Time-SLIP with pencil beam pulse for observing CSF flow dynamics

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INTRODUCTION:

Although cerebrospinal fluid (CSF) has influences of vascular pulsations, it has not been clarified completely [1]. With MRI, in addition to observation of CSF flow dynamics using phase contrast techniques [2], Yamada et al [3] reported a method which uses a time-spatial labeling inversion pulse (Time-SLIP). With the Time-SLIP technique, a region of interest labeled by selective inversion recovery (IR) pulse and nonselective IR pulse can be visualized selectively. Instead of a slab pulse, we used a pencil beam pulse as the selective pulse to improve the selectivity of the target region in Time-SLIP. We report the validation results for CSF flow dynamics observations with this method.

METHODS:

Phantom study:

We studied the flow effect using a handmade phantom, because Time-SLIP with pencil beam pulse (PB Time-SLIP) has a longer irradiation time than that with slab pulse (SP Time-SLIP) (Fig.1). At 1.5 T, Time-SLIP images were obtained under the following conditions: three-dimensional single shot T2WI, TR = 2000 ms, TE = 93 ms, flip angle (FA) = 90 degrees, field of view (FOV) = 300 × 300 mm², matrix = 256 × 256, slice thickness = 1.2 mm, number of slices = 80, TSE factor = 77, inversion delay (TI) = 800 ms, and selective pulse width = 40 mm and 80 mm. The flow rate was varied between 5 cm/s, 20 cm/s, and 50 cm/s as measured by the phase contrast technique. To evaluate PB Time-SLIP and SP Time-SLIP, the signal in the tube and the signal in the background were measured and the signal intensity ratio ($SIR_{tube/BG}$) was calculated.

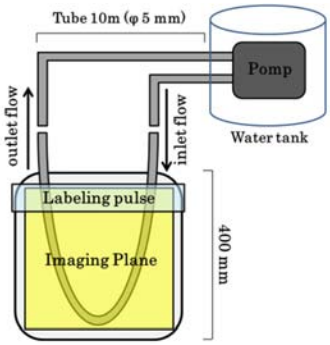

Fig. 1 Flow phantom.

Human study:

Labeling pulses were applied to regions of the fourth ventricle on mid-sagittal images in healthy volunteers (n=8). Time-SLIP images were obtained under the following conditions: two-dimensional single shot T2WI, TR = 6000 ms, TE = 83 ms, FA = 90 degrees, FOV = 250 × 250 mm², matrix = 256 × 256, slice thickness = 5 mm, TSE factor = 97, TI = 2500 ms, and selective pulse width = 30 mm. Measuring the signal intensity of the pontocerebellar cistern (PC), cisterna magna (CM), and fourth ventricle (FV), $SIR_{FV/PC}$ and $SIR_{FV/CM}$. Differences in SIRs with PB Time-SLIP and SP Time-SLIP were assessed using Wilcoxon signed-rank test.

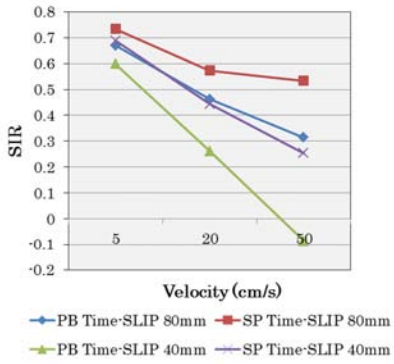

Fig. 2 Relationship between $SIR_{tube/BG}$ and flow velocity with each Time-SLIP method in phantom study.

RESULTS and DISCUSSION:

In the flow phantom, the difference between $SIR_{tube/BG}$ with SP Time-SLIP and PB Time-SLIP increased with increasing flow rate to fast, $SIR_{tube/B.G.}$ with 40 mm selective pulse in 50 cm/s became negative (Fig. 2). It was found that pencil beam pulse was affected by the irradiation time prolonged at high flow rate. In human study, no significant difference was found in $SIR_{FV/CM}$ between SP Time-SLIP and PB Time-SLIP, but $SIR_{FV/PC}$ with PB Time-SLIP was significantly higher than that with SP Time-SLIP (Fig. 3, Fig. 4). In the case of slow flow rates such as CSF, PB Time-SLIP enables more selective visualization than SP Time-SLIP (Fig. 5).

CONCLUSION:

PB Time-SLIP makes dynamic ultra-selective observation possible by improving the selectivity as in the third ventricle.

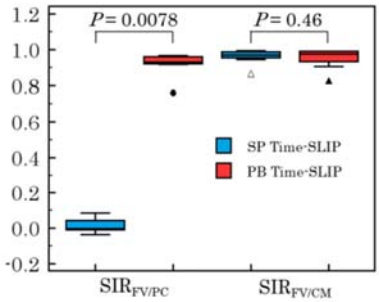

Fig. 3 Comparison between SIR with SP Time-SLIP and PB Time-SLIP in human study.

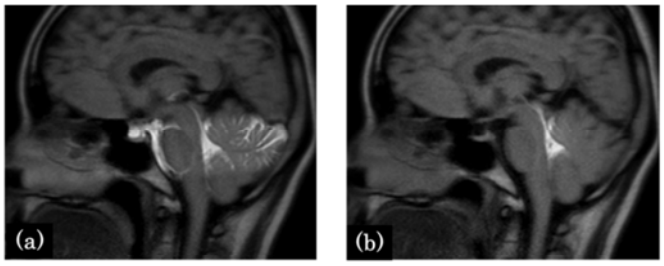

Fig. 4 Examples of (a) SP Time-SLIP image, and (b) PB Time-SLIP image.

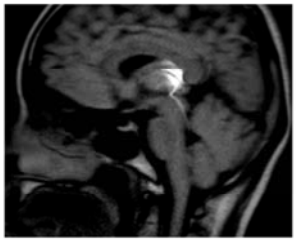

Fig. 5 CSF image labeled on the third ventricle using PB Time-SLIP. PB Time-SLIP clearly depicts CSF flow into the cerebral aqueduct.

REFERENCES:

[1] Henry-Feugeas MC et al. *Magnetic Resonance Imaging* 2000;18:387–95.
[2] Alperin N et al. *Magn Reson Med.* 1996;35:741-54.
[3] Yamada S et al. *Radiology* 2008:249:644–52.