Proton Spectroscopy Predicts Neuropychological Outcome After Pediatric Traumatic Brain Injury

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Description: Traumatic brain injuries (TBI) in children contribute to significant morbidity and mortality rates with increased severity and younger age at injury negatively correlating with neuropsychological outcome (1). Proton magnetic resonance spectroscopy (MRS), has shown potential for providing early prognostic information regarding clinical (2,3) and neuropsychological (4) outcome in pediatric patients with head injury. MRS has also been suggested to be more sensitive in detecting brain injury than MRI, with notable damage in specific structures despite normal imaging from conventional MRI (3). In this study, we assessed the efficacy of short echo time single voxel MRS from normal appearing brain and intermediate echo time MRSI which included normal appearing and visibly injured brain in predicting long-term intellectual and neuropsychological functioning in children following TBI.

Methods: Using a 1.5T MR scanner, MRS was acquired 6 $\pm$ 4 days after TBI in 20 children to predict long-term intellectual and neuropsychological functioning assessed 1-4 years post injury. Short echo time single voxel (STEAM; TR/TE=3000/20 ms) MRS (SVS) from normal appearing occipital gray matter (OGM) and parietal white matter (PWM) was compared to intermediate echo time multi-voxel MR spectroscopic imaging (MRSI) (PRESS; TR/TE=3000/144 ms) from normal appearing and visibly injured brain in a 10 mm thick slab through the level of the corpus callosum. Metabolite levels for N-acetyl-aspartate (NAA), creatine (Cr), choline (Cho), myo-Inositol (Ins), and glutamate/glutamine (Glx) and ratios for SVS in each patient were quantitatively measured using LCModel (5). For MRSI data, peak areas for NAA, Cr, Cho and Lac, if present, were measured using Luise (Siemens). Pooled mean ratios were calculated.

The neuropsychological measures used in this study assessed eight areas of functioning; including intelligence (Full Scale Intelligence Quotient or FSIQ), memory (verbal and nonverbal), attention/information processing speed, problem solving/executive skills, visual-perceptual abilities, language skills, academic achievement. An index score for a given domain was calculated by averaging individual standardized scores for each measure or scale used to evaluate a particular function. In addition to the FSIQ, a combined average of all other measures (not factored into IQ) was used in a single score representing an overall neuropsychological index or NPI.

Metabolite levels and ratios from SVS and MRSI were correlated with FSIQ and NPI using Pearson correlation coefficients. Using a multiple linear regression equation, FSIQ and NPI were modeled separately using MRS variables that were strongly correlated with outcome but did not contribute redundantly.

Results: NAA levels and associated ratios (NAA/Cr, NAA/Cho) were positively associated with intellectual and neuropsychological functioning, with correlation coefficients in the moderate to large range (.44 -.79) whereas, individual levels and ratios of Cho, Cr and Glx were not significantly associated with either FSIQ or NPI. This was true for short-echo time SVS as well as intermediate-echo time MRSI data. Moderate correlations (.4 -.59) were noted for Ins and FSIQ and NPI. Lactate was detected in one patient only. Due to the small sample size, predictor variables in regression models were limited to the NAA/Cr ratios from SVS and MRSI since these variables showed the strongest and most consistent correlations to FSIQ and NPI. The SVS NAA/Cr from OGM and PWM accounted for over 40% of the variance in FSIQ and NPI functioning whereas, pooled mean NAA/Cr from MRSI alone accounted for 37% and 48% of the variance in outcome for FSIQ and NPI respectively. When MRSI pooled NAA/Cr ratio was added to the NAA/Cr from the SVS model, it accounted for an additional 5% for FSIQ and 9% for NPI suggesting that MRSI measurements which included data from visibly injured brain are slightly better at predicting intellectual and neuropsychological outcome as compared to SVS measurements from normal appearing brain only.

Conclusions: This study's findings confirmed that SVS (from normal appearing brain) is a useful tool in predicting cognitive outcome following pediatric brain injury. Further, it suggested that MRSI (from normal and visibly injured brain), also a significant contributor to predicting long-term intellectual and neuropsychological functioning, may be slightly stronger in its prognostic efficacy compared to SVS from normal appearing brain.

References:

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