Long Echo MRS thermometry of childhood brain tumours

Ben Babourina-Brooks[1], Martin Wilson[1], Theo Arvanitis[2], Andrew Peet[1], and Nigel Davies[3]
[1]*University of Birmingham, Birmingham, West Midlands, United Kingdom,* [2]*Birmingham Children's Hospital NHS Foundation Trus, West Midlands, United Kingdom,* [3]*University hospitals Birmingham trust, West Midlands, United Kingdom*

Purpose: To investigate the MRS chemical shift in childhood brain tumour types at short and long echo times.

Introduction: The rate of improvement in survival, among children with brain tumours, has decreased in recent years. Novel prognostic markers that may contribute to associated treatment stratification and improved outcomes are required. Non-invasive measures of tumour microenvironment, which may provide such markers, have been relatively unexplored. In addition to metabolite levels, Magnetic Resonance Spectroscopy (MRS) can provide measures that are sensitive to temperature and micro-environmental factors; such measures could be useful for the characterisation of childhood brain tumours. A previous preliminary study showed differences between two broad categories of childhood brain tumours at a TE of 30ms [1]. In this study, the water Proton Resonance Frequency (PRF) measurements, relative to reference metabolite peaks, were compared between the same tumour groups at a larger echo time of 135ms. The PRF measure is affected by temperature and chemical exchange [2]. An increased echo time will indicate the chemical exchange affect on the PRF measure. The aim of this study was to investigate the TE on the PRF shift measure.

Method: Single-voxel MRS data, acquired using a 1.5T Siemens system (PRESS, TR 1500ms, TE 135ms) in 24 childhood brain tumour patients (12 Primitive Neuroectodermal Tumour (PNET) and 14 Gliomas) and 20 children with apparently normal brains, were retrospectively analysed. The apparently normal control data were acquired in two consistent brain regions containing the basal ganglia (BG) and parietal white matter (WM). Spectra were analysed using jMRUI (AMARES tool [3]); the water PRF shift relative to the reference metabolites was measured. The total choline (tCho) peak was chosen as a reference, since it was prominent in all tumour and healthy spectra. The relative shift was then calculated from the water to the tCho peak, $\delta_{(H20\text{-}tCho)}$, and compared across the cohort groups. This was then compared to the previous 30ms patient data results [2]. The mean (standard error) of the PRF shift was compared between the groups (PNET, Gliomas, BG,WM) using pair-wise two-tailed student t-tests. Statistical significance was deemed for $p<0.05$.

Results & Discussion: The PRF cohort shifts at 30ms were significantly different for PNET vs Glioma and Glioma Vs healthy cohorts, $p<0.05$, (Figure 1). The 135ms data produced different results, where the PRF shifts were significant for Glioma Vs white matter and white matter vs basal ganglia cohorts, $p<0.05$. This change in significance is due to the decrease in PRF shift for the PNETS (0.009ppm) and an increase of the white matter PRF shift (0.002ppm) across the 30ms echo time to 135ms. The other cohort groups did not significantly reduce or decrease in PRF shift. The temperature of the cohort regions should not have significantly changed within the scanning timeframe, suggesting the chemical exchange effect is the main cause. PNET tumours have high vasculature (grade IV) and generally have a larger amount of necrosis compared to low grade gliomas [4], therefore there will be smaller amount of chemical exchange sites compared to low grade gliomas. Chemical exchange has been shown to change the PRF shift linearly through protein concentration experiments in solutions [1]. The increased echo time allows more chemical exchange rates to effect on the PRF measure and therefore the PNET PRF would significantly decrease. The white matter increase, compared to the basal ganglia, observed may be explained by water content. In adult brain the protein concentration is similar, however the water content is different 70% vs 80%, in the basal ganglia and white matter, respectively [4]. Therefore there would be increased chemical exchange for the white matter, which would increase the shift. However, this has not been shown in child brain but may explain the difference observed in this study.

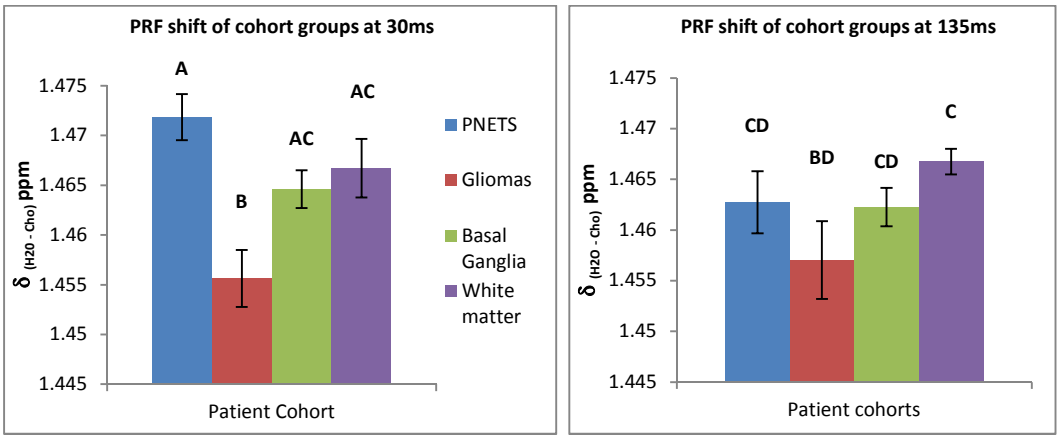

Figure 1: Mean (standard error) PRF shift values for the patient cohorts. Means with different letters are significantly different ($p<0.05$).

Conclusion: Differences were seen in cohort groups across echo times. The longer echo time reduced significant differences between cohort groups, however it provides an insight into the chemical exchange process. This information could be used to better understand the short echo data and aid in determining absolute temperature measures from MRS thermometry.

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