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Temperature measurements of pacemaker leads in a 1.0T high field open MRI using various MR sequences: initial results

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Introduction

Magnetic resonance imaging (MRI) is a valuable diagnostic method for many cardiovascular diseases. To date, patients with pacemakers are contra-indicated for cardiac MRI exams due to several effects that can occur during the MRI procedure: a) heating of the lead-tip, and b) less hazardous sensing errors and device malfunctions. Almost all measurements on MRI pacemaker compatibility have been conducted on classic 1.5 or 3T cylindrical whole-body MRI systems. In contrast, this study focused on the use of a high field open MRI (HFO) system due to its advantageous properties of RF fields which are commonly made responsible for the induction of lead heating.

Purpose

Determine the feasibility of MRI examinations of patients with cardiac pacemakers using an open 1.0 T MRT system and realistic cardiac imaging sequences.

Methods

Two high energy (1.+2.) and two realistic clinical cardiac (3.+4.) MR-sequences with artificial ECG-triggering at 60/min were used on the 1.0T HFO system: 1. T2-TSE (TR/TE=177/38ms;TSE-factor=16; time=58s;flip-angle=90°); 2. 3-D bTFE (TR/TE=4.7/2.4ms;TFE-factor=6; time=382s;flip-angle=70°;TFE-shot-duration=34ms;TFE-shots=532), 3. SSFP-cine (TR/TE=4.7/2.2ms;TFE-factor=16; time=90s;flip-angle=70°;TFE-shot-duration=76ms; TFE-shots=76), 4. 3D-FFE multi-shot (inversion-recovery; TR/TE=3.9/1.3ms;TFE-factor=21;time=23s;flip-angle=15°; TFE-shot-duration=157ms;TFE shots=46). Two types of bipolar cardiac pacing leads were evaluated: a) conventional lead (Medtronic Capsurefix Novus), 2. MR compatible lead (Medtronic Capsurefix MRI SureScan) both connected to a St. Jude Frontier II pacemaker. The pacemaker/lead system was placed in a saline-filled Plexiglas phantom imitating three clinically common lead positions

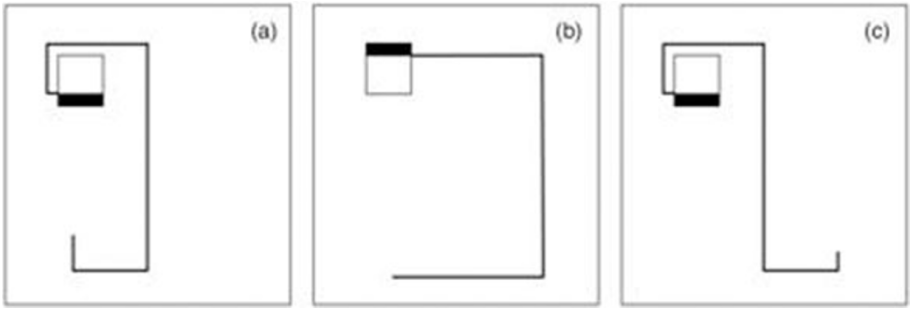

Figure 1 Pacemaker/lead configurations imitating common implantation patterns.

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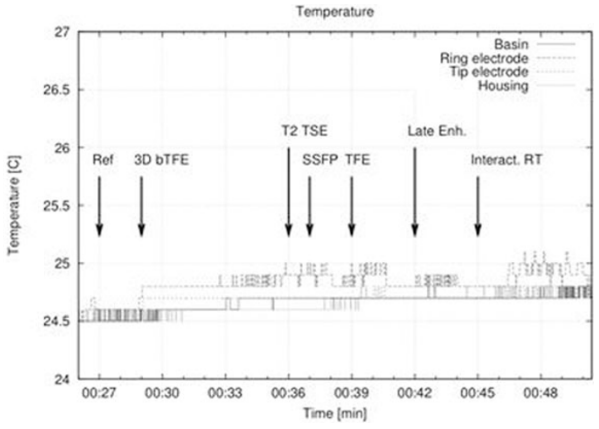

Figure 2 Development of temperature at four different positions (Tip electrode, ring electrode, pacemaker housing, basin/phantom) while exposed to a series for MRI sequences, pacemaker/lead configuration as shown in Fig. 1(a)

(figure 1). Temperature measurements were captured with a fiber-optic measurement system.

Results

The highest temperature increase (0.6 °C) was observed in the (a) configuration when exposed to the realtime interactive sequence (see fig. 2). In none of the utilized scan protocols severe heating could be measured.

Conclusions

In-vitro measurement of an MR compatible and a regular pacemaker lead in geometrically realistic positions in an HFO open MRI system showed no relevant tip heating for both ECG-gated high energy as well as clinically used cardiac MR sequences. Further in-vivo research has to be conducted to clarify the relevance of these findings.

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