Fast CSF MRI for brain segmentation; Cross-validation by comparison with 3D T1-based brain segmentation methods

Objective
In previous work we have developed a fast sequence that focusses on cerebrospinal fluid (CSF) based on the long T-2 of CSF. By processing the data obtained with this CSF MRI sequence, brain parenchymal volume (BPV) and intracranial volume (ICV) can be automatically obtained. The aim of this study was to assess the precision of the BPV and ICV measurements of the CSF MRI sequence and to validate the CSF MRI sequence by comparison with 3D T-1-based brain segmentation methods.

Materials and methods
Ten healthy volunteers (2 females; median age 28 years) were scanned (3T MRI) twice with repositioning in between. The scan protocol consisted of a low resolution (LR) CSF sequence (0:57min), a high resolution (HR) CSF sequence (3:21min) and a 3D T-1-weighted sequence (6:47min). Data of the HR 3D-T-1-weighted images were downsampled to obtain LR T-1-weighted images (reconstructed imaging time: 1:59 min). Data of the CSF MRI sequences was automatically segmented using in-house software. The 3D-T-1-weighted images were segmented using FSL (5.0), SPM12 and FreeSurfer (5.3.0).

Results
The mean absolute differences for BPV and ICV between the first and second scan for CSF LR (BPV/ICV: 12 +/- 9/7 +/- 4cc) and CSF HR (5 +/- 5/4 +/- 2cc) were comparable to FSL HR (9 +/- 11/19 +/- 23cc), FSL LR (7 +/- 4,6 +/- 5cc), FreeSurfer HR (5 +/- 3/14 +/- 8cc), FreeSurfer LR (9 +/- 8,12 +/- 10cc), and SPM HR (5 +/- 3/4 +/- 7cc), and SPM LR (5 +/- 4,5 +/- 3cc). The correlation between the measured volumes of the CSF sequences and that measured by FSL, FreeSurfer and SPM HR and LR was very good (all Pearson's correlation coefficients >0.83, R-2 .67-.97). The results from the downsampled data and the high-resolution data were similar.

Conclusion
Both CSF MRI sequences have a precision comparable to, and a very good correlation with established 3D T-1-based automated segmentations methods for the segmentation of BPV and ICV. However, the short imaging time of the fast CSF MRI sequence is superior to the 3D T-1 sequence on which segmentation with established methods is performed.