Flow sensitive cine MR imaging using Improved Motion Sensitized Driven Equilibrium (iMSDE)

Kazuyuki Endo[1], Tomohiko Horie[1], Isao Muro[1], Yutaka Imai[2], Kagayaki Kuroda[3], Tetsuo Ogio[4], Makoto Obara[4], Marc Van Cauteren[4], Thomas Kwee[5], and Taro Takahara[6]

[1]Department of Radiological Technology, Tokai University Hospital, Isehara, Kanagawa, Japan, [2]Radiology, Tokai University Hospital, Isehara, Kanagawa, Japan, [3]Information Science and Technology, Tokai University, Hiratuka, Kanagawa, Japan, [4]Philips Healthcare, Minato-ku, Tokyo, Japan, [5]Radiology, University Medical Center Utrecht, Utrecht, Utrecht, Netherlands, [6]Biomedical Engineering, Tokai University, Isehara, Kanagawa, Japan

INTRODUCTION

Improved Motion Sensitized Driven Equilibrium（iMSDE）is a kind of T2-prep pulse with motion probing gradients. Since this technique is effective to suppress signal where turbulence exists, and can be added in front of any conventional sequence as a pre-pulse, it can be widely used for clinical applications including black-blood vessel wall imaging [1], lower extremity MR venography [2], or suppression of flow artifacts in contrast-enhanced studies for brain metastasis detection [3]. We hypothesized that iMSDE can be applied to not only static images but also to cine MR imaging. The purpose of this study was to investigate basic appropriate parameters and evaluate the feasibility of this technique as “Flow sensitive cine MR imaging”.

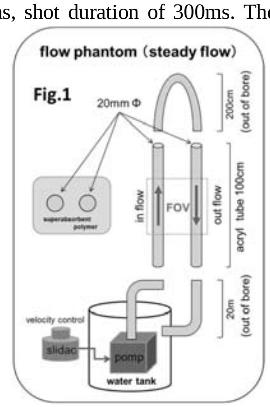
METHODS

The study was approved by the local institutional review board and written informed consent was obtained from all volunteers.

Basic parameters: The equipment we used was a 1.5T clinical scanner (Achieva nova dual, Philips, Best, the Netherlands) with either a 6ch SENSE head coil (volunteer study) or a 32ch SENSE torso cardiac coil (phantom and volunteer study). The basic parameters for cine MR imaging were as follows: 2D balanced TFE with iMSDE, FOV of 300×300mm^2, matrix of 192×259, slice thickness of 5mm, flip angle of 90°, TFE factor of 67, and NSA of 1.

Phantom study: The flow phantom was made with superabsorbent polymer and tubes (**Fig.1**) with steady flow. We investigated appropriate iMSDE parameters (not shown) and decided to use the following parameters: T2 prep TE of 50ms, shot interval of 1000ms, shot duration of 300ms. The signal intensity of flowing water in the tube was measured with varying flow speed (0.55–4.0cm/s) and venc (1–50cm/s) with three orthogonal venc directions in cross and longitudinal section.

Volunteer study: To evaluate the effect of iMSDE on cine MR imaging, 5 volunteers underwent cine MR imaging in 5 anatomical sites each (lateral ventricles through foramen of Monro, cervical spine, lumber spine, and urinary bladder). The duration of cine MR imaging was 60 sec, consisting of 30 sec for the scan without iMSDE and followed by 30 sec for the scan with iMSDE. The signal intensity of the CSF or urine without and without iMSDE was measured in each anatomical site (the lateral venclecles nearby the foramen of Monro, anterior cervical space, anterior lumbar space, and urine jet). Differences in signal intensity with and without iMSDE were assessed using two-sided unpaired *t* tests. A P value of less than 0.05 was considered to indicate a statistically significant difference.



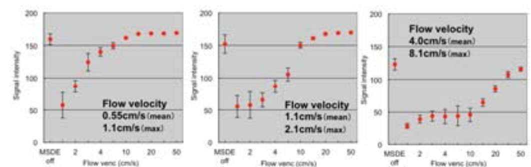


Fig. 2. Comparison of signal intensity of flowing water at 0.55, 1.1, and 4.0 cm/s (mean) with variable flow venc in cross section. Considerable signal drop was seen even at 0.55cm/s with flow venc of 1cm/s.

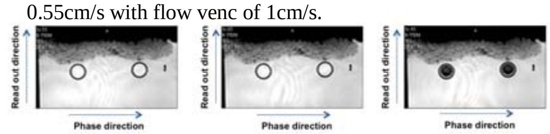


Fig. 3. Comparison of signal intensity of flowing water at 0.55cm/s (mean) with three orthogonal directions of flow venc in cross section. Signal drop was shown when flow venc direction was parallel to flow direction.

RESULTS

In the phantom study, considerable signal drop was seen even at 0.55cm/s with flow venc of 1cm/s (the strongest gradient with this scanner) (**Fig.2**). Signal drop was shown when flow venc direction was parallel to flow direction both in cross and longitudinal section (**Fig.3**). In the volunteer study, turbulent flow, which cannot be visualized with conventional cine MR imaging, could be easily detected with iMSDE (**Fig. 4, 5, 6**). The relative signal intensity of CSF at the lateral ventlecles near the foramen of Monro, cervical spine, and lumber spine, and urine in the urinary bladder with iMSDE compared to without iMSDE were 0.20±0.14, 0.13±0.01, 0.47±0.14, 0.17±0.08, respectively. All differences between the signal intensity with and without iMDSE were significant.

CONCLUSION Flow sensitive cine MR imaging with iMSDE pre-pulse allows visualization of flow phenomena very clearly, which was not able with conventional cine MR imaging. Since this technique can be applied with only a few limitations such as limited temporal resolution (minimum shot duration of 1000 ms), it may provide valuable insights into physiological and pathological flow phenomena.

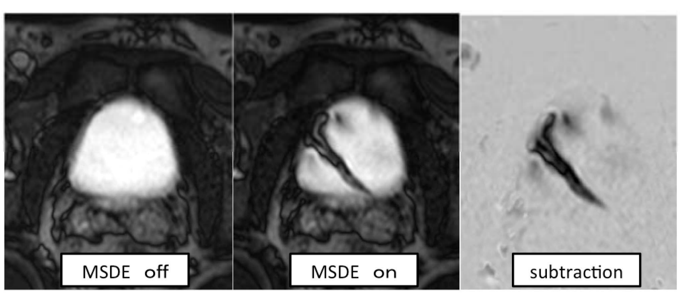


Fig. 4. One frame of cine MR imaging in the urinary bladder. Flow jet phenomenon is clearly visualized with iMSDE.

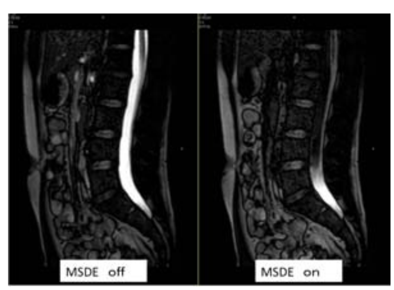


Fig. 5. One frame of cine MR imaging in the lumber spine. With iMSDE, the anterior part of the CSF space shows signal decrease, which may be useful to analyze flow mechanism of CSF.

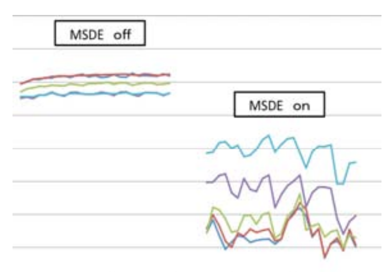


Fig. 6. Comparison of signal intensity of CSF at anterior lumbar spinal cord at L2 among 5 volunteers during 30 phases (each) without iMSDE and with iMSDE pre-pulse. Considerable signal drop was seen with iMSDE.

REFERENCES

[1] Wang J. et al : MRM 2007;58:973-981.
[2] Zhaoyang Fan. et al : MRM 2009;62:1523-1532.
[3] Yoneyama M. Rt al : Proc. Intl. Soc. Mag. Reson. Med. 20 (2012)
[4] Yamada S. Et al : Radiology. 2008;249(2):644-652.