T1 mapping in childhood abdominal tumours

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Introduction

Magnetic resonance (MR) imaging has the potential to provide information on changes in tumour size and volume in cancer patients undergoing anti-tumoural treatment. However, MR signal intensity images are poor in detecting tumoural response to treatment and tumour volume is an unreliable measure of therapy effectiveness. Furthermore, MR imaging of paediatric abdominal tumours is challenging due to respiratory movements and the smaller size of these patients. A more quantitative approach in the diagnosis and follow-up of these patients would greatly improve patient management. In this work we describe a quantification method for abdominal tumours in free-breathing paediatric patients based on comparing T1 maps acquired before and after the injection of a paramagnetic contrast agent.

Methods

***Imaging protocol*:** Imaging was carried out on a 1.5T Siemens Avanto scanner. To generate the T1 maps we acquired several T1-weighted images using a respiratory-gated inversion-recovery 2D turbo-FLASH pulse-sequence and six different inversion times (128, 250, 500, 1000, 2000, 3000 ms). Respiratory gating was performed using a 2D navigator-echo, and 3 slices positioned through the tumour and adjacent tissues were acquired. The imaging protocol was run both before and after the administration of a low dose of a MRI contrast agent (Magnevist) and post-contrast imaging was done after allowing the agent to fully mix in the body. Pre and post contrast injection T1 maps were calculated from the inversion-recovery T1-weighted images. Several regions of interest were drawn on the T1 maps both in normal and tumoural tissues and mean T1 values were obtained. These were converted into relaxation rate values $R = 1/T_1$. For low doses of gadolinium we can assume that the relationship between relaxation rate (1/T1) and contrast agent concentration is linear and expressed by the formula

$$R_1 = R_0 + [Gd]r$$

where R_1 is relaxation rate of the tissue after contrast injection, R_0 the relaxation rate of the same tissue before contrast, *[Gd]* the gadolinium concentration in that tissue and ***r*** the relaxivity constant. Knowing the pre and post contrast relaxation rates, we were able to generate quantitative maps based on the amount of gadolinium entering the tissue of interest (reflected by the **[Gd]r** factor).

***Patient population*:** Our subjects (6 patients in total) were paediatric oncology patients undergoing routine MRI clinical scans for diagnosis or follow-up purposes.

Results

Figure 1 shows results obtained from an MRI scan of a 3 year-old patient. The first two images are IR signal intensity images (TI = 250ms) pre (A) and post (B) contrast injection of a slice through the liver. Normal liver tissue as well as multiple nodular tumours can be easily seen. The second set of images are T1 maps pre (C) and post (D) contrast injection of the same slice calculated from the IR images. As expected, a significant drop in T1 values was observed both in normal and tumoural tissues following contrast injection. For this patient T1 values for normal hepatic tissue dropped from 450 ms to 353 ms after contrast injection (corresponding to an increase in relaxation rates from $2.2s^{-1}$ to $2.83\ s^{-1}$), while the reduction in T1 for tumoural tissue was greater – from 1065 ms to 543 ms (corresponding to an increase in relaxation rates from $0.94s^{-1}$ to $1.84s^{-1}$). The difference in the increase of R_1 values between normal tissues and tumour was present in all our patients. The ratio image (E) in figure 1 is derived from the pre and post contrast T1 maps and reflects the relative ralaxation rate in a tissue of interest due to the presence of gadolinium in that tissue (**[Gd]r/R_0**). As R_0 is readily available from the pre-injection T1 maps we can determine the **[Gd]r** product which gives us direct information on the amount of gadolinium present in the region of interest.

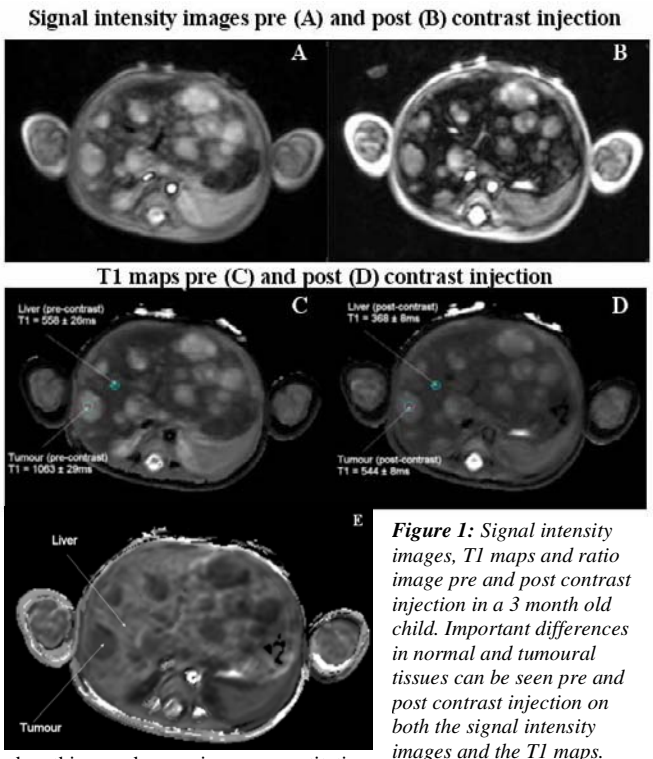

Figure 1: *Signal intensity images, T1 maps and ratio image pre and post contrast injection in a 3 month old child. Important differences in normal and tumoural tissues can be seen pre and post contrast injection on both the signal intensity images and the T1 maps.*

Conclusion

We have shown that T1 mapping in childhood abdominal tumours is feasible in free breathing and can give us quantitative information on the amount of gadolinium present in a region of interest. An important strategy in treating oncological patients is to reduce or block blood being delivered to tumors, thus inducing necrosis and cellular death. As the amount of gadolinium present in a tumour is associated with the perfusion level, a drop in tumoural perfusion will result in reduced levels of gadolinium in the tumoural tissue. Thus, this method might provide us with a useful clinical tool for oncological treatment monitoring and tumoural response to radio/chemotherapy.

References

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