Lateral ventricular size in extremely premature infants: 3D MRI confirms 2D ultrasound measurements

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Introduction: Cerebral ventriculomegaly at term equivalent age has been shown to be an important and independent predictor of adverse cognitive and motor development in preterm infants [1]. It can easily be detected with cranial ultrasound - the most commonly used imaging technique in neonatal care. However, quantification of ventricular dilatation in 2D ultrasound has been a matter of concern. 3D MRI volume measurements provide a valid assessment of brain tissue and fluid volumes [2]. Previous studies have found limited correlations between 2D ventricular ultrasound measurements and 3D MRI volumes, but CSF volumes were not subdivided into extracerebral and ventricular CSF [3]. We present, to our knowledge, the first study about the correlation of lateral ventricle 2D ultrasound measurements to lateral ventricle 3D MRI volumes in a cohort of extremely low gestational age infants.

Methods: Paired cranial MRI and ultrasound scans of a non-selected cohort of 34 preterm infants born at a gestational age below 27 weeks were included in the study (birth weight: 773±162g (mean±SD), gestational age: 25+4weeks ± 9days). Due to MRI image movement artefacts 6 cases were excluded from analysis. Infants were scanned at term equivalent age using a Philips Intera 1.5 T (Best, Holland) MRI system. A coronal T1-weighted 3D Gradient Echo sequence (TR 40ms, TE 4.6ms, Flip angle 30, NSA 2, scanning matrix 256x206, slice thickness 2mm (1mm spacing), FOV 180mm, SENSE R=1.5) was used in order to allow exact volumetric measurements. To segment the lateral ventricles, an image processing software was developed and implemented in Matlab 7.0 (Mathworks, Michigan, USA). This software uses a semi-automatic Active Contour model [4] that is attracted to the edges of the lateral ventricles. Apart from reducing inter- and intraobserver variability compared to fully manual segmentation, the edge-based segmentation approach is beneficial due to the decreased risk of ventricular plexus/white matter misclassification. To minimize the manual input, the contours were propagated through the image volume treating the volume as a 2D dynamic stack. The active contours were placed in the coronal and axial planes and merged to create a final segmentation result (see Figure 1). Cranial ultrasound (ACUSON Sequoia, Siemens, Germany) was performed in the coronal and parasagittal planes through the anterior fontanelle obtaining sequential sections according to Levene [5]. The images were stored digitally and analysed by two independent observers measuring 5 different ventricular dimensions on each side (coronal: short and long axis of the frontal horn, parasagittal: frontal horn height, Ment midbody index [1], thalamus-occipital horn distance, see Figure 2). Correlations between 2D measurements and total ventricular volumes were calculated using SYSTAT 10.0 (SSPS, Illinois, USA).

Results: The mean lateral ventricle volume measured with 3D MRI was 5.4±6.4ml (left ventricle) and 4.3±4.6ml (right ventricle). The difference between left and right ventricular volume was significant ($p = 0.019$). Of the 10 ultrasound ventricular measurements, 6 showed very good correlations to ventricular volumes measured with MRI (Table 1). The best correlation was found to the measurements of the frontal horns (frontal horn product= short axis∗long axis of the frontal horn, $r^2 = 0.947$), the poorest correlation was to the thalamus-occipital horn distance.

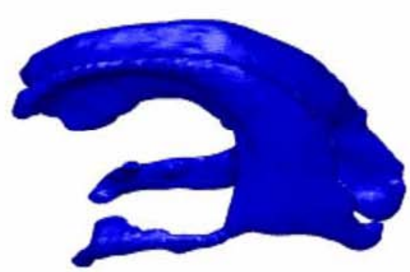

Figure 1: MRI segmented lateral ventricles.

US dimension measurement	r^2, left side	r^2, right side
1. Frontal horn short axis (cor)	0.872	0.875
2. Frontal horn long axis (cor)	0.572	0.641
3. Frontal horn height (sag)	0.775	0.929
4. Ment midbody (sag)	0.731	0.869
5. Thalamus-occip.horn (sag)	0.373	0.483
6. Frontal horn product (sag), (1)*(2)	0.947	0.937

Table 1: MRI-ultrasound correlations.

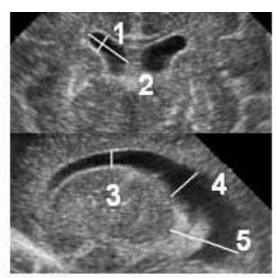

Figure 2: Ultrasound measurements. 1: Short axis of frontal horn. 2: Long axis of frontal horn. 3: Height of frontal horn. 4: Ment midbody index. 5: Thalamus-occipital horn distance.

Discussion/Conclusion*:* Using MRI as a gold standard for ventricular volume measurements, we have been able to show that 2D ultrasound measurements of the frontal horns have a very good correlation to the total ventricular volume. Measurement of the occipital horn had the poorest correlation, which is probably due to the fact that correct visualization of the posterior borders of occipital horn through the anterior fontanelle is difficult and results in high interobserver variability. Highest correlation was achieved by combining the coronal frontal horn measurements.

References:

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