In-vivo 3D Magnetic Resonance Volumetric Analysis of Fetal Cerebellum: From normal to pathology (unilateral cerebellar hypoplasia)

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INTRODUCTION – MR imaging (MRI) is increasingly being used for the fetal central nervous system studies in vivo. Fast MR acquisition schemes in combination with advanced image processing reconstruction methods allow the quantitative studies of cerebral volume of the fetus in-utero based on high resolution MRI. There is thus an increasing number of quantitative studies dedicated to early brain development in fetuses, mostly focused to normal development and to some frequent pathologies such as ventriculomegaly or intra-uterine growth restriction. Quantitative studies of development of the cerebellum based on 3D MRI are rare [1,2]. However, both developmental and clastic cerebellar pathologies include abnormal biometry and are in daily clinical practice explored using MR imaging especially during the second half of the pregnancy [3,4].

PURPOSE – In this work we present the quantitative study of cerebellum volume from 3D high resolution reconstructed MRI in healthy population of fetuses from 26 to 34 weeks of gestational age (GA) and we report one case study with unilateral cerebellar hypoplasia. Our aim is two fold: on one side we would like to study the validity of having data coming from different MR scanners with slightly different acquisition parameters, and, on the other side, to test the validity of 3D cerebellar volume measurements from MR for diagnosis.

METHODS – Data: Imaging was performed on ten subjects. Two healthy fetuses (26 and 28 GA) acquired at Lausanne University Hospital (CHUV) using a T2-weighted HASTE sequence (TE/TR = 180/7000ms) on a 1.5T Siemens Aera with resolution 1.125 × 1.125 × 3.6mm^3 and on 8 fetuses (from 29 to 34 GA) from Hôpital Femme Mère Enfant (HFME), using a SSFSE sequence (TE/TR =180/7000ms) on a 1.5T Philips with resolution 1.09 × 1.09 ×5.5mm^3 (see Fig.1 with the age distribution of the healthy subjects, CHUV in green and HFME in blue; in Fig. 2 a 2D slice of the pathological brain of 33.5 weeks GA). **Image reconstruction**: for each fetus, all available low-resolution stacks (at least three different orthogonal acquisitions) were reconstructed into a high-resolution image using the motion compensation and registration approach in [5]. **Segmentation**: manual delineation of the cerebellum was done using MITK [6] primarily on the axial plane and with review of the coronal and sagittal planes. Volume computation was done as number of voxels by the voxel resolution and the separation into two hemispheres was done by the supervised extraction of the mid sagittal plane for each fetus. **RESULTS –** We first report the total cerebellar volume of our healthy data set as function of the GA (see Fig. 3, in red). We compare our values with those initially published in [1] by Grossman et al (Fig.3 in blue) observing very close behaviour. Our values are also in accordance with most recent studies [2] . We also studied the cerebellar volume per hemisphere in Fig. 4 : healthy hemispheric volumes, left and right confounded, are in pink ; the patient with cerebellar hypoplasia is depicted in green (healthy right hemisphere) and red (pathological left hemisphere). A polynomial fit on healthy population is estimated (solid blue) with the confidence margins at 0.05 significance level (dashed lines). We can observe that the hypoplasic hemisphere is not included within the confidence interval. **DISCUSSION –** To our knowledge, only one recent study attempt to quantify cerebellar fetal volume from 3D high-resolution reconstruction MRI data [2]. Our findings confirmed data reported in there [2] and in previous studies [1] in which segmentation was based on low-resolution stacks. We concluded, that, despite the differences in acquisition conditions and image resolution, volumetric results between different datasets can be compared and used together to increase statistical power when few dataset are available. We reported a case of unilateral hemispheric hypoplasia, showing a significant decrease of one hemispheric volume using 3D MRI quantitative analysis. This suggests that quantitative volumes extracted from 3D MRI could be used as complementary tool to diagnose and evaluate pathologies of the cerebellum. Such quantitative measures could therefore be used for other developmental pathologies, like hemorrhagic or ischemic lesions.

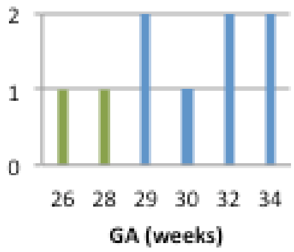

Fig 1. Age distribution of healthy subjects: CHUV (green), HFME (blue).

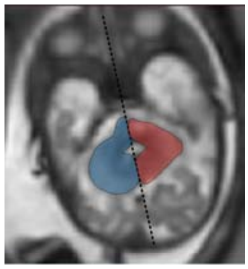

Fig. 2 Axial slice of HR MRI image of fetus with unilateral cerebellar hypoplasia.

REFERENCES – [1] Grossman et al, Neuroimage 2006, [2] Scott et al, Cerebellum 2012, [3] Garel et al J Child Neuro 2011, [4] Massoud et al Ultrasound Obstet Gynecol. 2013, [5]F.Rousseau et al., Comp.Meth.Prog.Biomed. 2013,[6] http://www.mitk.org.

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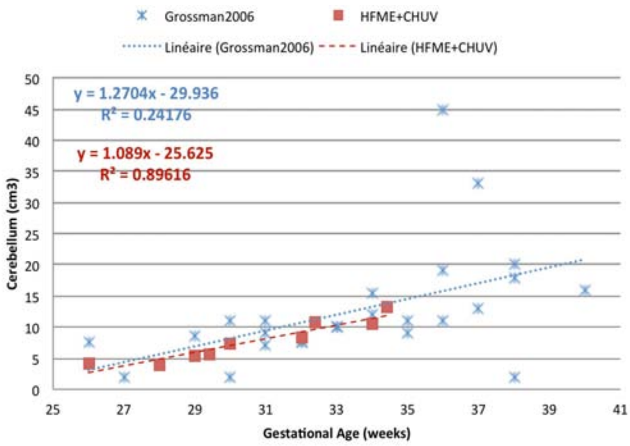

Fig. 3 Regression of total cerebellar volume in healthy subjects. Comparison with first studies based on low-resolution stack segmentations [2].

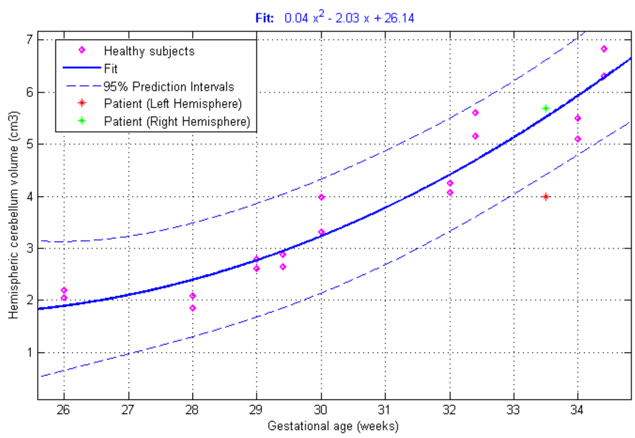

Fig. 4 Polynomial regression of our dataset and outlier detection of the left hemisphere volume of pathological subject.