Pulsatility artifact suppression using slice-selective motion-sensitized driven-equilibrium (MSDE): A feasibility study

Maggie M Fung[1], Lloyd Estkowski[2], and Ersin Bayram[3]

[1]*Global MR Applications and Workflow, GE Healthcare, Jersey City, NJ, United States,* [2]*Global MR Applications and Workflow, GE Healthcare, Menlo Park, CA, United States,* [3]*Global MR Applications and Workflow, GE Healthcare, Houston, TX, United States*

Target audience: Radiologists, Technologists

Purpose:

In body & breast MR imaging, pulsatility artifacts are often observed due to high aortic flow or cardiac motion. Recently, blood suppression technique such as low b-value motion-sensitized driven-equilibrium (MSDE) pulse was proposed to suppress the flow related artifacts[1,2]. Although MSDE technique can suppress the flow and moving tissue, it also reduces the signal-to-noise ratio (SNR) of the imaging volume due to T2 decay and diffusion effects[3]. We proposed a slice-selective MSDE technique that enables selective suppression of unwanted flow signal in user specific planes, ideally outside of the main region of interest (ROI). We hypothesize that since the MSDE is applied outside the main ROI, the SNR at the main ROI would not be affected while achieving blood suppression effect.

Methods:

The pulse sequence diagram of the slice-selective MSDE module is illustrated in Fig 1. The slice-selective MSDE module consisted of 90-180-180-90 RF pulses. Low-b-value MSDE gradients (b=0.98s/mm^2) were applied in X, Y & Z direction (grey trapezoids) between the RF pulses to dephase any spins with motion (e.g. flowing blood). Slice selective gradients (white trapezoids) were calculated based on user prescribed orientation & location, and were applied to the 90° and 180° pulses. Adiabatic 180° refocusing pulses were used to reduce B1 sensitivity, especially on 3T. In this feasibility study, we applied this MSDE module to a 3D 2 point Dixon FGRE (LAVA-FLEX) sequence. The module was applied at the beginning of every segment (every 12-18 view encodes) to ensure signal continuity in k-space and prevent ghosting artifacts.

The study was performed on healthy volunteers on a GE 3T 70cm bore scanner (MR750w) using the anterior & posterior array in the Geometry Embracing Matrix (GEM) coil suite. Imaging parameters were: FOV: 40cm, phase FOV = 0.8, Matrix: 176x192, TR/TE:4.1ms/1.7ms, Flip angle: 15, Bandwidth: 166.7 kHz, Slice thickness: 4.4mm, ARC acceleration factor: 2x1.5, Number of slices: 56, Scan time: 8s. The slice-selective MSDE pulse was applied at the heart, upstream from the imaging volume at the liver. Figure 2 shows the prescription of the imaging volume (yellow box) and the slice-selective MSDE volume (blue box).We compared the presence of pulsatility artifact under the following conditions: a) No MSDE, b) non-selective MSDE and c) slice-selective MSDE.

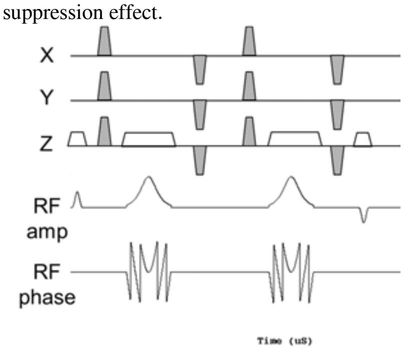

Fig 1. Slice selective MSDE module.

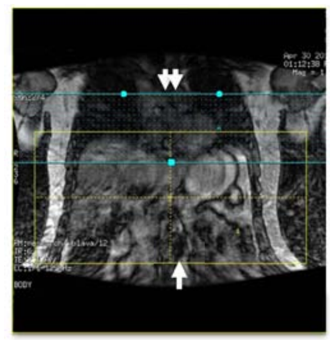

Fig 2. Prescription of imaging volume (yellow box with arrow) & slice-selective MSDE module (blue box with double arrow). The MSDE module is applied at the cardiac area, outside the main region of interest.

Results & Discussion:

Fig 3 shows a comparison of 3D LAVA-FLEX acquisition with a) no MSDE, b) non-selective MSDE and c) slice-selective MSDE. Ghosting of the aorta (arrows) was observed in a). But in b) and c), the MSDE module suppressed the blood signal from the aorta (diamond arrow) and removed the artifact. However, the non-selective MSDE applied to the entire imaging volume negatively impacted the signal intensity level (Fig.3b), while the slice-selective MSDE pulse applied outside of the imaging volume (ie. At the cardiac area above the liver) did not impact the signal intensity level (Fig. 3c). Also, note that in Fig 3c., the venous system (double arrow) was not suppressed since the MSDE pulse was only applied to the upstream flow. This technique also provides more flexibility compared to saturation techniques because saturation pulse will eliminate signal from the sat band area, while slice-selective MSDE will only eliminate flowing signal in that area. For example, the signal at the doom of the liver, although attenuated by MSDE band, will not be completely eliminated.

Conclusion:

In this work, we demonstrated the use of a slice-selective MSDE module to suppress upstream flow and therefore remove pulsatility artifacts. We showed the advantage of such slice selective MSDE pulse in preserving the signal in the main region of interest. Further investigation will be planned to investigate this technique in imaging in subjects with pathology to see if there is additional benefit or negative impact in contrast enhanced dynamic scans due to suppression of the incoming flow using selective MSDE pulses.

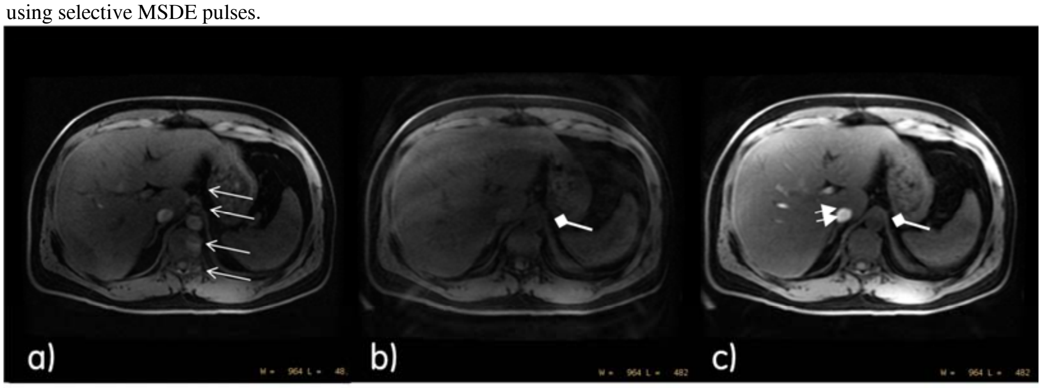

Fig 3. 3D LAVA-FLEX acquisition with a) no MSDE, b) non-selective MSDE & c) slice-selective MSDE. Pulsatility artifact is eliminated with the application of MSDE technique, while the slice selective MSDE preserves the signal in the imaging volume.

References:

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