LAVA Dual Echo with Water Reconstruction: Preliminary Experience with a Novel Pulse Sequence for Gadolinium-Enhanced Abdominal MR Imaging

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Purpose: To evaluate the use of 3D LAVA Dual Echo (DE) with water reconstruction for gadolinium-enhanced abdominal MR imaging compared to 3D LAVA. The 3D dual gradient echo imaging pulse sequence acquires in-phase (4.6ms) and opposed-phase (2.3ms) echoes in the same TR in sequential mode. The two-point Dixon image reconstruction uses a novel phase correction algorithm proposed by Ma [1] that can robustly decompose water-only and fat-only images from a dual-echo acquisition.

Materials and Methods: Eighty-nine patients (29 men, 60 women, mean age 56 years) referred for abdominal MRI were imaged on a 1.5-T General Electric Signa® HD MR scanner with an EchoSpeed gradient system. All patients were imaged with axial and coronal gadolinium-enhanced LAVA and LAVA DE. LAVA DE with a 2-point Dixon reconstruction produces four sets of images from a single breath hold acquisition including 1. In-phase 2. Opposed-phase, 3. Fat-only, and 4. Water-only images. Imaging parameters for the LAVA DE included TR 6.9 ms, TE 2.38 ms, 4.47 ms, flip angle 12 degrees, 1 NEX, matrix 320 x 192, slice thickness 3 - 4 mm, bandwidth 83.33, Asset factor 2.15. Partial field of view factor 0.8. Fat suppression and PURE was used to reduce artifacts from image inhomogeneity. Elliptical centric k-space ordering was utilized. Time of acquisition was 27 seconds for 68 slices.

Review of Images: The LAVA and LAVA DE with Dixon Reconstruction images were reviewed qualitatively and quantitatively. Qualitatively the LAVA DE with water reconstruction images were reviewed for completeness of separation of the fat and water signals on the fat and water images. Areas of fat and water swapping were noted. The LAVA and LAVA DE Water images were reviewed separately for any abnormalities of the liver, kidneys, pancreas, bile ducts, spleen, bowel, bones, lymph nodes, adrenal glands, and peritoneum. Ascites, pleural effusions and pericardial effusions were also noted. The LAVA and LAVA DE Water images were then compared side by side for homogeneity of fat suppression, anatomic detail, and depiction of the vessels, liver, kidneys, spine, muscles, and subcutaneous fat. Quantitatively, the LAVA and LAVA DE images with water reconstruction were evaluated by measuring the mean signal intensity of the liver parenchyma, spleen, and liver lesions, and the standard deviation of the background noise.

Results: The homogeneity of fat suppression was superior on the LAVA DE water images in 73 (.82) of the 89 cases. In 12 (.13) cases the homogeneity of fat suppression was equivalent on the LAVA and LAVA DE water images. In 4 (.04) cases the fat suppression was superior on the LAVA images. Anatomic detail was equal for the LAVA and LAVA DE water images in 58 (.65) cases, and superior for the LAVA in 25 (.28) and the LAVA DE water images in 6 (.07) cases. Depiction of skin & subcutaneous fat was superior on LAVA DE water images in 76 (.85) cases. For the depiction of all other anatomic areas including vessels, liver, kidneys, spine, and muscles there was no significant difference between the LAVA and LAVA DE water images.

In the blinded review of images for disease sites, liver lesions were depicted in 12 cases for LAVA compared to 10 for LAVA DE water images. Kidney lesions were depicted in 11 cases for both LAVA and LAVA DE water images. Biliary abnormalities were seen in 13 cases for LAVA and 15 for LAVA DE water images. Splenic lesions were depicted in 6 cases for LAVA and 3 cases for LAVA DE water images. Bone lesions were seen in 2 cases for both. Bowel abnormalities were seen in 4 cases for LAVA compared to 5 cases for LAVA DE water. A single adrenal mass was depicted for both. Peritoneal tumor was depicted in 7 patients for LAVA and 8 patients for LAVA DE water. Ascites in 1 case and pleural effusions in 3 cases were depicted equally. In 8 cases in the in phase and opposed phase LAVD DE images provided additional information. In the quantitative analysis the mean liver signal for LAVA was 2115 compared to LAVA DE water 2367.9. The mean signal intensity of the spleen on LAVA was 2479.2 compared to LAVA DE water 2344.7. The mean liver lesion signal for LAVA was 1367.9 compared to LAVA DE water 1864.8. The mean Liver – Lesion contrast for LAVA was 993.2 compared to LAVA DE 947.3. The mean standard deviation of background noise for LAVA was 13.6 compared to LAVA DE water 32.9.

Discussion: The LAVA Dual Echo sequence with water reconstruction shows several advantages for abdominal imaging. The water-only image demonstrates much more homogeneous fat suppression compared to the standard LAVA sequence. The most current version of the LAVA DE sequence with Dixon reconstruction shows nearly perfect separation of fat and water. A modest improvement in signal on the LAVA DE water image was noted compared to the standard LAVA images. We noted an improvement in signal and image quality near the edges of the surface coils. This improvement was present on the far anterior and posterior images of a coronal acquisition. The LAVA DE water images were equal to the LAVA images for depicting abnormalities of multiple abdominal organs. This is notable since the LAVA DE water images were always obtained after the LAVA images often during the equilibrium phase of enhancement. The increase in background noise on the LAVA DE water images was due to the deployment of an unoptimized version of the parallel imaging reconstruction algorithm. Future versions of this reconstruction algorithm will address this current limitation.

Conclusion: The LAVA DE sequence with Dixon reconstruction produces four sets of images in a single breath hold including in-phase, opposed-phase, fat-only, and water-only images. The use of the LAVA DE water image for gadolinium-enhanced abdominal MRI provides volumetric imaging with equivalent lesion detection but more homogeneous fat suppression and an improvement in image signal and homogeneity.

References

[1] Jingfei Ma. MRM, 52:415-419, 2004.

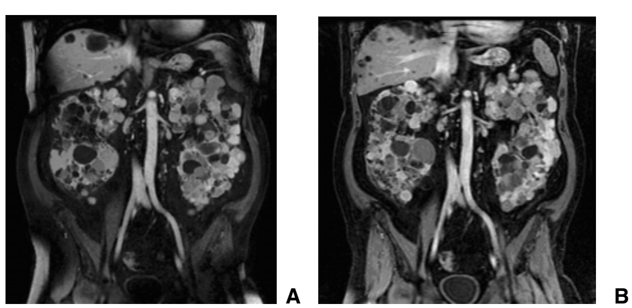

Figure 1(A) LAVA image shows inhomogeneous fat suppression.
Figure 1 (B) LAVA DE Water image shows excellent separation of fat and water signal and overall superior image quality.