Evaluation of Lactate Detection Using Selective Multiple Quantum Coherence in Phantoms and Brain Tumours

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Purpose

Lactate is a product of glucose metabolism and is an important metabolite in the assessment of malignant tissues[1]. In tumour tissues, which exhibit enhanced glycolytic metabolism, lactate signal is elevated[2] making it a useful tumor biomarker, but methods of quantitation are complicated because of overlap between the lactate methyl resonance at 1.3ppm with a lipid resonance[3]. The purpose of this study was to use a selective homonuclear multiple quantum coherence transfer (SelMQC) sequence[3] as a method of accurately quantifying lactate by suppressing lipid signals between 1.3-1.4ppm. Both the lipid suppression and the lactate detection of the SelMQC sequence were tested using a phantom. Following this, the performance of the sequence was assessed in 5 brain tumours where the presence of lactate and lipids are both expected.

Methods

Samples of both lactate (20mM) and 100% safflower oil were prepared in 50ml phantoms, to assess both lactate detection and lipid suppression. The phantom was imaged on a 1.5T Siemens Avanto with the standard body and phased array receiver coils. The SelMQC sequence was run with a TR of 1500ms, TE=144ms, 16x16 grid of cubic voxels (20mm side), 2kHz bandwidth, 1024 sampling points, 1 average, Qsel gradient strength 26mT/m. The SelMQC sequence only recovers only 50% of the lactate signal, due to the selection of a single coherence-transfer pathway[4]. Following this, a standard CSI sequence was run, with the same parameters, for comparison. Single voxel spectroscopy was used to collect data to provide a water reference (TE=135ms, 20mm cubic voxel, TR=1500ms, 4 averages). CSI and SVS experiments were compared to ensure SVS was an appropriate measure for water reference. The SelMQC sequence was tested on 5 patients with one of the following primary (low grade glioma [LGG], glioblastoma multiforme [GBM], epethelioid haemangioendothelioma) or secondary (metastases from small cell lung cancer or cholangiocarcinoma) brain tumours. Standard single voxel spectra (TE=135ms, 20mm cubic voxel, TR=1500ms, 128 averages) were acquired to compare lactate visibility between the 2 sequences.

Results

The phantom experiments (fig 1) showed the lactate peak area at 1.3ppm was reduced by approximately 57%, while the main lipid peak (1.3-1.4ppm) was reduced by over 98% in the SelMQC sequence compared with the standard CSI. Due to the SelMQC sequence not producing pure absorption data, all results are shown in magnitude mode. There was little effect on the lipid resonances at 2ppm, but these are reasonably well separated from the lactate peak and do not affect it. The ratio between the areas of the lactate peak and that of the water peak, integrated using in house software, offered an estimated concentration of 14.6mM.

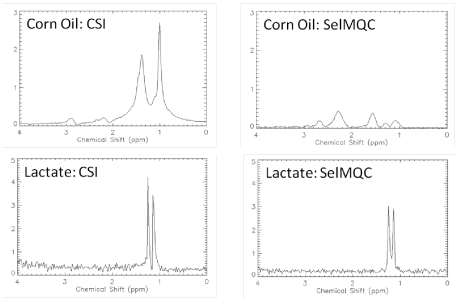

Figure 1: Phantom spectra (magnitude data)

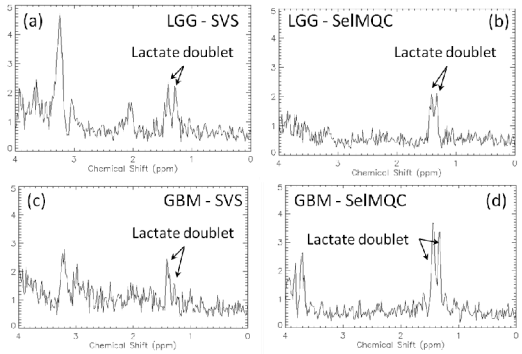

Figure 2: Magnitude spectra for LGG and GBM

In both the patients with gliomas the SelMQC spectrum of the tumors showed a distinct lactate doublet at 1.3ppm: in the LGG, lactate was clearly visible and quantifiable in both the SVS spectra and SelMQC (Lac/W=0.000013)and (fig 2 (a) and (b)), whereas in the GBM, the lactate peak in the SVS spectrum overlapped with lipid resonances, but was clear using the SelMQC sequence (Lac/W=0.00019) (fig 2 (c) and (d)). The SNR was comparable using both sequences, given that the SVS data was collected for 128 averages. The apparent increase in lactate signal in the SelMQC sequence is because it is no longer partially cancelled by lipid signals of the opposite phase. Thus the SelMQC sequence gives a better estimate of real lactate concentrations, which may often be larger than non-MQC sequences suggest. In the metastatic lesions lactate was absent on both the single voxel and SelMQC spectra.

Discussion and Conclusion

Data collected on phantoms demonstrated that the SelMQC sequence detected lactate with good efficiency (43%), with substantial lipid suppression. This allowed quantification of lactate in primary brain tumours and confirmed the absence of lactate in metastases.

This work was funded by Cancer Research UK project grant (C7270/A13149). Additionally, we acknowledge the support received from the CRUK and EPSRC Cancer Imaging Centre in association with the MRC and Department of Health (England) grant C1060/A10334, also NHS funding to the NIHR Biomedical Research Centre; The SelMQC sequence was kindly made available to us by the group of Prof Jerry Glickson, with modifications by Dr Seung Cheol

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