Improvements to Time-SLIP Imaging of CSF Flow

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Introduction:

The *time–SLIP* modality has potential to assist the management of hydrocephalus and related disorders. With this method CSF flow is visualized by tagging a slab of the brain and observing CSF flow from this area into other parts of the brain[1]. However in practice, there are variable delay times between tagging and readout that result in different levels of background suppression. Hence, there can be contrast differences due to flow, as well as due to different background suppression. This can lead to difficulties with the clinical interpretation. We have tested a new approach, where background signal is kept constant and flow is visualized with the MR readout occurring at different cardiac cycle time points.

Methods:

Seventeen patients were studied. For all patients, clinical MR examinations were requested by physicians as a baseline study for a planned intervention or to evaluate the impact of interventions such as a 3rd ventriculostomy or fenestration. Our imaging was added at the end of the MR examination. All studies were performed on a clinical 3T system (Philips Healthcare, Best, The Netherlands) with the following parameters: 6.2/10,000/2,500 ms TE/TR/ delay time (TD), 1.5x1.5x9.0 mm voxels, 3 to 10 real dynamics, 1 dummy dynamic.

Results:

Preliminary studies included 22 measurements in 17 patients. Some studies were of locations with obstructed pathways or places where minimal or no flow was expected; there were 14 such measurements, and 13 demonstrated minimal or no flow. Other studies were of locations with no obstruction or with the obstruction surgically corrected; there were 8 such measurements, and 7 demonstrated flow (**Fig. 1**). While preliminary, this included several patients where the added information from this measurement (e.g. **Fig. 2**) resulted in a positive change of patient management.

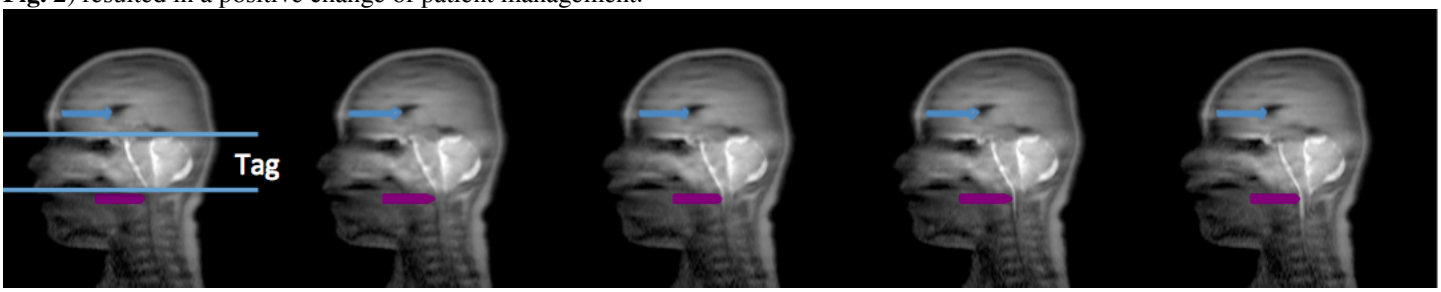

Figure 1: *As with time-SLIP, a pair of inversion pulses first non-selectively inverts all magnetization and then selectively restores magnetization in a slab (tag). The visualization of CSF flow relies on bright CSF flowing from the tagged region into untagged areas of the brain. In contrast to an earlier method in which the time delay between tagging and readout was varied[1], the delay time (TD) remained constant in above study (here TD = 2.5 sec). Instead, the MR data readout for each image was at different time points of the cardiac cycle. Note that the presence of identical levels of background signal makes interpretation easier. The purple arrow indicates CSF that has flown out of the tagged slap. There is no non-nulled CSF so the effect of the motion observed without concerns varying background signal stemming from recovering magnetization. The blue arrows point to the ventricles which are full of CSF and which show a constant signal level.*

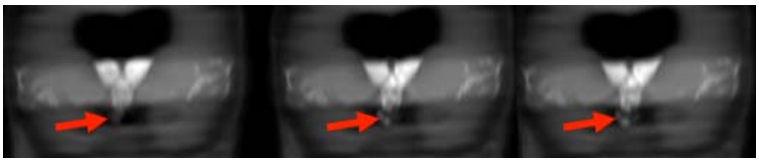

Figure 2: *Illustration of a potential positive impact on patient management. The arrow denotes flow, which indicated successful endoscopic 3rd ventriculostomy. Hospital observation was subsequently shortened in this individual; this earlier discharge had no adverse effect as of today.*

Discussion:

We have evaluated a modified *time-SLIP* methodology that allows the visualization of CSF flow in a robust way in a clinical environment. Unambiguous observation of CSF bulk flow has an immediate impact on the management of patients that undergo interventions that aims establish/restore CSF communication. The advantage over a previously published methodology[1] is the consistent background signal for easier interpretation. A study that evaluates whether this imaging has a *positive* impact on the management of patients is currently being conducted.

References:

1. Yamada S, Miyazaki M, Kanazawa H, et al. Visualization of cerebrospinal fluid movement with spin labeling at MR imaging: preliminary results in normal and pathophysiologic conditions. Radiology. Nov 2008;249(2):644-652.

Acknowledgment:

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