MR-guided RF liver ablation: continuous RF application or intermittent RF-MRI switching?

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Introduction

Radiofrequency (RF) liver ablation is widely used for tumor treatment as an alternative to surgical resection. Due to optimal tissue contrast, lesion visibility, and possibility of temperature mapping control during the procedure, MRI has been gaining interest as guidance and monitoring tool for RF thermotherapy. The RF-MRI incompatibility can be avoided by RF filtering [1] or alternating switching between RF emission and MR imaging [2]. The aim of this study is to compare the heating efficiency of the two methods in ex-vivo liver sample.

Methods

MR imaging and RF ablation were performed on a 1.5T Intera MR system (Philips Medical Systems, Best, NL). Imaging parameters were: 2D FFE sequence, surface coil (12 cm diameter), water selective excitation, EPI factor 5, TR/TE 260/15 ms, 3 x 5 mm slices, 85x96 acquisition matrix, 16 cm FOV. Temperature maps were calculated by proton resonance frequency (PRF) from the phase images with Thermoguide software (IGT SA, Pessac, F) on a separate workstation. RF lesions were induced in an ex-vivo liver sample with a CelonLab Power (Celon AG, Berlin, D) RF generator placed outside the MR room, and a bipolar CelonProSurge electrode. The RF filter was designed by Image Guided Therapy SA to remove RF perturbations induced by the generator, as previously reported [1]. Power output of 20W was applied, with internal electrode cooling, a) continuously until the impedance cut-off, and b) by alternately switching on and off every 5 seconds until the impedance cut-off. Five lesions were induced with each mode. Lesion diameter perpendicular to the electrode axis was measured from the thermal dose prediction [3].

Results

Figure 1 shows time temperature profile in a pixel 9 mm away from the electrode. For the same power output, maximum temperature is reached after one minute, and 1.2 kJ energy is delivered. It took 2:25 minutes to deliver the same energy with the switching RF application, resulting in a smaller lesion. Maximum temperature was reached with the switching power application only after 6 minutes delivering a total energy of 3.17 kJ. Average lesions sizes are shown in figure 2. For the same amount of energy delivered, lesion sizes were 29% (±13%) larger with continuous RF application (p = 0.0026). At the end of the switching RF application, however, lesions induced were 31% (±23%) larger than in the continuous case (p=0.028).

Discussion/Conclusion

Although performed without real physiological conditions, this ex-vivo study indicates that for the same amount of delivered energy, the continuous RF application mode generates larger lesions. Since the impedance cut-off is delayed by the switching RF application, it allows to deliver more energy, resulting in a larger final lesion, but substantially prolongs RF application duration. However, an impedance-control mode RF ablation can avoid premature impedance cut-off in case of continuous heating. Therefore, RF-filtering allows better time efficiency and more flexibility in RF application procedure than intermittent switching between RF ablation and MR imaging.

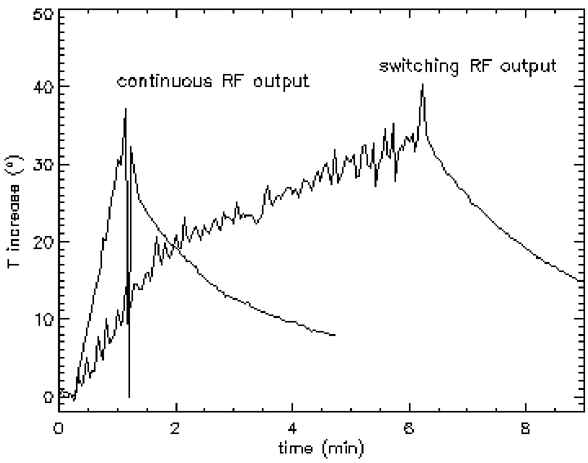

Figure 1. Time-temperature profile in a pixel 9 mm away from the electrode, for the continuous and intermittent RF application.

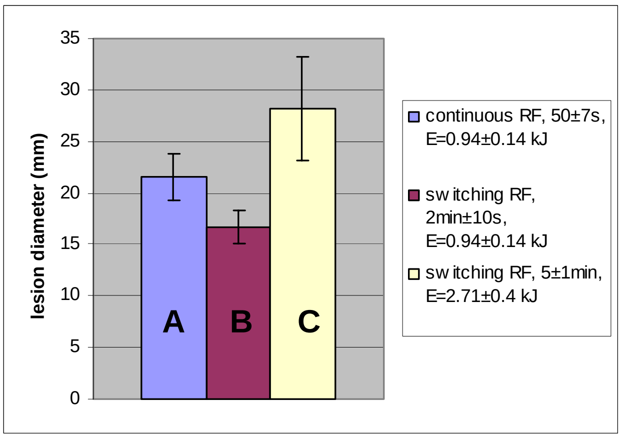

Figure 2. Average lesion size for: a) continuous heating, b) switching heating for the same energy delivered as in the continuous (a) procedure, and c) at the end of the switching heating.

References: [1]Lepetit-coiffé M. ESMRMB 2002 Proceedings, 251. [2] Zhang Q. JMRI, 8: 110 (1998). [3] Sapareto S.A. Int. J. Radiat. Oncol. Biol. Phys. 10: 787-800 (1984).