Water chemical shift differences detected in childhood brain tumours may indicate temperature variations and fast exchange effects

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Introduction:

In addition to metabolite profiles, *in-vivo* ^{1}H MRS can potentially provide absolute local temperature measurements through the empirical linear relationship between temperature and the chemical shift of water relative to reference metabolite peaks [1]. It is hypothesised that temperature may be a useful supplementary biomarker for the clinical management of brain tumours, due to disruption of normal thermoregulatory control caused by abnormal vasculature and metabolic rate. Indeed, Jayasundar & Singh [2] have measured large variations in water chemical shift for different brain tumour types. These variations were attributed to large temperature differences. However, such measurements are potentially affected by other contributions to water chemical shift, originating from fast magnetization and/or chemical exchange effects, which are dependent on factors such as macromolecular content and dynamics, microstructure, and pH. The aim of this study was to investigate water chemical shift differences due to temperature and fast exchange effects in two types of childhood brain tumours, by measuring water chemical shift relative to reference metabolite peaks in short-TE and long-TE ^{1}H MRS.

Method:

Single-voxel (SV) ^{1}H MRS was acquired using a standard protocol (PRESS, TE 30 ms or 135 ms, TR 1500 ms, 2 cm or 1.5 cm sided cubic voxels with 128 or 256 averages respectively, water reference with 8 or 16 averages) on a 1.5 T scanner. The patient cohort consisted of 24 children, who underwent SV MRS prior to treatment, with a brain tumour subsequently diagnosed by biopsy. The biopsy identified 15 gliomas (7 grade 1, 5 grade 2, 3 grade 3 or 4) and 9 primitive neuroectodermal tumours (PNET). Of these, 15 (8 gliomas, 7 PNET) had both short-TE (30 ms) and long-TE (135 ms) SV ^{1}H MRS. Spectra were processed and analysed using jMRUI and AMARES to fit Lorentzian lineshapes to the water peak and each of the major metabolite peaks. In the absence of a reliable peak from N-acetyl aspartate (NAA), choline (Cho) at 3.22 ppm and (Cr) at 3.03 ppm (if present) were chosen as reference peaks. The chemical shift of water relative to Cr, δ(H2O-Cr), and Cho, δ(H2O-Cho), was measured for each spectrum and compared between PNET and gliomas by using Student's t-tests; between short-TE and long-TE by using paired Student's t-tests.

Results and Discussion:

As shown in figure 1, the mean values of δ(H2O-Cr) and δ(H2O-Cho) at short TE were significantly larger in the PNET group compared with gliomas ($P < 0.05$), with the same observed difference in the average shift between tumour types of 0.014 ppm. However, δ(H2O-Cr) and δ(H2O-Cho) measured at long TE showed no significant differences between tumour types. The intra-group variance was significantly larger for the gliomas than the PNET, possibly reflecting the diversity of tumour grade in the glioma group.

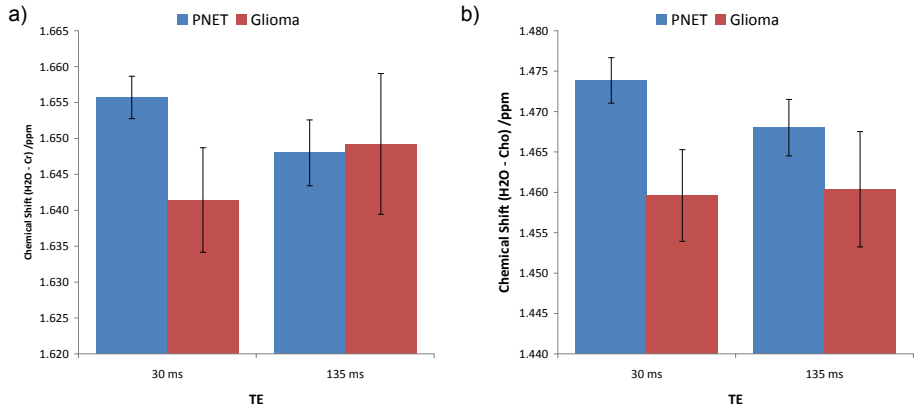

Figure 1: Bar charts showing water chemical shift differences relative to a) Cr and b) Cho for PNETs and gliomas measured using short-TE (30ms) and long-TE (135ms) MRS (error bars indicate standard errors).

In paired t-tests, δ(H2O-Cr) and δ(H2O-Cho) were significantly different between short TE and long TE MRS ($P < 0.05$).

Conclusions:

This preliminary study suggests that water chemical shift, relative to reference metabolites, is significantly different between brain tumour types in children. Disparity between short-TE and long-TE MRS suggests that fast exchange effects may contribute significantly to the observed chemical shift differences. Further investigation is warranted to determine the relative contributions of temperature and fast exchange effects to the observed differences and their biological and clinical significance. Such measurements may provide an additional tool for characterising brain tumours using ^{1}H MRS studies that are already being used in clinical practice.

REFERENCES:

1. Cady EB, et al. The estimation of local brain temperature by in vivo ^{1}H magnetic resonance spectroscopy, Magn Reson Med 1995; 33: 862-867.

2. Jayasundar R & Singh VP. In vivo temperature measurements in brain tumours using MR Spectroscopy. Neurol India 2005; 50: 436.