Perinatal Stroke: Understanding Brain Reorganization through Infant Neuroexcitability and Neuroimaging

Chao-Ying Chen¹, Michael Georgiell², Jed Elison³, Mo Chen⁴, Bryon Mueller⁵, Raghavendra Rao⁶, Kyle Rudser⁶, James Stinear⁷, Bernadette Gillick⁸
¹Department of Physical Medicine & Rehabilitation, University of Minnesota, Minneapolis, Minnesota, USA; ²Department of Pediatrics, University of Minnesota, Minneapolis, Minnesota, USA; ³Institute of Child Development, University of Minnesota, Minneapolis, Minnesota, USA; ⁴Institute for Engineering in Medicine, University of Minnesota, Minneapolis, Minnesota, USA; ⁵Department of Psychiatry, University of Minnesota, Minneapolis, Minnesota, USA; ⁶Clinical and Translational Science Institute, University of Minnesota, Minneapolis, Minnesota, USA; ⁷Department of Exercise Sciences, University of Auckland, New Zealand

BACKGROUND/OBJECTIVES

Little is known about the pattern of brain reorganization that often eventually manifests as cerebral palsy (CP) following perinatal stroke. Understanding early brain reorganization in these high-risk infants will help to facilitate the development of intervention programs to enhance their motor outcomes. Therefore, the main purpose of this study is to evaluate brain reorganization patterns in infants with perinatal stroke. For this pediatric population we will adapt adult transcranial magnetic stimulation (TMS) protocols and use non-sedative magnetic resonance imaging (MRI) including diffusion weighted magnetic resonance imaging (DWI) protocols for use with infants between 3 and 5 months of age. The general movement assessment (GMA) protocol will also be included. The latter will help identify infants who are at either a high or low risk of developing CP.

DESCRIPTION-METHODS

During the first of two visits, infants will have an MRI scan during natural sleep. Infant participants will receive GMA and TMS assessments during the second visit within seven days after the scanning to avoid developmental changes of the brain.

- MRI: Infant-size headphone and ear plugs will be used to diminish MRI machine noise (Figure 1). One researcher will stay with the infant as a baby monitor throughout the scanning. The scanning protocol takes about 38 minutes.
- TMS: A 50-mm figure-of-eight coil will be used to assess the excitability of cortical representations of arm muscles, optimizing coil position for the wrist flexors. During the assessment, a parent will hold and interact with their child to facilitate arm muscle contraction (Figure 2). TMS pulses can only be delivered when the muscle contraction level is above resting EMG levels. To guide TMS assessment, individual anatomical MRI images will be utilized in a frameless stereotactic neuronavigation system, with minor equipment modification for an infant population (Figure 3).
- GMA: Infants will be videotaped for 5-10 minutes to assess their fidgety movements for predicting motor outcomes.

DESCRIPTION-PRELIMINARY TEST

With parental consent, three typically developing infants between 3-5 months of age visited our lab for EMG observation. The EMG activity of five muscles included the abductor digiti minimi, wrist flexor, wrist extensor, biceps, and triceps were observed in the following three testing conditions: 1) when infants moved their arms freely without any constraint (Figure 4); 2) when infants’ arms were constrained to limit movements and muscle contraction (Figure 5); and 3) when infants’ upper extremities were being extended by a parent to facilitate muscle contraction.

Optimal resting EMG activity was between ±10 and ±20 μV in the wrist flexors and biceps. Cardiac rhythm artifacts were evident during bilateral biceps assessment (Figure 6). As a result, the wrist flexor is currently identified as the optimal muscle for our TMS assessment.

SIGNIFICANCE

A greater understanding of immediate cortical reorganization after perinatal stroke will promote our development of an infant-specific assessment protocol and serve to optimize intervention effects on motor outcomes in infants with perinatal stroke. With the completion of this preliminary pilot, we will design a larger study to comprehensively assess brain changes after stroke and the longitudinal assessment of outcomes. We plan to develop novel intervention programs to facilitate optimal brain reorganization and improve motor outcomes, positively impacting lifetime function in individuals with CP due to perinatal stroke.

ACKNOWLEDGEMENTS

We would like to acknowledge the funding support from American Academy for Cerebral Palsy and Developmental Medicine (AACPDM) and the Cerebral Palsy Alliance, Academic Health Center (AHC) at the University of Minnesota and Minnesota DRIVE brain conditions fellowship. We sincerely thank the families who participated in our pilot observation and the future families who will be involved in this intended study.