High Resolution Double Arterial Phase Hepatic MR Imaging Using Adaptive 2D Centric View Ordering: Initial Clinical Experience

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Purpose: To evaluate the use of a new 3D Fast Spoiled Gradient Echo (FSPGR) sequence, referred as modified LAVA (Liver Acceleration Volume Acquisition), to perform high resolution dynamic gadolinium-enhanced liver MR imaging with two arterial phases within a single breath-hold and to determine its effect on timing of the contrast bolus and lesion detection.

Background: The modified LAVA sequence enables fast abdominal MR imaging with high spatial and temporal resolution without the need for hardware improvements such as higher channel coil support. Three key elements provide the necessary efficiency : 1)Robust 2D parallel imaging using ARC (**A**uto Calibrating **R**econstruction for **C**artesian Sampling) without the need for external calibration , [1] 2) Novel adaptive view ordering that supports efficient auto-calibrated sampling scheme and elliptical sampling Partial Fourier (corner removal) that are otherwise not compatible with segmented fat suppression [2] and 3) SPECIAL (SPECtral Inversion At Lipids) fat suppression scheme that is centric in 2D dimensions (ky-kz) and adaptively adjusts segmented k-space view ordering according to Fat inversion recovery [2]. This technique can result in shorter breath hold times, higher temporal and spatial resolution with good fat suppression for dynamic gadolinium-enhanced imaging. Double arterial phase MR imaging can be performed with the identical slice thickness, spatial resolution, and anatomic coverage as is used in single-phase imaging.

Materials and Methods: Dynamic gadolinium-enhanced dual arterial phase liver MRI was performed in 108 patients with a new 3D FSPGR based modified LAVA sequence. Following injection of 0.1mmol/kg gadolinium chelate and a fixed 20 second scan delay, dynamic breath-hold imaging of the abdomen was performed using the modified LAVA pulse sequence. Imaging parameters included: TR 3.7ms, TE 1.8ms, flip angle 12 degrees, 1 NEX, matrix 320 x 192, slice thickness 4.4 mm, receiver bandwidth +/- 83.33kHz, net acceleration factor 2.5, and FOV 34 -44 cm. Time of acquisition was 24 seconds with 56 slices per pass before zero fill interpolation. Images from the two phases were retrospectively reviewed for timing accuracy relative to liver and vascular enhancement, image quality, and lesion conspicuity and detection. Image timing was scored as non contrast, early arterial, mid arterial, late arterial or portal venous for each of the two passes. Image quality was scored on a 5-point scale. Qualitative and quantitative analysis of liver lesion depiction was performed.

Results: For the 108 patients the dynamic gadolinium-enhanced modified LAVA 2 phase acquisition produced at least one set of arterial phase images in all 108 patients and two sets of arterial phase images in 84 patients. Optimal timing with one of the two passes obtained during the mid to late arterial phase was observed in 99 (.92) of the 108 patients. Using a 5 point scale for image quality the mean score was 4.2 for the first pass images and 4.4 for the second pass images. Of the sixty-two patients that had focal liver lesions, 17 (.27) demonstrated greater lesion conspicuity on the first phase images and 45 (.73) on the second phase images. For 28 hypovascular lesions twenty-four (.86) showed greater conspicuity on the second phase images. Of 34 hypervascular lesions 13 (.34) showed greater lesion conspicuity on the first phase images and 21 (.66) on the second phase images. The first set of images detected 169 liver lesions compared to 238 for the second set of images.

Conclusions: High resolution 3D FSPGR MR imaging with two arterial phases can be achieved using modified LAVA sequence, which improves and simplifies timing of the arterial phase of dynamic liver enhancement and provides additional information for liver lesion detection.
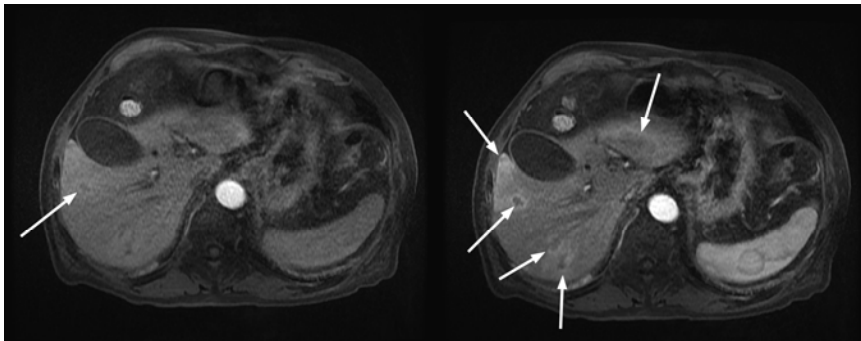

Figure 1: 82 year old with pancreatic cancer. First pass (left) from a gadolinium-enhanced dual arterial phase Modified LAVA acquisition obtained during the early arterial phase shows poorly defined lesion (arrow) in the right hepatic lobe. Second pass (right) obtained during the mid to late arterial phase shows multiple liver metastases (arrows) with an irregular rim of peripheral enhancement. The modified LAVA acquisition provides high temporal and spatial resolution with excellent depiction of normal anatomy and liver metastases.
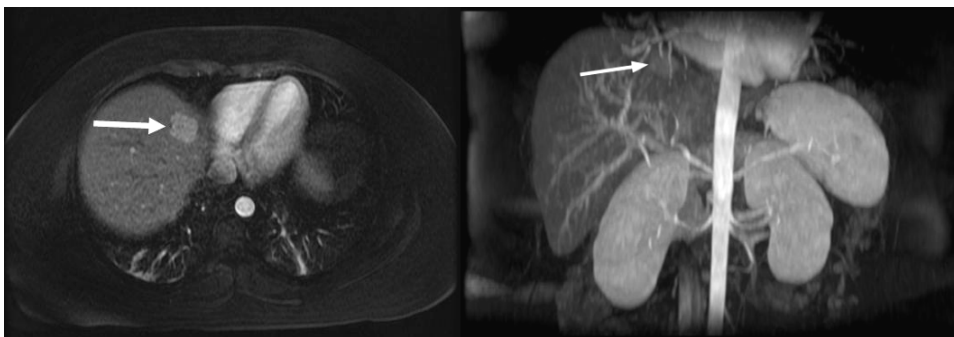

Figure 2: 48 year old. First pass image (left) from a gadolinium-enhanced dual arterial phase Modified LAVA acquisition obtained during the mid arterial phase shows a 2 cm hypervascular lesion (arrow). The MIP image (right) confirms the small enhancing hypervascular tumor (arrow) as well as the high spatial resolution and consistent fat suppression across nearly the entire image.

References: 1. Beatty PJ, Brau AC, Chang S, Joshi SM, Michelich CR, Bayram E, Nelson TE, Herfkens RJ, and Brittain JH. The International Society for Magnetic Resonance in Medicine 15th Scientific Exhibit, May 2007. 1**.** Bayram E, Michelich CR, Vu AT, Akao JH, Chang S, Joshi S, Busse RF, Brau ACS, Beatty P, Estkowski L. Proc. ISMRM, 16th Scientific Meeting. 2008.