The Effect of Lead Length on Lead Tip Heating in Orphan Leads verses Leads Connected to Pacemakers at 1.5T

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Introduction: Current safety guidelines label implanted pacemakers as a contraindication for MRI scanning due in part to risks of tissue damage from pacemaker lead tip heating. The heating at the lead tip has been extensively investigated with a pacemaker connected to the leads (1,2) but there are many situations where orphan leads remain in a patient due to the risks associated with lead removal (3). The goal of this research is to outline the difference in lead tip heating between orphan leads and leads connected to pacemakers while specifically exploring the effect of lead length in both connection situations.

Experimental Set-up: Measurements were taken in a torso/head phantom (torso: 24in x 17in, head: 6.5in x 11.5in) filled with 0.45% saline solution to a height of 12cm. An Identity DR+ St. Jude Medical pacemaker and 1688T St. Jude Medical leads were used. The temperature was recorded with Luxtron fiber optic probes positioned in the helix of the lead. All measurements were taken on a 1.5T Avanto Siemens scanner. A Steady State Free Procession sequence with SAR = 0.6 W/kg was used to induce current in the pacing lead. Leads of lengths 50, 40, 30, and 20cm were positioned parallel to the long axis of the bore 5cm from the right edge of the phantom at a depth of 5.5cm from the top of the gel. The lead tip heating at each length was measured with the lead connected to the pacemaker, with a plastic cap on the lead tip, and with the lead tip un-capped and exposed to the saline solution. The lead tip heating of the straight lead configurations were compared to a clinical scenario modeling an implanted atrial lead, see Figure 1. The clinical scenario was tested with a pacemaker connected and as an orphan lead with and without the plastic cap.

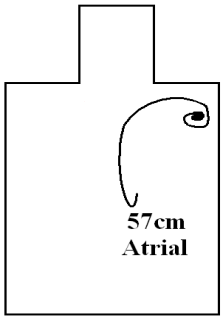
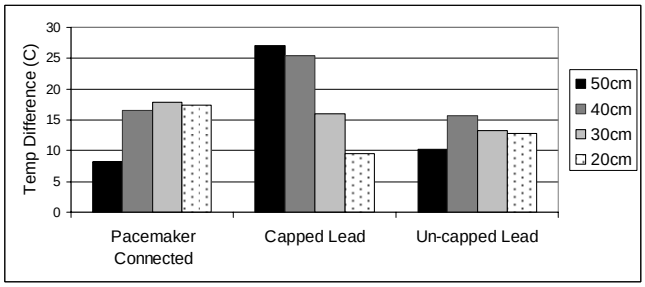


Figure.1 The clinical scenario is a 57cm lead configured in a left side chest implant with the lead tip in the right atrium.

Results: The lead tip heating of each lead length in the straight configuration is given in Figure 2a and the heating in the clinical scenario is shown in Figure 2b. The 50cm lead results in the smallest amount heating with the pacemaker attached, however the 50cm lead results in the greatest heating when the lead is capped. The lead tip heating measurements for the 57cm atrial lead show similar results with greatest heating occurring when the lead is capped.

a)



b)

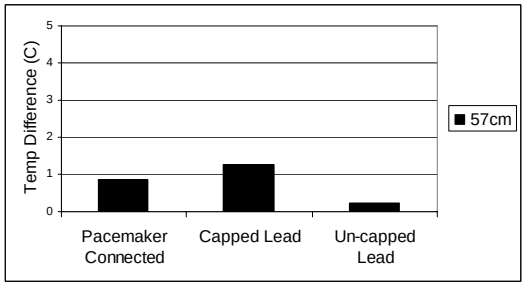


Figure.2 The temperature increase at the tip of the pacing lead was measured for lead lengths 50, 40, 30, and 20cm leads along the side of the phantom (a), the temperature increase at the tip of the lead was measured in the clinical 57cm atrial lead (b).

Discussion: For each of the lead lengths, heating at the tip was similar whether the connector end was connected to a pacemaker or exposed to the saline solution. This is expected since at 64MHz, the pacemaker effectively connects the lead to the saline solution which operates as a ground for the current. Insulating the connector end with a plastic cap alters standing waves of voltage and current on the lead, and therefore changes the relationship between lead tip heating and lead length. The heating of a 50cm straight lead nearly triples from 7.6°C to 21.0°C when the pacemaker is connected verses capped. For the 40cm straight lead the heating increase from 16.6°C to 25.3°C when the pacemaker is connected verses capped. This same relationship is mirrored in the clinical scenario with the 57cm atrial lead; the greatest heating is also seen with the capped orphan lead. For shorter lead lengths the resonance effect diminishes lead tip heating when the lead is capped, however heating increases when the pacemaker is connected.

Conclusion: For 40-57cm leads the greatest heating will be observed in orphan leads with plastic caps, as seen in the case of the straight 40cm and 50cm lead and the clinically configured 57cm lead. For shorter lead lengths, the configuration of capped orphan lead results in less heating because of changes in the standing wave in the lead which is length dependent. It is therefore important to consider the length of the lead implanted when comparing the lead tip heating effects of orphan leads to leads connected to pacemakers. For lead lengths between 40cm and 57cm, our results indicate that capped pacing leads present a higher risk for lead tip heating than leads attached to the pacemaker.

References

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