In vivo Renal Thermoablation under MR control : Feasibility study in Rabbits

A-S. Delemazure[1], R. Salomir[1], C. Deminière[2], J. Palussière[1], C. Moonen[1], N. Grenier[1]

[1]ERT-CNRS-Laboratoire d'Imagerie Moléculaire et Fonctionnelle, University Victor Segalen-Bordeaux 2, Bordeaux, France, [2]Pathology, Groupe Hospitalier Pellegrin, Bordeaux, France

Introduction

Among the developments of mini-invasive techniques of thermoablation, only radiofrequency and laser have been proposed in humans for ablation of renal tumors with MRI. In vivo focused US (FUS) have received only little attention to now (1) because of some challenging aspects of this organ which is deeply located within the abdomen, mobile during respiration and highly perfused. The purpose of this study was to evaluate the feasibility of heating in vivo, under the MR control of measured temperature and calculated thermal dose, the cortex and medulla of normal rabbit kidneys and ablating VX2 tumors implanted within the cortex.

Materials and methods

After general anesthesia, New-Zealand white rabbits were installed in a plastic tube to decrease respiratory movements, with a window in front of the left flank allowing the US-beam to reach the kidney. A spherical 1.5 MHz monoelement transducer, with a fixed focus distance (8 cm), a 0.7x0.7x3.2 mm focus size and a 200W maximum electric power, was inserted into the MR table and used in all experiments. XY directions were mecanically adjusted, and the heigth of the animal could be adjusted to position the focal zone at the depth of interest.

PRF-based method was used for temperature control with respiratory-gated and fat-suppressed GE-EPI sequences. A constant power protocol (50W, 90sec), with cortical and medullary heatings, was compared to a protocol automatically adjusting the power of the transducer, according to the target temperature based on PID method, through a home-made interface (2).

Two VX2 tumors were implanted in upper and lower pole of 4 rabbits. One tumor only was treated in each rabbit, the second used as a control, when tumor size reached 5-10 mm. All were heated with the automatical MR-controled protocol, with 3 to 7 spots, according to the size of each lesion, and 20° to 28° as target temperature. Kidneys were removed 48 hours after treatment for pathological examination.

Results

Precision of temperature measurements was 0.5° to 1° in both cortex and medulla. A good stability of the temperature was obtained during automatic protocols, as shown in fig. 1a, during periods as long as 10 min. In normal kidneys, thermal lesions could be obtained in both the medulla and the cortex and their size was well correlated to area of lethal thermal dose (fig1) and to pathological size. In cases of medullary thermal necrosis, cortical ischemic lesions were also noted on pathology, probably related to interrupted arterial blood flow.

Tumors treated with the 28° target temperature were completely necrosed on pathological examination. The size of necrotic area correlated with the size of the predicted area of lethal thermal dose (fig 2).

Conclusions

Whereas the kidney is a deep and highly perfused organ (mostly the cortex), thermal lesions can be obtained in vivo with automatic MR control. Precision and stability of temperature measurements are satisfactory. The size of the treated area is well predicted by follow-up of the growing area of lethal thermal dose. Complete necrosis of implanted tumors in the cortex can also be obtained.

References

1-Damianou C, Pavlou M, Velev O, Kyriakou K, Trimikliniotis. Ultrasound Med Biol. 2004;30:397-404

2-Mougenot C, Salomir R, Palussiere J, Grenier N, Moonen CT. Magn Reson Med. 2004 Nov;52(5):1005-15

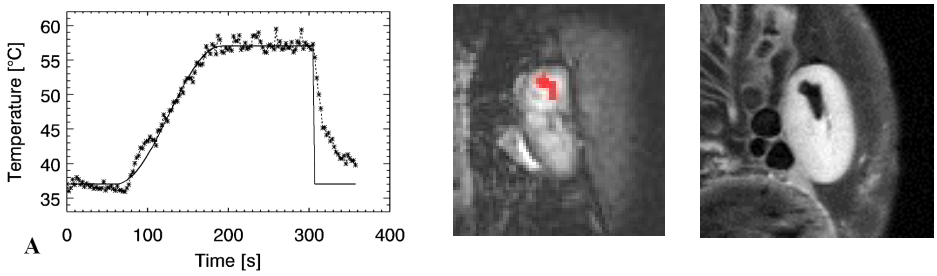

Figure 1: Automatically MR-controlled heating of a normal kidney: note the good stability of the temperature during all the procedure and the good correspondance between the size of the area with a lethal thermal dose (in red) and the necrosed area on Gd-enhanced image

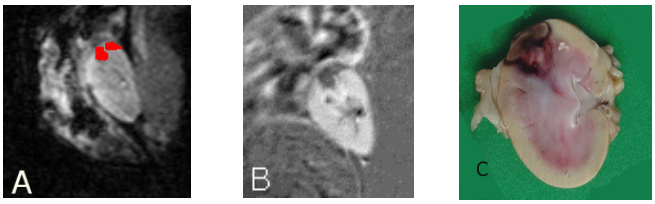

Figure 2: Treatment of an implanted tumor: the size of the area with a lethal thermal dose (in red) and the necrosed area on Gd-enhanced image are well correlated with macroscopic image. No viable tumor cell was found on pathological examination.