Cerebrospinal fluid and brain matter repartition in neurodegenerative diseases

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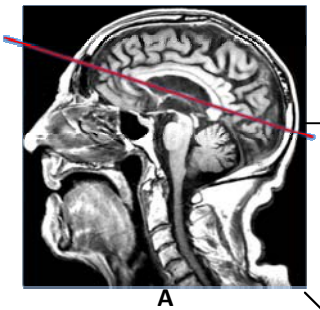
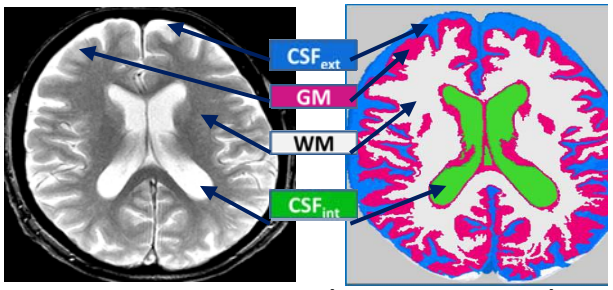
Introduction: Adult chronic Hydrocephalus (ACH), Alzheimer's disease (AD) and vascular dementia (VD) are associated with brain atrophy, Cerebrospinal fluid (CSF) dynamics changes and ventricular dilatation [1]. This leads to confusions in the differential diagnosis in a non-negligible part of aging patients presenting one or more of the common pathological features. 3D MR imaging may help improve the differential diagnosis but it can be very time-consuming to acquire and to process, and is very motion and noise sensitive. Hence, we propose a fast and conventional 2D MRI approach to evaluate the CSF and the grey/white matter repartition in healthy (H), ACH, AD and VD patients.

Materials and Methods: After a clinical, neurological and neurophysiological dedicated examination, 43 subjects (mean age: 65±6) were divided into 4 groups: 12 H, 10 ACH, 11 AD and 10 VD, without intergroup age differences. All subjects underwent 2D axial T2*- weighted and axial T2 fluid-attenuated inversion recovery (FLAIR) acquisitions with a 3T MRI scanner.

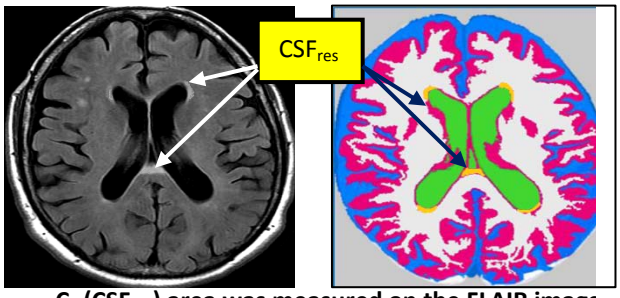


A



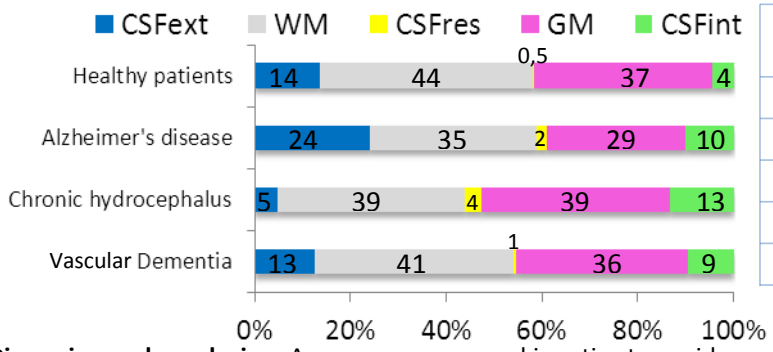
B - CSF$_{int}$, CSF$_{ext}$, GM and WM were assessed on the axial T2*weighted image

A common reference plane intersecting the anterior horn and the body of the lateral ventricles was defined for all patients (A). Afterwards, areas of: the ventricular CSF (CSF$_{int}$), extra-ventricular CSF (CSF$_{ext}$), the grey (GM) and white matter (WM) were assessed on the axial T2* image (B). Then, the transependymal CSF resorption (CSF$_{res}$) area was measured on the FLAIR image (C). Segmentations were done using a medical image processing software (MIPAV) (2-3 minutes/patient). For each subject, repartition ratios of CSF and grey/white matter within the total slice area were calculated then compared between the four groups.



C- (CSF$_{res}$) area was measured on the FLAIR image

Results: The highest (p<0.01) CSF$_{int}$ and the lowest (p<0.01) CSF$_{ext}$ ratios were detected in ACH, while AD patients presented the largest CSF$_{ext}$ and the smallest GM+WM area (p<0.001). The CSF$_{ext}$/CSF$_{int}$ ratio were lower (0.37) in ACH than in the other groups (>1 for the three measurements). The most important transependymal CSF resorption was found in ACH patients.



Areas in % (mean ± SD)	Vascular Dementia	Chronic hydrocephalus	Alzheimer's disease	Healthy patients
CSFint	9 ± 2	13 ± 4 *	10 ± 3	4 ± 1
CSFext	13 ± 3	5 ± 1.5 *	24 ± 4 *	14 ± 3
WM	41 ± 4	39 ± 6	35 ± 5	44 ± 7
GM	36 ± 5	39 ± 8	29 ± 5*	37 ± 8
CSFres	1	4 *	2	0.5

(*) = significant differences with the other 3 groups with p < 0.05

Discussion and conclusion: Areas were expressed in ratios to avoid morphological differences in the brain. In ACH, there is no matter los as in AD but a volume redistribution of CSF$_{ext}$ towards CSF$_{int}$ compartments. Paradoxically, in our population, CSF volume in ACH an healthy patients is found to be similar, whereas it has increased in the other groups. Preservation of brain matter in ACH could also b considered as an argument for potential recovery of brain functions after CSF treatment (shunt or ventriculocisternostomy).In contrast t ACH, AD and VD patients showed increases in both CSF compartments, and therefore a decreased brain matter surface due to th incompressibility of the tissue. Brain atrophy was most notable in AD patients, as expected. The transependymal resorption was no measurable on the T2*-weighted images, which explains the use of the FLAIR acquisition in order to assess this spinal fluid diffusion mos observed in ACH patients [2]. In conclusion, brain matter and CSF repartition over the brain can be quickly estimated from single 2D MR highlighting morphological differences in these neurodegenerative diseases. ACH seems to result from a CSF repartition disorder wherea AD and VD seem to rather result from a brain tissue loss.

References: [1] Chakravarty et. al, Unifying concept for Alzheimer's disease, vascular dementia and normal pressure hydrocephalus - a hypothesis. *Med Hypotheses. 2004* [2] Ulug et. al, Diffusion imaging in obstructive hydrocephalus.*AJNR,*2003