BRAIN TEMPERATURE MAPPING USING MR SPECTROSCOPIC IMAGING

Jehill Parikh[1,2], Ian Marshall[1,2]

1) SFC Brain Imaging Research Centre, Dept of Clinical Neurosciences (part of SINAPSE collaboration). 2) Department of Medical Physics, University of Edinburgh

Introduction

❖ The study of Brain Temperature and benefits associated with hypothermia are of increasing importance in the study of Stroke[1] and Head Injury[2]

❖ Thus a precise non-invasive method to measure temperature is of much importance.

❖ Temperature sensitivity of various MR imaging parameters make MR Thermometry a promising candidate.

Method

❖ Internal reference Proton MR spectroscopy is an accurate technique to obtain absolute temperature.

❖ As illustrated in fig1 we use the difference between position of the temperature sensitive water peak and a temperature insensitive reference ('NAA or N-acetylaspartate') to obtain absolute temperature using the equation[3].

$$T = T_{ref} + 100\,(CS_{H2O} - CS_{ref}) \quad T_{ref} = 37^{o}C$$

❖ We use 2D PRESS Chemical Shift Imaging or MRSI (described in ref [3]) to obtain brain temperature maps shown in figure 2

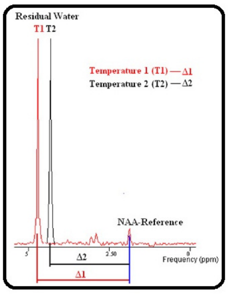

Figure 1 A typical Proton MR spectra used to obtain temperature by computing frequency difference (Δ) between water and NAA (reference) peak.

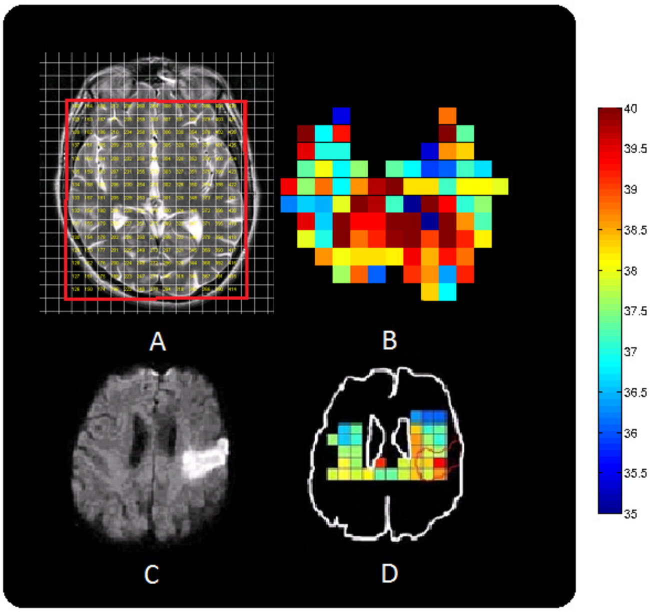

Figure 2 a) Typical MRSI grid overlay with press box on an axial T2 image of a healthy volunteer, b) corresponding temperature map, c) Diffusion weighted image from stroke patient d) corresponding temperature map (from[3]).

MRSI is technically demanding as compared to single voxels spectroscopy (SVS), main challenges for MRSI-BTM

SHIMMING

❖Magnetic field in-homogeneity and tissue susceptibility across the imaging volume is important factors for spectral broadening, thus increases line-width of the peaks.

❖This may results in a rejection of number of voxels from which temperature can be estimated.

❖We intend to use the Bo distribution to increase spatial resolution by using methods i.e. SPREAD[4], QUECC[5] to increase reliablity in MRSI-BTM.

SNR

❖MRSI produces smaller voxels thus SNR is low as compared to relatively large voxels obtained using SVS.

❖We employed an 8 channel head coil (HC) for RF signal reception to increase the SNR for MRSI-BTM our initial results are summarized in Table 1.

❖We modified Brown's[6] approach to combine spectra from phased array coils.

❖We report at least 35% increase in SNR in-vivo with use of 8channel HC

WATER SUPPRESSION

❖Water suppression using frequency selective 'CHESS pulses'

❖In MRSI field in-homogeneity over FOV may introduce a bias in BTM

❖We compared water suppressed and non water suppressed version of the same commercial MRSI pulse sequence for BTM.

❖Our preliminary results on phantom experiments (Table 2) suggest better repeatability with the use of water suppression.

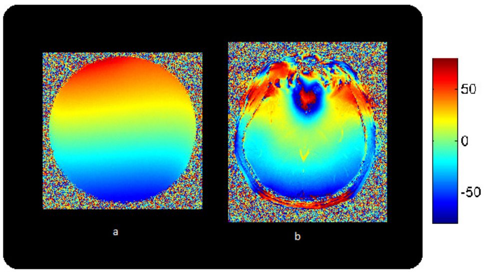

Figure 3: Typical B_0 Map along the MRSI scan plane a) phantom b) healthy volunteer, showing field distribution in Hz

	COIL	NAA-freq (ppm)	NAA-amp (I.U)	LW (Hz)	Temp (°C)	SNR	
Phantom	QUAD	2.839	143.96	1.502	19.580	2.708	MEAN
		0.002	0.32	0.139	0.022	0.283	COV
	PA	2.837	200.37	2.923	19.832	4.343	MEAN
		0.005	0.38	0.378	0.042	0.419	COV
In-vivo	QUAD	2.657	63.54	4.885	37.840	2.110	MEAN
		0.011	0.431	0.383	0.058	0.484	COV
	PA	2.657	79.42	6.587	37.768	3.637	MEAN
		0.010	0.467	0.402	0.056	0.501	COV

Table 1 Comparing results from Quadrature coil (QUAD) AND Phased array coil (PA), using same set up as in ref[3],CSI_FOV=240mm, COV=SD/Mean, NOISE as obtained from jMRUI.

Figure 4 Uniform water suppression (%) across central FOV of the phantom used for quality assurance.

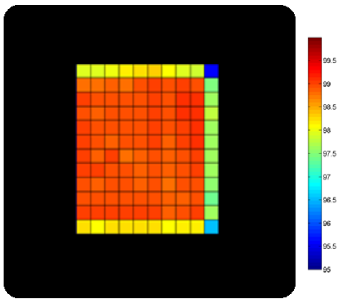

Table 2 Mean (SD) of Temperature and NAA estimates of the all voxels obtained by using with and without water suppression (WS), version of our QA protocol CSI_FOV=320 on the 'GE BRAINO' spectroscopy phantom.

	Acquisition	Temp (°C)	NAA-Amp (I.U.)	Noise (I.U)	LW-NAA (Hz)
Session 1	WS	20.43 (0.198)	298.48 (57.03)	224.4 (40.76)	1.35 (0.13)
	No-WS	20.58 (1.01)	272.65 (77.87)	1799.85 (2293.7)	1.483 (2.216)
Session 2	WS	20.43 (0.198)	298.48 (57.03)	224.5 (40.76)	1.35 (0.13)
	No-WS	20.59 (1.01)	276.19 (78.81)	1841.566 (2277.12)	1.51 (2.29)

Conclusion and Future work

MRSI-BTM is an important tool in study of Brain Temperature

We propose advance development and validation of MRSI-BTM, by

1.Assessing the benefits of using 3T scanners in MRSI-BTM

2.Improved calibration for MRSI-BTM

3.Study repeatability and reliability of MRSI- BTM

Reference

1) Karaszewski B, et al, Ann Neurol 2006, 60: 438-446. 2) Harris B, et al, BJ Anaesthesia, 2008,100: 365-372. 3) Marshall I, et al, MRI, 2006 24(6): 699-706. 4) Dong Z, et al, JMRI, 2009, 36:1395-1405. 5) Bartha R, et al, MRM, 2000,44: 641-645. 6) Brown M, MRM 2004, 52: 1207-1213.

Funding: Chief Scientist Office, Centre for Cognitive Ageing and Cognitive Epidemiology (CCACE), SINAPSE PhD studentship (JP) and Scottish ORS Scholarship (JP).

Acknowledgements: Staff at SBIRC and CRIC, Ms Catherine Murray, Ms Bridget Harris, Prof Barrie Condon (Glasgow).