A Magnetic Resonance Spectroscopic Imaging (MRSI) mapping technique for radiotherapy planning

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Introduction

Although the use of 3D MRSI in radiotherapy planning has been established, there have been no studies addressing the geometric uncertainties of this technique. Metabolic ratio maps are initially generated by defining some threshold. The volume, shape and position of these maps depend critically upon the choice of this threshold. This work presents a thresholding technique and a method to quantify the uncertainty associated to the derived metabolic maps

Methods

3D-MRSI data from a cohort of eight volunteers was utilised to determine the within-voxels standard-deviation (Std_w from ANOVA), an initial threshold and its corresponding 95% confidence interval (measurement error). Variability in the Centre-of-mass (COM) position and volume of NAA/Cho metabolic-maps from two patients were calculated by changing this threshold over the 95% confidence-interval.

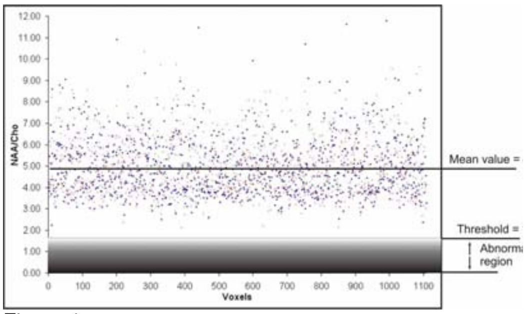

Figure 1

Data was acquired on a 3.0 Tesla scanner. Contiguous axial T_2-weighted slices were followed by two 3D PRESS sequences (FOV=12x12x8 cm, phase encoding matrix = 12x12x8, TE/TR = 144/1000 ms). Concentrations of Cho and NAA were quantified with LCModel. Voxels with poor signal-to-noise (SNR) and %SD > 20 (from the Cramer-Rao inequality) were eliminated from the calculations. The 95% confidence-interval was defined as follows:

$$\left[\frac{1.64}{\alpha_{Std_w}^{\;1.96}}, 1.64\,\alpha_{Std_w}^{\;1.96}\right]$$

Where αStd_w is the geometric standard deviation, deduced as the Std_w of the transformed logarithmic data. This approach by Bland&Altman [1] is valid under the assumption that the measurement error is proportional to the magnitude measured (i.e. NAA/Cho).

Finally radiotherapy margins associated to the 95% confidence-interval around a proposed NAA-to-Cho threshold were derived from the variability of the Centre of Mass (COM) position, using the McKenzie's method [3].

Results

Figure 1 shows the NAA/Cho values of all the voxels obtained from the subject's study (2216 measurements). The convention for defining the threshold (=1.64) was chosen to coincide with the minimum ratio value. In Figure 2 the absolute ratio difference for each voxel is plotted against its mean. The data exhibits a relationship between ratio variability (vertical spread) and magnitude [Kendall's τ=0.2385, p<0.0001]. The αStd_w was equal to 1.10 and hence the 95% confidence-interval = [1.36, 1.98]. Figure 3 demonstrates the effects of varying the threshold in patient 1 between the lower and upper limits of 95% confidence-interval. The top and bottom rows were generated with SIRAMAS [2] using a nearest-neighbour and 3D linear interpolation methods respectively. Table 1 shows the calculated radiotherapy margins for each patient and metabolite method.

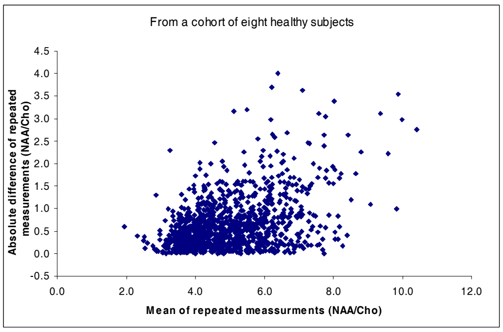

Figure 2

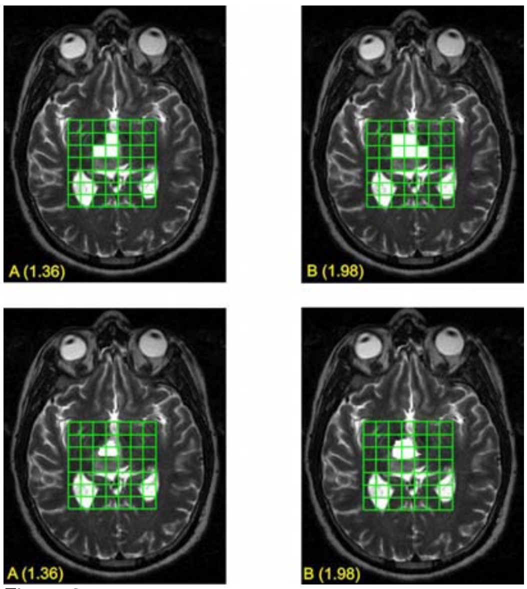

Figure 3

Conclusions

This study proposes a threshold (=1.64) as the means to differentiate between normal and abnormal NAA/Cho data.
The observed dependence of ratio variability with magnitude justified the use of Bland&Altman's method for defining a 95% confidence-interval around the threshold. A radiotherapy margin (table 1) around the metabolic-maps (for threshold=1.64) can know be derived from the COM variability (McKenzie's [3]).

References

1. Bland&Altman, British-Medical-Journal 1996;313:106.
2. SIRAMAS ISMRM-2005 Abstract-2468.
3. McKenzie British-Institute-of-Radiology 2003;11-28.

Margins (mm)	*3DLinear*	*Nearest neighbour*
Patient 1	0.50	2.05
Patient 2	1.43	4.13

Table 1