Dynamic Gadolinium-Enhanced Liver Imaging Using LAVA Dual Echo with Water Reconstruction

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Purpose: LAVA Dual Echo with water reconstruction now known as LAVA-IDEAL is a new 3D dual echo FSPGR pulse sequence which acquires in phase and opposed phase images in a single breath-hold. Using a 2-point Dixon reconstruction algorithm separate water and fat images are generated from the in phase and apposed phase images. We evaluated the use of LAVA-IDEAL for dynamic gadolinium-enhanced liver imaging.

Materials and Methods: Twenty-nine patients with focal liver lesions were imaged on a 1.5T GE HealthCare Signa® HDx MR scanner equipped with Echo Speed gradients (23 mT / m, 120 mT / m / sec) and HDx system software (GE HealthCare, Waukesha, WI). MR imaging included unenhanced T1-weighted 2D dual echo FSPSGR and T2-weighted 2D FRFSE imaging. Following injection of 0.1 mmol/kg gadolinium dynamic LAVA-IDEAL imaging was performed during the arterial and portal venous phases of liver enhancement. Imaging parameters for the LAVA-IDEAL images included TR 7.06ms, TE 2.39 and 4.78ms, flip angle 12 degrees, 1 NEX, matrix 320 x 192, slice thickness 3 - 4 mm, receiver bandwidth +/- 83.33kHz, acceleration factor 2.15. Partial field of view factor 0.8. An image filter algorithm (named as PURE) was applied to the reconstructed water and fat images to reduce shading artifacts from RF coil inhomogeneity. Elliptical centric k-space ordering was utilized. Time of acquisition was 27 seconds for 68 slices. Delayed 2D SGE imaging was obtained during the equilibrium phase.

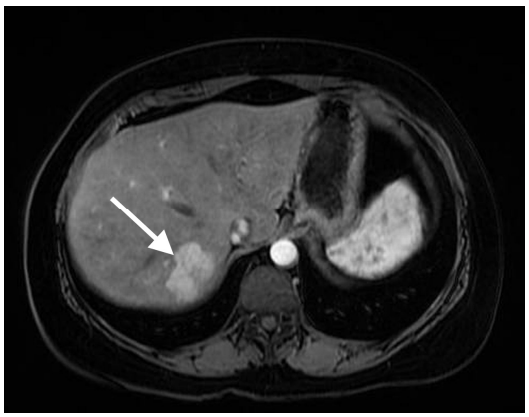
The arterial and portal venous phase LAVA-IDEAL water images were evaluated qualitatively and quantitatively. Areas of fat and water mismapping were noted. The T1 FSPGR, T2 FRFSE , delayed SGE, and LAVA-IDEAL water images were scored using a four-point scale (1=best, 4=worst) for overall image quality, depiction of normal anatomy, depiction of liver lesions, and image artifacts. The image type that best depicted the focal liver lesion was recorded for each patient. Quantitatively, the T1, T2 FRFSE, arterial and portal venous phase LAVA-IDEAL images, and delayed SGE images were evaluated by measuring the mean signal intensity of the liver parenchyma, spleen, and liver lesions, and the standard deviation of the background noise. For each patient an ROI was placed over the liver parenchyma in the right hepatic lobe avoiding hepatic vessels, the spleen, and background outside the abdominal wall. Liver lesions were similarly evaluated by placing an ROI over the lesion. Mean liver signal, liver lesion signal, mean splenic signal, and the standard deviation of the background noise were recorded. Liver-lesion contrast was calculated by subtracting the mean liver signal intensity from the mean liver lesion signal intensity.

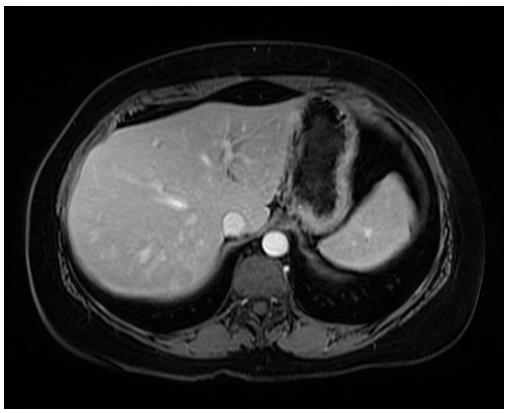
Results: Liver lesions in the 29 patients included five patients with cysts, seven with hemangiomas, and one with an FNH, one with a liver abscess, nine patients with liver metastases, three with hepatocellular cancers, and three with a cholangiocarcinoma. LAVA-IDEAL water and fat images were successfully reconstructed in all 29 patients. There were no areas of fat and water mismapping in any of the LAVA-IDEAL images.

Qualitatively the LAVA-IDEAL arterial and portal venous phase images received the highest score for overall image quality (score 1) in 21 (.70) and 22 (.73) patients compared to T1 19 (.48), T2 5 (.17), and delayed SGE 18 (.60). For depiction of normal anatomy LAVA-IDEAL arterial images received the highest score in 24 (.83) patients compared to LAVA-IDEAL portal venous 26 (.90), T1 22 (.76), T2 4 (.14), and delayed SGE 22 (.76). Excellent depiction of liver lesions (score 1) was recorded for LAVA-IDEAL arterial images in 23 (.79) patients compared to LAVA-IDEAL portal venous 15 (.52), T1 14 (.48), T2 16 (.55) and delayed SGE 8 (.28). The best score for minimal artifacts was recorded for the LAVA-IDEAL arterial images in 19 (.66) patients, LAVA-IDEAL portal venous 20 (.69), T1 15 (.55), T2 0 (0.0), and delayed SGE 13 (.45). Overall preference was for the LAVA-IDEAL arterial images in 13 patients (.45), LAVA-IDEAL portal venous images in nine patients (.31), T1 in one patient (.03), T2 in five patients (.17), and delayed SGE in one patient (.03).

Quantitatively the LAVA-IDEAL portal venous images had the highest liver signal intensity (1970.2) compared to the arterial LAVA-IDEAL images (1487.6), T1 (979.6), T2 (334.8), and delayed SGE (1415.5). Liver lesion contrast was highest on the LAVA-IDEAL portal venous images (833.3) compared to LAVA-IDEAL arterial images (603.3), (T1 (284.5), T2 (326.9), and delayed SGE (358.6). For detection of individual liver lesions the LAVA-IDEAL arterial images depicted 86 lesions compared to LAVA-IDEAL portal venous (65 lesions), T1 (55 lesions), T2 (92 lesions), and delayed SGE (55 lesions).

Conclusions: Dynamic gadolinium-enhanced MR imaging with LAVA-IDEAL produces water images with nearly perfect separation fat and water signal. Arterial and portal venous phase LAVA-IDEAL water images show excellent liver lesion contrast and consistently high image quality.


A.


B.

Arterial phase gadolinium-enhanced LAVA-IDEAL image (A) depicts a rapidly enhancing FNH (arrow). On the portal venous phase LAVA-IDEAL image (B) the mass is isointense to the liver. Note the perfect separation of fat and water signal and the overall excellent image quality.