Clinical Feasibility of High-Resolution Navigator-Gated 3D T1w Hepatobiliary MRI with Gd-EOB-DTPA Enhancement

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Introduction:

Conventional contrast-enhanced 3D T1w hepatic imaging using Gd-based extracellular contrast agents requires serial breath-hold acquisitions to capture the contrast dynamics, inherently limiting spatial resolution and signal-to-noise ratio (SNR). The recently available hepatobiliary-specific contrast agent Gd-EOB-DTPA (Eovist, Bayer Healthcare) exhibits relatively slow biliary excretion and offers a prolonged time window of contrast-enhancement over which data can be acquired. Recently, free-breathing approaches to 3D T1w liver imaging based on navigator-triggering and navigator-gating have been developed that eliminate the breath-hold constraint [1-4]. This work evaluates the clinical feasibility of using a navigator-gated 3D T1w sequence to improve the spatial resolution and image quality of Gd-EOB-DTPA-enhanced hepatobiliary imaging compared to conventional breath-hold imaging.

Methods:

The prototype navigator-gated 3D T1w SPGR liver sequence (based on product LAVA, GE Healthcare) included a low flip angle, cylindrical excitation navigator pulse positioned over the right hemi-diaphragm from which a breathing waveform was derived in real-time based on the S/I translation of the lung-diaphragm interface (**Fig. 1, top**). The navigator was interleaved with data acquisition throughout the scan to provide a frequent update of respiratory position. For every 200-ms imaging block, the navigator (NAV) was first acquired, followed by spectrally-selective fat inversion (SPECIR) and segmented image data acquisition (ACQ). The navigator readout and processing took only 25ms, adding minimal scan time overhead. The excited volume location was prospectively adjusted based on measured breathing motion to track the underlying anatomy [2,5]. Data from a given imaging block was accepted only when the breathing waveform fell within the ±2mm acceptance window; otherwise, data was rejected (**Fig. 1, bottom**). Compared to a navigator-triggered approach [1], this navigator-gated approach ensures that steady-state magnetization is maintained and expected T1w contrast is preserved, while ensuring that all data segments are acquired during a period of quiescent breathing.

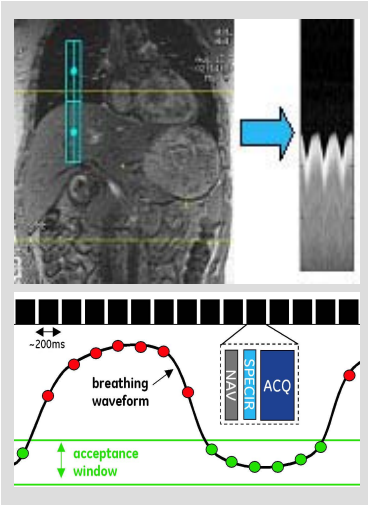

Fig. 1. (top) Navigator placement and measured breathing waveform. (bottom) Navigator (NAV) is interleaved with data acquisition (ACQ) every 200ms and data is accepted (**green dots**) or rejected (**red dots**) based on breathing position.

Followed informed consent, 12 patients referred for Eovist-enhanced hepatobiliary imaging were scanned on a 1.5T system (Signa HDx, GE Healthcare) using an 8-channel torso coil. The conventional breath-held LAVA protocol was first performed at multiple phases post- injection, followed by a higher resolution navigator-gated LAVA acquired during delayed enhancement at 15-20 mins. Typical voxel sizes for breath-hold scans ranged from 0.8x0.8x4 mm^3 to 1.2x1.6x4.4 mm^3 and for free-breathing scans were reduced between 2-6 fold to a range of 0.6x0.5x2.2 mm^3 to 0.7x0.7x4 mm^3. All scans used auto-calibrated parallel imaging with 2x outer acceleration and flip angles of 12-15°. Breath-hold scan times were ~25s, while navigated scan times ranged from 3-6 min, depending on breathing rate and prescribed resolution/coverage. Two board certified radiologists independently evaluated the breath-hold and navigated LAVA images on a 6-pt scale for overall image quality, quality of liver depiction, sharpness of vessels, visualization of bile ducts, lesion conspicuity, and on a 5-pt scale for level of artifacts. Differences between scan methods were tested with paired Wilcoxon tests. $P<0.05$ was considered to be significant. Agreement between readers was assessed with a linearly weighted kappa statistic. Confidence intervals were computed by 2000-sample bootstrap. All statistical analyses were done with Stata Release 9.2 (StataCorp LP, College Station, TX).

Results:

High resolution navigator-gated LAVA was significantly better than conventional breath-held LAVA in lesion conspicuity ($p=0.0297$). There was no significant difference between the two in overall image quality, quality of liver depiction, sharpness of vessels, visualization of bile ducts, and level of artifact. The agreement between the two radiologists was low to moderate ($\kappa = 0.14$-0.57).

Discussion:

The results demonstrate high resolution Gd-EOB-DTPA-enhanced navigator-gated LAVA improves lesion conspicuity compared to conventional breath-held LAVA. The longer scan time of the navigator-gated LAVA can easily be accommodated in the typical Eovist scan protocol in which delayed-phase images are acquired up to 20-30 mins post-injection.

References 1. Asbach et al. Invest Rad 43(11),809-815,2008. 2. Brau et al. ISMRM 2010, 4443. 3. Young et al. AJR 2010 Sep;195(3):687-91. 4. Vasanawala et al. Pediatr Radiol. 2010 Mar;40(3):340-4. 5. McConnell et al. MRM 37(1), 148-152.

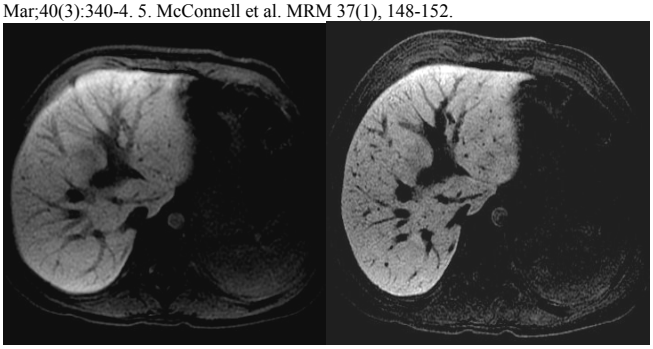

Fig. 2. a) Breath-held LAVA vs. b) high-resolution navigator-gated LAVA in Gd-EOB-DTPA hepatocyte phase. Voxel size is reduced more than twofold from 0.8x0.8x4.0mm^3 to 0.7x0.7x2.0mm^3, offering improved visualization of hepatic vessels and biliary structures.

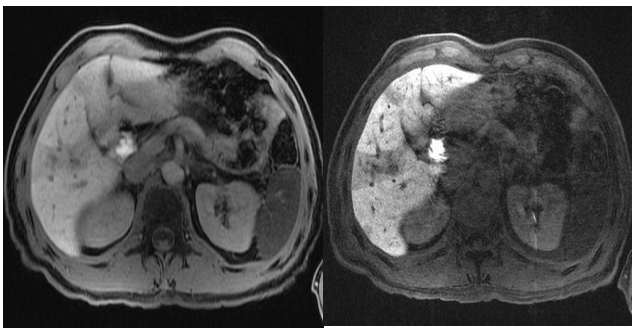

Fig. 3. a) Breath-held LAVA vs. b) high-resolution navigator-gated LAVA in Gd-EOB-DTPA hepatocyte phase. Voxel size is reduced by nearly four fold from 1.1x1.5x4.4 mm^3 to 0.7x0.9x3 mm^3, offering improved visualization of hepatic lesions.