Cerebrospinal fluid flow detection on diffusion-weighted reversed fast imaging with steady-state precession

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Introduction

The assessment of cerebrospinal fluid (CSF) flow is important for intracranial disease such as hydrocephalus and congenital malformation. Conventionally, phase-contrast imaging (PC) with cardiac gating has been used to assess CSF flow. However, it takes at least several minutes for scanning, which is sometimes long for patients who cannot stand still. Diffusion-weighted (DW) imaging has been known to exhibit signal decrease at the moving objects [1-3]. Although DW echo-planar imaging has been a standard DW sequence, it often contains distortion or artifact, especially at the skull base. The purpose of this study was to assess whether DW reversed fast imaging with steady-state precession (PSIF) can present CSF flow.

Subjects and Methods

PC and DW-PSIF were undertaken in normal 14 volunteers on a 3T-MRI. Images were obtained at the brain stem in the sagittal plane, the aqueduct in the transverse plane, and the Monro foramen in the coronal plane. The parameters of PC were TR/TE, 27/8.8 ms; flip angle, 15 degrees; velocity encoding, 5ms/s; scan time, around 5 minutes; those of DW-PSIF were TR/TE 1.7-2.3/7.8; flip angle, 90 degrees; slice thickness, 4 mm; moment, 0,25,50,75, and 100 mT/m*ms, respectively; each scan time, 2 seconds. The portions of the phase changes at CSF on PC were considered as CSF flow, which was used as a gold standard, and compared to the portions where signal changes in DW-PSIF. The evaluated portions include the anterior and posterior portion of the brain stem on sagittal image, the aqueduct of the midbrain on transverse image, and the Monro foramen on coronal images. Signal decrease on DW-PSIF compared to PSIF without diffusion moment was rated by an experienced neuroradiologist by four-point scale: 0, no signal decrease; 1, slightly signal decrease; 2, prominently signal decrease. The visibility of the anatomical structures on each DW-PSIF images were also rated using a four-point scale; 0, poorly visualized; 1, partially unclear demonstration; 2, well visualization. Signal-to-noise ratio (SNR) was calculated on DW-PSIF with each diffusion moment.

Results

Signal decrease was observed at all the assessed portions in the CSF on DW-PSIF, those were corresponded to the phase shift on PC (Figures 1,2). More signal decrease was observed with greater moment on DW-PSIF (Figure 3). The lower score of anatomical visibility was noted on DW-PSIF with higher moment. The highest SNR was noted on DW-PSIF with moment of 25 mT/m*ms. Lower signal-to-noise ratio was shown on DW-PSIF with higher diffusion moment.

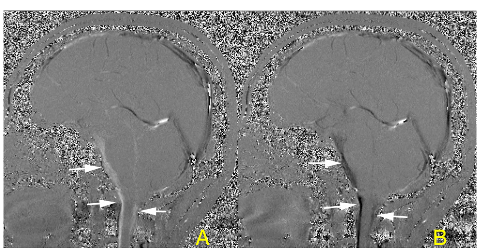

Figure 1
Phase-contrast images of different cardiac cycle (Figures A, B)
Images show phase shift at the cerebrospinal fluid of the anterior and posterior portion of the brain stem, indicating cerebrospinal flow (Figures A, B, arrows).

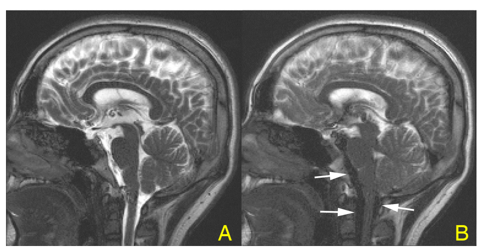

Figure 2
Diffusion-weighted reversed fast imaging with steady-state precession (DW-PSIF).
A: PSIF without moment, B: DW-PSIF
DW-PSIF image shows signal decrease at cerebrospinal fluid of the anterior and posterior portions of the brain stem (Figures A, B, arrows), corresponding to the CSF flow at phase-contrast imaging.

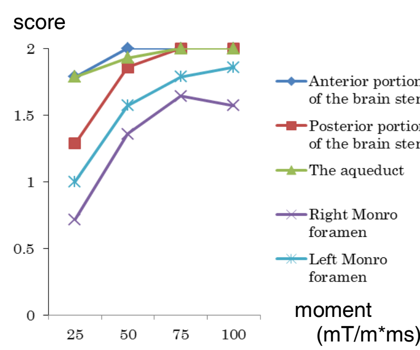

Figure 3
The scores of signal decrease on diffusion-weighted reversed fast imaging with steady-state precession (DW-PSIF).
More signal decrease is identified with greater moment.

Discussion and Conclusions

We found signal decrease at the CSF on DW-PSIF compared to PSIF without the diffusion moment, correlated with CSF flow on PC. Although more signal decrease corresponding to CSF flow was revealed on DW-PSIF with higher moment, imaging quality of DW-PSIF was decreased. Therefore, a low diffusion moment may be preferable for the assessment of the CSF flow using DW-PSIF. The major advantages of DW-PSIF include overall relatively good imaging quality compared to echo-planar DW imaging, and short imaging acquisition (i.e., only several seconds).

In conclusion, DW-PSIF can be a method to assess CSF flow in a relatively good imaging quality and in a short time.

References

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