Local Volumetric Analysis of the Brain Ventricles in Alzheimer's Disease using MRI

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Introduction

The brain ventricles are surrounded with many sub-cortical gray and white matter structures that are often affected by dementia diseases in general and AD in particular. In presence of dementia, most of these structures are subject to atrophy. It is common knowledge that the brain ventricles volume is significantly higher in AD patients compared to age matched healthy subjects. The purpose of this work was to perform a more detailed volumetric analysis of the ventricles and measure the enlargement ratio between AD subjects and controls, in order to identify the areas with the most severe enlargement factors.

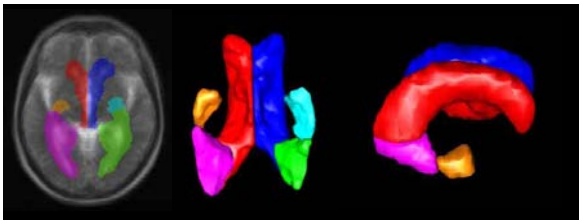

Figure 1: Manual definition of 6 ventricular areas on an average T2-weigthed image. See Table 1 for description

Material and Method

Twenty-nine patients with probable AD (12 men, mean age 73 years, age range 60-83 years) and 25 volunteers with normal cognitive function (11 men, mean age 74 years, age range 64-89 years) were included. Of the 29 AD patients, 2 patients had an MMSE < 10, 20 had 9 < MMSE < 21, and 7 had an MMSE > 20. MRI was performed on a 1.5 Tesla MR-system (Philips Medical Systems, Best, The Netherlands) and had the following characteristics: Dual fast spin-echo (proton density and T2 weighted): TE 27 ms, TR 3000 ms, 48 contiguous 3 mm slices with no gap, matrix 256x256, FOV 220. FLAIR (fluid attenuated inversion recovery): TE 100 ms, TR 8000, 48 contiguous 3mm slices with no gap, matrix 256x256, FOV 220.

In-house developed automated segmentation software (SNIPER, Software for Neuro-Image Processing in Experimental Research) was used to pre-process the images. Using the method described in [1], the software extracted fully automatically the intra-cranial cavity, the cerebrospinal fluid (CSF) and the white matter hyper-intensities. The brain-ventricles were semi-automatically extracted by re-labeling, with few mouse clicks and automatic region growing, the ventricular CSF to ventricles.

Table 1: Local volumetric analysis (values in cc). See Fig. 1 for the location of the different parts of the ventricles. *P* values result from the AD vs. control t-test comparison

	Mean (SD) AD	Mean (SD) controls	%	P value
Total Vent. Vol	115.94 (37.27)	82.91 (40.59)	40	0.003
Left Vent. Vol.	56.59 (20.87)	40.24 (19.68)	40	0.005
Right Vent. Vol.	59.34 (18.27)	42.66 (21.40)	39	0.003
Left. Ant.Vent.	44.50 (15.22)	33.59 (15.35)	33	0.012
Right Ant. Vent.	44.98 (12.60)	33.69 (14.94)	33	0.004
Left Inf.Vent.	1.5 (1.14)	0.51 (0.29)	200	0.000
Right inf. Vent.	1.43 (1.16)	0.57 (0.49)	150	0.001
Left Post. Vent.	10.58 (5.51)	6.12 (4.63)	72	0.002
Right Post. Vent.	12.92 (6.18)	8.39 (6.51)	53	0.011

All the images have then been normalized (corrected for head-size and orientation) using affine 12-parameters registration to the LUMC brain template for geriatrics [2]. In the template space and on the average T2-weighted image, we defined 3 regions on both the left and right hemispheres (see Fig. 1): for each hemisphere, we defined a posterior ventricular region and an inferior ventricular region. The third region consisted of the remaining lateral ventricle. We refer to this region as the anterior-superior ventricle. Figure 1 shows the spatial location of different regions: left inferior ventricle (LIV), right inferior ventricle (RIV), left posterior ventricle (LPV), and right posterior ventricles (RPV), the left anterior ventricle (LAV) and right anterior ventricle (RAV). As showed in Fig.1, the manual region delineation was coarse and made large enough to cover the ventricles of the whole data set (AD and controls). This manual delineation is done only once on the average normalized T2-weigthed image of the whole data set. For each subject, the volume measurement of each region was made on the respective intersection of the segmented ventricles and the defined regions (see Fig. 1). This way, the region definition is systematic and consistent for the whole data set.

Results

All the volume measurements are summarized in Table 1. The different ventricular regions present different enlargement factors ranging from 30% to 200%. The inferior ventricles present a much higher enlargement factor, compared to the total ventricular enlargement. Note the asymmetric (in respect to left and right) enlargement factors. The left inferior and posterior areas have the highest enlargement factors (200% and 150% resp.)

Conclusion

The brain ventricles are relatively easy to segment in most structural MR sequences. High resolution MR is not a requirement, clinical routine MR protocols can be used. Our work shows that the inferior parts of the temporal horns present a good potential as biomarkers for AD. However, because of their relatively small size, we recommend the analysis in images with a minimum of 3 mm slice thickness with no gap.

Further work comparing mild cognitive impairment, frontal lobe dementia and AD is in progress.

References

1. F. Admiraal Behloul et al., NeuroImage 8 (23), 2005.
2. F. Admiraal-Behloul et al., ISMRM, 2004.