base resolution, but an acquisition time of only 13 seconds (Fig. 4). This allows a successful and comfortable breath-hold for almost any patient. Partial phase Fourier of 6/8 with phase correction* provides the additional time savings, while preserving gains in resolution and preventing artifacts. The images of figure 5 were acquired in the delayed phase of enhancement, but tissue contrast is maintained. In addition to the above parameters, these images were acquired with a bandwidth of 360 Hz/pixel, flip angle of 10°, partition thickness of 3.5 mm, 60 slices per slab, reversed asymmetric echo acquisition*, Quick FatSat and opposed phase TE.



4 Postcontrast delayed equilibrium images of a patient with cirrhosis at 320 base resolution on a 1.5T MAGNETOM Symphony, A Tim System. 6/8 phase partial Fourier with phase correction* and reversed asymmetric echo* shorten acquisition time to 13 seconds. Excellent sharpness and contrast are maintained without artifacts.

Conclusion

VIBE provides state-of-the-art dynamic contrast enhanced imaging of the liver. It allows improved and robust fat suppression, image sharpness, tissue contrast, anatomic coverage, and shortened acquisition times even in challenging clinical scenarios. Image quality is maintained on the open 70 cm bore diameter 1.5T MAGNETOM Espree system and the standard 60 cm bore diameter 1.5T MAGNETOM Symphony, A Tim system.

References

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2 Danet IM, Semelka RC, et al. Giant Hemangioma of the liver: MR imaging characteristic in 24 patients. Magnetic Resonance Imaging 2003 Feb; 21(2): 95–101.
3 Vitellas KM, Tzalonikou MT, et al. Cirrhosis: spectrum of findings on unenhanced and dynamic gadolinium-enhanced MR imaging. Abdominal Imaging. 2001 Nov–Dec;26(6):601–15.
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* WIP – Works in progress. The information about this product is preliminary. The product is under development and its future availability in the U.S. cannot be ensured.

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