Cerebrospinal fluid volumetric MRI mapping as a simple measurement for evaluating brain atrophy.

Jill Britt De Vis[1], Jaco J Zwanenburg[1], Jolanda M Spijkerman[1], Geert J Biessels[1], Jeroen Hendrikse[1], and Esben T Petersen[1]
[1]*University Medical Center Utrecht, Utrecht, Utrecht, Netherlands*

Introduction:

The purpose of this study was to assess if volumetric cerebrospinal fluid (CSF) MRI [1] can be used as a surrogate for brain atrophy assessment. For this, the long transverse relaxation rate (T_2) of the CSF was exploited to obtain CSF volumes and these were compared to clinically used atrophy rating scales. We also evaluated how the T_2 of the CSF relates to these brain atrophy scores.

Methods:

This study was approved by the institutional review board. Twenty-eight subjects (mean age 64 (sd 2) years) were included; 3D T_1 MRI, transverse T_2-FLAIR, and CSF MRI[1] (scan parameters; voxel 3x3x6 mm, TR 7917 ms and scan time 1min 11s) were performed. For the latter, an MLEV T_2-preparation scheme [2] with a multi-slice EPI readout was used from which the T_2 of the CSF ($T_{2,\,CSF}$) was calculated voxelwise and of which the M_0 map was used to obtain the intracranial volume (Figure 1). The CSF partial volume within each voxel was calculated by scaling the signal to pure CSF voxels. From these, relative total, peripheral subarachnoidal, and ventricular CSF volumes and $T_{2,CSF}$ values were obtained (Figure 2). The relation between these values and brain atrophy scores (global cortical atrophy (GCA)[3] and medial temporal lobe atrophy (MTA)[4]) was evaluated.

Results:

We found relative total, peripheral subarachnoidal, and ventricular CSF volumes to significantly increase with increased scores on the GCA scale (R^2 = 0.68, 0.60 and 0.27, respectively) and MTA scale (R^2= 0.50, 0.38 and 0.43, respectively). The total, peripheral subarachnoidal, and ventricular T_2 of the CSF increased significantly with higher scores on the GCA scale (R^2= 0.52, 0.49 and 0.24, respectively) and MTA scale (R^2= 0.36, 0.33 and 0.17, respectively) (Figure 3).

Discussion and conclusion:

A fast and easy implementable CSF MRI quantitative volumetric sequence can be used as an alternative for the qualitative GCA and MTA scales. The method could be improved further by implementing more specific regional segmentation. For instance, future work will investigate if hippocampal atrophy is more closely related to the MTA scale. We hypothesize that the measured increase in the T_2 of the CSF with increased scores on the qualitative atrophy scales is caused by changes in the oxygenation status of the CSF which occur during the ageing process. In any case, the T_2 of the CSF is related to brain atrophy and could thus be a marker of neurodegenerative disease.

Acknowledgements:
This work was supported by the Dutch technology foundation STW and the European Research Council (grant n° 337333).

References:
[1] Qin Q. MRM 2011. [2] Brittain JH et al. MRM 1995. [3] Scheltens P et al. Eur Neurol 1997. [4] Scheltens P et al. J Neurol Neurosurg Psychiatry 1992.

Figure 1:

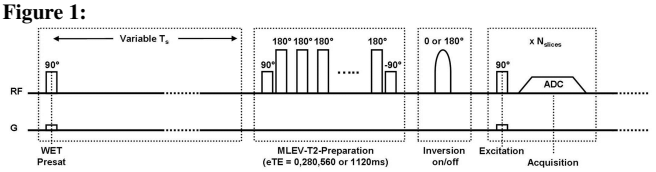

Figure 1: CSF MRI sequence chart, the sequence is built of four parts. Part one, a nonselective (NS) saturation pulse followed by a time delay. Part two, a NS MLEV T_2-preparation, based on a τ_{CPMG} of 70 ms and 0, 4, 8, and 16 refocusing pulses. From these, effective TE's of 0, 280, 560, and 1120 ms are created. Part three, an (optional) inversion pulse which can compensate for slice-timing differences in multi-slice readout. Part four, a multi-slice single-shot echo planar imaging (EPI) readout.

Figure 2:

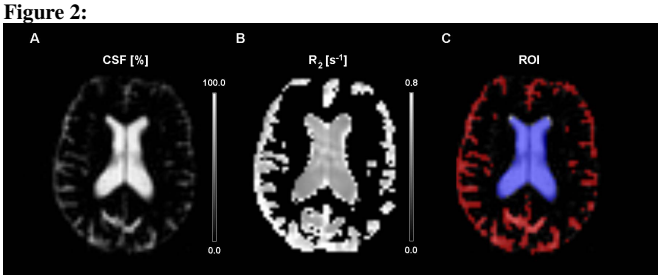

Figure 2: **A)** CSF M_0 map, the signal in each voxel is scaled to pure ventricular voxels to estimate the partial volume effect from which the CSF volume can be calculated. **B)** R_2 (= the inverse of the T_2) CSF map. **C)** Regions of interest used to retrieve the peripheral subarachnoidal (red) and ventricular $T_{2,\,CSF}$ values.

Figure 3:

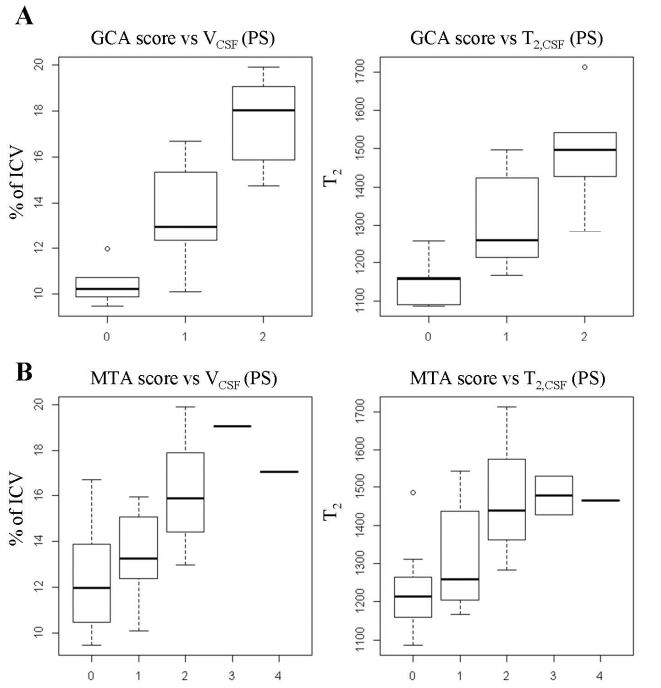

Figure 3: **A, left)** Relative peripheral subarachnoidal CSF volume (V_{CSF} (PS), which is the peripheral subarachnoidal CSF volume expressed as a percentage of ICV) increases with an increased GCA score ($p < 0.001$). **A, right)** The T_2 of the peripheral subarachnoidal CSF ($T_{2,CSF}$ (PS)) increases with increased GCA score ($p < 0.001$). **B, left)** V_{CSF} (PS) ($p < 0.001$) and **B, right)** the $T_{2,CSF}$ (PS) ($p < 0.001$) increase with increased MTA score.