Fluoroptic Measurements of MRI-related Heating at Cardiac Pacemaker Leads in Vivo: Initial Results

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Introduction: In vitro investigations have shown that there is a high potential for RF-related heating to appear at the tip of cardiac pacemaker leads during MRI. On the other hand, recent clinical studies found only inconsistent evidence for adverse events due to pacemaker lead heating in MRI. Therefore, some authors have suggested that the actual patient risk might be relatively small, while others confirmed serious concerns regarding MRI in pacemaker patients. Until then, there is a lack of sufficient systematic *in vivo* investigations which would support either of these suggestions. Therefore, this study aimed at developing a measurement setup for reproducible and precise investigations on the temperature evolution at the tip of cardiac pacemaker leads *in vivo*.

Methods: An MRI-compatible temperature measurement system with modified fluoroptic probes was used to prevent interferences of the measurement system with the electromagnetic fields inherent in MRI technology. The probe was incorporated inside a slightly modified commercially available passive pacemaker lead, allowing for precise measurements of the temperature evolution at the lead tip. After in vitro confirmation of the device functioning, the lead was implanted through the left jugulary vein in the right atrium of a mini pig (55 kg) and connected with a commercially available pacemaker. Temperature recordings were then performed in various scenarios while imaging the pig in a 1.5 T MR scanner.

Results: The measurement system revealed to be able to precisely measure the temperature evolution at the lead tip in MRI both *in vitro* and *in vivo*. First investigations in a scenario with a passive pacemaker lead implanted from the left jugulary vein in the right atrium of a pig revealed remarkable heating at the lead tip during MRI, with an increase of 14.3 +/- 0.8 K after 30 seconds at an SAR of 2.1 W/kg, thus being in the same range as found in a comparable setup *in vitro*. Adding a second, ventricular lead only slightly affected the amount of heating, while connecting a pacemaker to the lead in this scenario greatly decreased heating. After euthanizing the pig, heating only slightly increased further than in the living pig (<15%), suggesting that blood flow at least under certain conditions might play a minor role to prevent heating at the tip of cardiac pacemaker leads.

Conclusion: In this study, a new technology for *in vivo* measurements of unintended heating at a pacemaker lead tip in MRI was developed. The preliminary investigations in pigs prove that lead tip heating *in vivo* can be in the same range as shown for *in vitro* conditions before. Ongoing investigations now focus on the various aspects affecting implant heating *in vivo* to further specify the risk of relevant heating and, thus, adverse events for patients with cardiac pacemakers to undergo MRI.