Validation of automated motion assesment in the abdomen

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Purpose/Introduction

Abnormal small bowel motility is a frequent cause of a variety of gastrointestinal disorders [1]. Several diagnostic tests are available for the assessment of small bowel motility including scintigraphic techniques (evaluation of transit time), impedance monitoring and manometry [2]. Scintigraphy gives limited insight into motility while implementation of the latter two tests is hampered by their invasiveness. A motion sensitive MRI technique: SPatial Modulation of the Magnetization (SPAMM) was first described by Axel et.al. in 1989 [3] and developed for cardiac imaging. We reconfigured the technique for abdominal imaging making it single readout and non triggered. In this abstract we show three different methods to validate that this technique is able to estimate relatively small deformations in colon and small bowel.

Methods

The SPAMM prepulse imposes a line pattern on the magnetization. The distortion of the line pattern can be directly related to the motion that occurred between prepulse and readout. The SPAMM sequence was reconfigured for detecting aperiodic motion by removing the ECG trigger dependence, adding a constant delay between every prepulse and readout, and performing a full readout after every SPAMM prepulse (see figure 1). Determining the position of the SPAMM lines becomes a more difficult task in abdominal imaging compared to cardiac imaging; the SNR ratio is lower and there is no option of C-SPAMM or reference images for line enhancement because of the lack of periodicity. Line tracking gives best results in temporal direction as there is better CNR and less interference of water-fat shift distortions (see figure 2).

All scans were acquired with a healthy volunteer on a 3.0 Tesla Philips Intera scanner using a 16 channel SENSE-XL Torso coil and a TFE sequence with scan parameters: TR/TE 2.9/1.8 ms; FA 8˚; 12 slices; FOV 400x400mm; voxel size 3.0x3.0x3.0mm; readout duration 300 ms.

For validating the deformations measured by this technique in the abdomen we focused on three motion phenomena (figure 3). **Method A.** SPAMM line patterns in the liver near the heart are predictable. Possible patterns of the temporal SPAMM lines in the liver caused by coupling between the SPAMM sampling frequency and the motion of the liver induced by the heart are simulated. **Method B.** The relation between SPAMM line displacement and breathing curve during a free breathing acquisition. In each delay the displacement that occurs between prepulse and readout is measured. Consequently, by dividing the displacement by the delay time, the velocity is determined. Therefore a phase difference of 90 degrees should exist between SPAMM- and breathing curve. Displacement due to breathing was detected by following the diaphragm. **Method C.** The relation between line deformation and the delay between prepulse and readout is assessed. The deformation is expected to increase with delay provided there is no aliasing. Data for method A and C was measured during breathhold, B during free breathing.

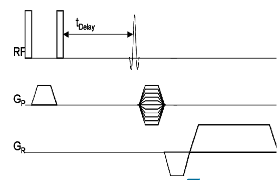
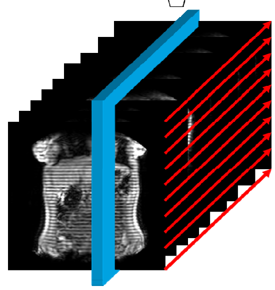


Figure 1: The non -periodic motion sensitive SPAMM sequence. A delay is inserted between SPAMM prepulse and readout.



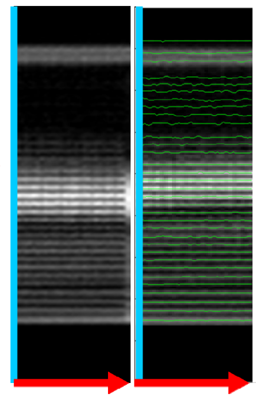


Figure 2: Coronal slice with SPAMM lines (left) and visualization of line tracking in temporal direction (right).

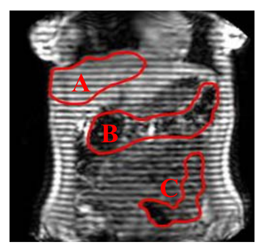


Figure 3: Coronal slice with SPAMM lines and ROIs in which different validation methods are illustrated in figure 4, 5 and 6.

Results

Method A. The SPAMM line patterns seen in the liver tissue can be identified as coupling between the heart rate and SPAMM sampling frequency as seen in the simulations in figure 4. **Method B.** A phase difference of 90 degrees between breathing curve and SPAMM velocity curve is visible (figure 5). **Method C.** The increase of delay between SPAMM pulse and readout results in an increase in line displacement in the temporal direction (figure 6).

Conclusion

Non triggered SPAMM is a promising technique for qualitative and quantitative assessment of gastrointestinal motility patterns with high temporal and spatial resolution. It can provide a valuable alternative to the presently used diagnostic tests as it combines non-invasiveness with high accuracy.

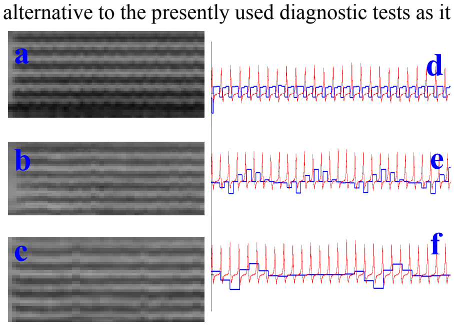


*Figure 4: **Method A**. Three examples of linepatterns that can occur in the liver (ROI A) caused by coupling between the frequency of the heart and the SPAMM sampling frequeny. Figures a to c show line patterns acquired in the liver area of a volunteer with a heartrate of 80 beats/min with delays of 50, 250 and 400 ms. Figures d to f show simulations of these SPAMM lines in the liver.*

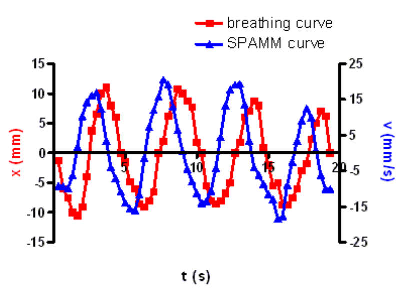


*Figure 5: **Method B.** During free breathing, SPAMM displacement in ROI B is largely determined by the breathing motion. By dividing the SPAMM displacement by the delay time, the velocity is measured. The velocity has a 90 degree phase difference with the displacement of the diaphragm (breathing curve).*

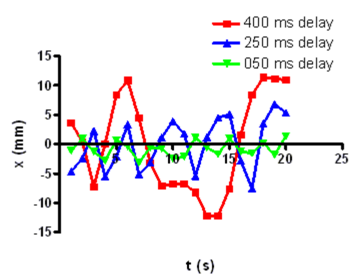


*Figure 6: **Method C.** Mean SPAMM displacement in ROI C in the small bowel area with increasing delay. As the delay between SPAMM prepulse and readout sequence increases, the amount of displacement increases accordingly.*

References

[1] Husebye E et al. *Neurogastroenterol. Mot* 1999; 11: 141-161, [2] Jones P. et al. *Curr Opin Gastroenterol* 2008; 24: 164-172, [3] Axel L, et al. *Radiology* 1989; 171:841-845