Corpus Collosum Shape Analysis on Premature Neonates - A Surface mTBM Study

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INTRODUCTION: Approximately 13% of all births in the United States are preterm (i.e., occurring before 37 weeks gestational age). While advances in neonatal care have improved clinical outcome significantly, being born prematurely is associated to a higher risk for various developmental disorders. In particular, multiple cognitive domains can be affected by neonatal brain injury and prematurity - executive function, learning, memory, high visual processing, etc - therefore we need new methodology that can better characterize subcortical structures that are involved in these processes. Here we use a new pipeline that we designed to compare the anatomy of subcortical structures to understand differences in the corpus callosum between premature neonates and term-born controls.

SUBJECTS AND METHODS: Our dataset comprises 12 premature babies (post-conception ages 25-36 weeks) with normal MR scans and 11 healthy term born infants (post-conception ages 37-42 weeks at scan time for both groups), scanned on a 1.5T GE scanner. We manually traced the subcortical structures on the SPGR images using Insight Toolkit's SNAP program [1]. Tracings were done by an experienced pediatric neuroanatomist. We reconstruct topologically correct corpus collosum surfaces by building a set of parametric surfaces using holomorphic one-forms and conformal nets [2]. The procedure to compute holomorphic one-forms includes (1) computation of the exact harmonic one-form; (2) computation of its conjugate one-form; (3) building of the holomorphic one-form. After we compute the conformal parameterization, surface registration is done by computing a constrained harmonic map [2].

The statistical analysis is done by performing a Hotelling's T^2 test at each vertex on the deformation tensors $\sqrt{J^T J}$, where J is the Jacobian matrix of the transformation from registering all subjects to a common template (multivariate tensor-based morphometry; mTBM). In order not to assume a normal distribution, we compare the T^2 results to a permutation distribution created from 10,000 random assignments of subjects to groups.

RESULTS: We found more clusters of significance around genu than splenium areas. We also compared the mTBM results to 3 other statistics, the radial distance ρ, the determinant of J, and mTBM + ρ. While all measures gave similar clusters of significance, mTBM demonstrated the strongest statistical power over det J and the radial distance.

CONCLUSION: We have built a surface mTBM based subcortical structure morphometry pipeline, which has been especially adapted to studying neonatal data. Our prior work has focused on the thalamus and lateral ventricle [3]. Here we reported our latest results on the corpus collosum and even with our small sample, we detected significant results. In the future, we will increase the sample size to confirm the results from the preliminary study described here.

REFERENCES: 1. Yushkevich PA et al, NeuroImage, 2006. 31(3): p. 1116-1128. 2. Wang Y et al, NeuroImage, 2010. 49(3): p. 2141-2157. 3. Wang Y et al, *Ventricular and Thalamic Surface Morphometry in Premature Neonates,* submitted to Neuroimage, 2011.

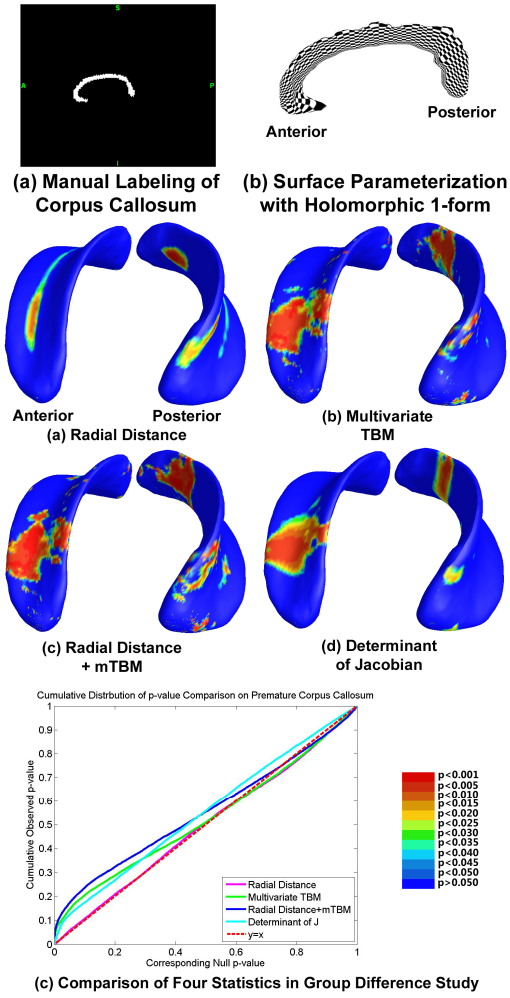

Fig.1 Diagram of our mTBM method for the corpus callosum (CC). a) manually traced binary CC. b) parametrized CC surface. 2nd and 3rd rows: P-value maps on the on the CC using as metric (from left to right and top to bottom): ρ, mTBM, ρ + mTBM and det J. Last row: comparison of the different statistics using the cumulative distribution function of p-values. Statistics that are higher above the x=y line show more detection power. MTBM is more powerful here than ρ and det J.

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