Quantification of the Cerebellar Lobe Volumes using a 2D T2 TSE PROPELLER Sequence: Reliability Analysis.

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Introduction: Cerebellar volumetry helps correlating a multitude of clinical findings (autism, seizures, gait ataxia, nystagmus, schizophrenia, Williams syndrome – to cite only a few) with atrophy of specific cerebellar areas. Therefore, researchers have thought to perform the detailed volumetry of the physiologically and anatomically relevant parts of the cerebellum.[1, 2] These developments used relatively high resolution T1 weighted 3D ultrafast spoiled gradient echo (GE) sequences with an intrinsic low contrast between the CSF and the grey matter and high motion sensitivity.

On the other hand, the routinely provided description of cerebellar regional loss of volume (i.e. atrophy) and its temporal evolution is examiner-dependent and subtle atrophy is often missed, due to the low contrast and lower resolution of the 3D T1-weighted GE clinical data. This explains the only coarse volumetry (grouping lobes I-V, VI-VII and VIII-X) reported in clinical studies of cerebellar atrophy.

Despite technological improvements, in order to avoid poor patient cooperation issues and artifacts, 2D turbo spin echo (TSE) sequences are still (the) mostly used in the clinic. Therefore, we tested the ability of high-resolution 2D TSE to clearly depict cerebellar borders and to allow a precise quantification of the volume of the individual cerebellar lobes. The quantitative results obtained where tested on intra-rater reliability. The inter-subjects variability was also estimated.

Methods: Using "motion correction with radial blades" (PROPELLER/MultiVane[3]) 2D T2-weighted sagittal TSE MR images on a 3T Philips Ingenia Scanner with a 32 Channels headcoil: ACQ matrix MPS = 480 x 480 x 48; ACQ voxel = 0.57 x 0.57 x 2.00 mm^3; slice gap = 0.4 mm; MultiVane percentage = 160%; shots per blade = 1; TSE factor = 31; Flip angle = 90°; adaptive RF Shims; SPIR fat suppression; scantime = 7min; TR/TE = 4000/117 ms; BW = 400.6 Hz; the borders of the single cerebellar lobes were identified interactively on the individual slices accordingly to the Schmahmann labeled cerebellum atlas.[4] Beginning from the mid-saggital slice on which anatomical landmarks are clearly visible, we then followed the cerebellar fissures laterally. We separate lobes I/II, III, IV, V, VI, VIIa, VIIb, VIIIa, VIIIb, IX, and X. This procedure was repeated twice on five healthy subjects (two males, three females, between 20 and 22 years old) to determine intra-rater reliability and inter-subjects variability.

Results: The high resolution and contrast of the MultiVane 2D T2 TSE images enabled the detailed and clear separation of the individual cerebellar lobes (Fig. 1). All mean lobe volumes could be reliably quantified with very similar results between the two independent ratings (Table 1). Only for lobe I/II, a learning effect could be observed. The inter-subjects relative variability of the lobe volumes (i.e. Subjects' standard deviation (STD) divided by the mean lobe volume) tends to decrease with increasing lobe volume (Fig. 2).

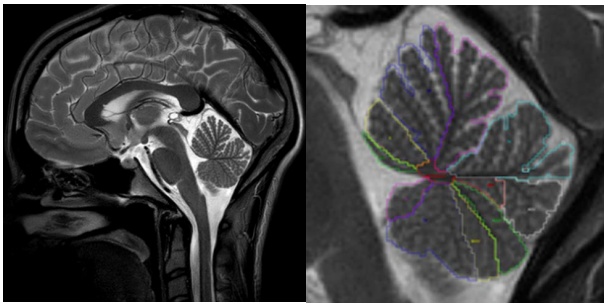

Figure 1: *High resolution, high contrast whole head 2D T2-weighted MultiVane TSE mid-sagittal image (left) enabling a reliable segmentation of the individual cerebellar lobes (detail on the right). 48 slices were needed to cover the whole cerebellum.*

Lobe	Rating 1		Rating 2	
	Mean Volume (cc)	Subjects STD	Mean Volume (cc)	Subjects STD
I/II	0.33	0.11	0.23	0.07
III	1.56	0.42	1.62	0.43
IV	5.37	0.90	5.67	0.72
V	7.57	1.58	7.39	1.44
VI	18.28	1.81	18.39	1.33
VIIa	38.94	2.90	40.08	2.20
VIIb	4.37	0.92	4.17	0.80
VIIIa	11.71	2.32	11.98	2.43
VIIIb	14.06	1.99	14.56	2.48
IX	2.39	0.44	2.28	0.32
X	1.52	0.21	1.50	0.25

Table 1: *The volume of the individual cerebellar lobes could be quantified reliably, with only small intra-rater differences.*

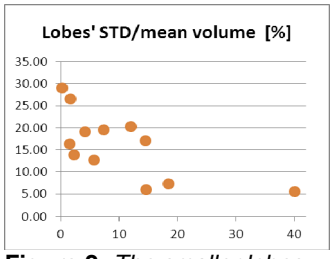

Figure 2: *The smaller lobes have a ~30% volume variation between subjects. Bigger lobes show only a 5% volume variation. Horizontal axis: volume in cubic centimeters (CC), rating 2 was used.*

Conclusion: The proposed intrinsically motion insensitive 2D sequence enables a reliable quantification of the individual cerebellar lobe volumes, with similar intra-rater and inter-subjects variability to the one obtained from 3D data.[1] Further, the volumes of lobes I/II, III, IV, V, VI, and X are similar to 3D results, but the volumes of lobes VII-IX differ. These results set the basics of a clinically useable, motion resistant method for the quantification of cerebellar atrophy, and give a reference to further volumetric analysis of the individual cerebellar lobes.

References:

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