Real Time Quantitative Temperature Imaging Allows Accurate Prediction of the Size of Radiofrequency Ablation in Rabbit Liver

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Purpose/Introduction

At present, Radiofrequency (RF) ablation is performed without real time assessment of the lesion size despite the fact that heat conduction is known to influence the size and shape of the treated zone. MR temperature mapping may offer a prediction of the efficiency of liver tumour treatment based on continuous thermal dose assessment. However, quantitative temperature mapping in the liver during simultaneous high power RF deposition is challenging. The study demonstrates the technical feasibility and the accurate prediction of lesion size in rabbit.

Subjects and Methods

New Zealand rabbits (n=7, 3kg) were anaesthetised and positioned inside the magnet for real-time temperature imaging.120 dynamics of segmented gradient-echo EPI [1] images (3slices of 5mm, TE/TR=16/43 ms, spatial-resolution=1.5 x 1.4 mm, time-resolution=9 s) were acquired during 20 minutes on a 1.5T Intera Philips scanner to monitor phase changes related to temperature evolution (Proton Resonance Frequency technique). RF energy was applied simultaneously during 10 minutes using a 2.5 cm long bipolar coaxial needle [2], connected to 80kHz home-made RF generator and a 63.5 MHz LC notch filter [3] to suppress artefacts. Standard clinical T1w-TSE (TE/TR = 7/525 ms) and T2w-TSE (TE/TR = 80/1200 ms) images were acquired immediately after the ablation procedure and 4 and 8 days post-ablation. Rabbits were sacrificed and liver was taken out for histology.

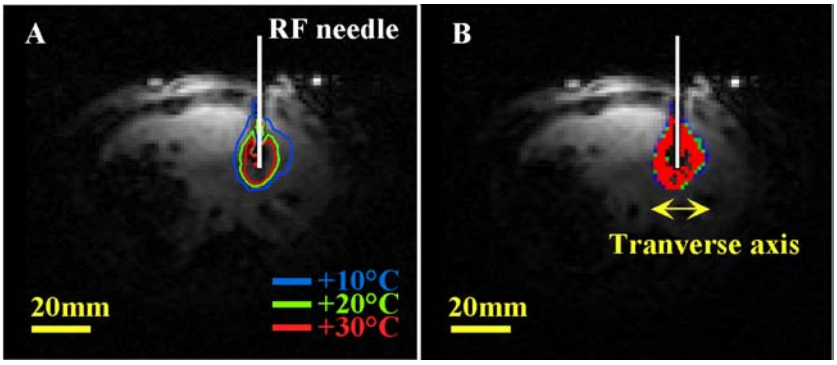

Figure1: Magnitude images of rabbit liver (gray scale) on which temperature (A) and lethal dose map (B) are superimposed, obtained during RF ablation.
A: Blue, Green and Red colours correspond to temperature increase of +10 °C, +20°C and +30 °C, respectively
B: White bar indicates RF needle position. Red pixels indicate twice lethal dose**.**

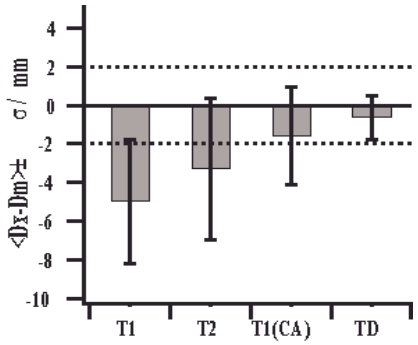

Figure2: Average lesion size and standard deviation expressed as difference between that measured along small axis on T1, T2, T1 with contrast agent (T1CA) weighted images and thermal dose (TD) map compared with histologically determined size (gold standard).

Results

High quality temperature maps were acquired from each animal. Only minor remaining artifacts could be observed due to residual respiratory motion. Typical temperature precision was better than 3°C in the region of interest. Figure1A shows a transverse magnitude image obtained during the RF procedure. Figure1B presents the thermal dose map calculated in real time from the temperature evolution in each pixel according to previously established relations [4]. The resulting ovoid shape of lesions corresponded with standard clinical T1w-TSE and T2w-TSE imaging and histological findings. However, clear differences appeared between absolute dimensions of RF lesion measured with the different imaging modalities. Figure2 shows the combined results for all animals, showing underestimation of T1w, T2w and, albeit to a lesser extent, T1w with contrast agent (T1CA). The thermal dose maps allow accurate prediction of the final lesion. The T1, T2 and T1CA maps show a more pronounced underestimation at day 0 and day 8 (the underestimation is an average obtained at day 0, day 4, and day 8). Note that TD maps are obtained in real time.

Discussion/Conclusion

High quality, real-time, thermal dose maps can be obtained during RF ablation of rabbit liver allowing accurate prediction of final lesion size. This study shows promise towards clinical end-point determination of RF ablation based on real time quantitative temperature MRI.

References

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