Fully automated estimation of brain volumes in post-mortem newborns and fetuses

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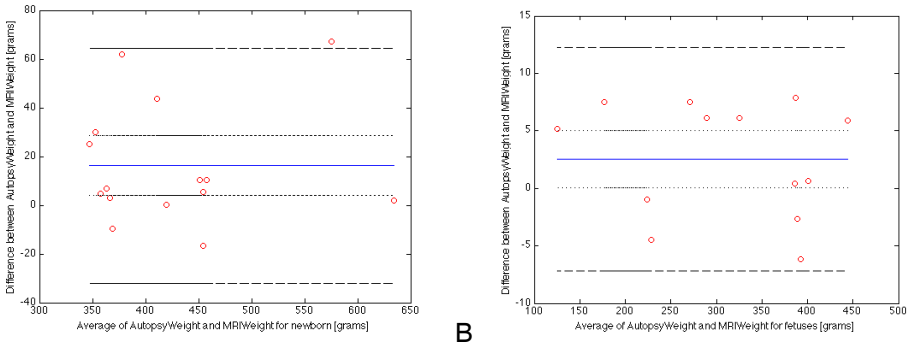
Introduction: The loss of a fetus, an infant or a child is traumatising and devastating for a parent. Knowing the exact reason why their child died and establishing any risk for further pregnancies or existing children is comforting and can help them cope with their loss. Autopsy is needed for establishing this precise diagnostic. However, autopsy rates have been declining worldwide, mainly because of its invasive nature [1]. Minimally invasive autopsy using post-mortem magnetic resonance imaging (MRI) is a valid alternative for conventional autopsy in fetuses and infants [2]. Accurate estimation of brain weight is an integral part of autopsy, however manual segmentation of visceral organ volumes on MRI is labour intensive [3] and unsuitable for routine clinical practice. In this paper we aim to show that the brain weights obtained during conventional autopsy can be accurately estimated from the post-mortem MRI using a fully automated technique.

Methods: We performed pre-autopsy post-mortem cerebral MRI using a 1.5 Tesla Siemens Avanto MR scanner in 13 fetuses (with gestational ages greater than 24 weeks) and 15 newborns, as a part of the Magnetic Resonance Imaging Autopsy Study (MaRIAS) [2]. We automatically segmented the cerebrum, cerebellum and brainstem from the 3D T2-weighted MR images (Constructive Interference in Steady State sequence). For this we used an atlas-based segmentation using a publicly available neonate brain atlas [4] and an Expectation-Maximisation process with relaxation priors (AdaPT [5]). The cerebrum segmentation volume obtained was thresholded in order to exclude the contribution of cerebrospinal fluid (CSF) to the final weight, to adjust for the CSF loss during conventional autopsy [6]. We multiplied the computed volumes by previously reported brain density (1.08 g/mL [3]) to estimate the brain weight. We then compared these values with the actual brain (cerebrum) weight measured during conventional autopsy (the gold standard).

Results: The mean weight estimated by MRI and conventional autopsy in fetuses and newborns was 310 g versus 312 g (mean difference 4 g, 95% CI 10 g), and 418 g versus 434g (mean difference 20 g, 95% CI 48 g), respectively. Modified Bland-Altman plots comparing the MR and autopsy weights of the cerebrum for the fetuses (B) and newborn (A) subjects are given in Figure 1.



A B

Figure 1) Bland-Altman plots showing differences between the conventional autopsy weights of the brain (cerebrum only, no fluid) and the automatically segmented ones from the MR images for the MaRIAS newborn (A) and fetus (B) cohorts

Discussion/Conclusion: In this paper we showed that brain weight can be estimated from post-mortem brain MRI with a maximum error of 2% in fetuses and 11% in newborns using a fully automated technique. The fetuses results were more accurate due to the smaller variations in gestational age of this cohort. The newborn cohort shows more variation among the subjects because of their different ages and different morphologies. The cerebrum segmentation of the newborn outlier appears accurate and we do not have enough information to reason the discrepancy between the estimated and autopsy volumes. In the computation of the MRI brain weight, all fluid was excluded based on the assumption that it leaks in the autopsy process and is therefore lost before weighing. However, some fluid might still be embedded in the tissue, contributing to the autopsy weights and thus influencing the results. This technique can be used in routine clinical practice to estimate the brain weights and may increase the uptake and accuracy of minimally invasive autopsy.

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