RF Impedance of MR-Conditional Pacemaker Leads when Connected to Implantable Pulse Generators from Different MR-Conditional Systems

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IMPULSE DYNAMICS MTL

RF-induced heating of an active implantable medical device (AIMD) composed of a pulse generator (IPG) and leads depends on the transmission line impedance of the lead and its proximal-end termination by the impedance of the IPG. In this study we demonstrate that at 63.87 MHz the RF impedance of IPGs is minimal relative to that of the leads, which dominates the overall impedance of the implantable system. Accordingly, mixed hybrid systems composed of MR Conditional leads and any MR Conditional IPG are expected to have a comparable overall impedance and consequently produce the same RF-induced heating as their corresponding original systems specified by the manufacturers.

METHODS: The RF input impedance at the 1.5T MRI frequency of 63.87 MHz of several MR-conditional cardiac leads and IPGs were measured and compared to evaluate their relative contribution to the overall RF impedance of potential hybrid systems that can be formed from mixed combination these leads and IPGs. Lead impedance was measured to incorporate the effect of the implantable device's enclosure in gel slurry was used since it represents the worst-case condition. The RF-induced heating safety of the hybrid systems was assessed by comparing their RF impedances to that of corresponding original systems specified by the manufacturers.

RESULTS: The lead is overwhelmingly responsible for limiting 63.87 MHz RF currents from flowing through the Tip electrode in an implanted system. The IPG's contribution to the limitation of RF currents is relatively small (range of 1.03 to 8.04%, mean 2.72%).

The following table presents the worst-case IPG contributions to the total lead/IPG impedance to 63.87 MHz RF currents at the lead's tip electrode with different IPG/lead combinations. Whenever two IPGs were evaluated for the same leads, the lowest IPG input impedance was used to be representative of the worst-case condition. Items marked in red correspond to the combination labeled as MR-conditional.

	IPGs →	Biotronik Iperia	Boston Sci Dynagen	Medtronic Visia	Abbott Assurity
LEADS	|Z|	1.37 Ω	1.75 Ω	1.45 Ω	3.62 Ω
Biotronik Solia S 53cm	103.77 Ω	1.30 %	1.66 %	1.38 %	3.37 %
Biotronik Solia S 60cm	57.19 Ω	2.34 %	2.97 %	2.47 %	5.95 %
Boston Scientific Ingevity+ 7841 52cm	120.24 Ω	1.13 %	1.43 %	1.19 %	2.92 %
Boston Scientific Ingevity+ 7842 59cm	91.63 Ω	1.47 %	1.87 %	1.56 %	3.80 %
Medtronic CapsureFix 5076 52cm	139.09 Ω	0.98 %	1.24 %	1.03 %	2.54 %
Medtronic CapsureFix 5076 58cm	97.29 Ω	1.39 %	1.77 %	1.47 %	3.59 %
Abbott (St Jude Medical) Tendril 2088 52cm	103.21 Ω	1.31 %	1.67 %	1.39 %	3.39 %
Abbott (St Jude Medical) Tendril 2088 58cm	81.66 Ω	1.65 %	2.10 %	1.74 %	4.24 %

The minimum contribution (0.98%) to total impedance happens when the Medtronic CapsureFix 5076 52 cm lead is connected to the Biotronik Iperia IPG. However, the contribution of the Medtronic Visia IPG with the same lead in a configuration labeled as MR-conditional is 1.03%, which is a difference of barely -4.85%. This is probably negligible when compared to possible changes in lead impedance as a function of water content, medium conductivity, aging, etc.

CONCLUSIONS: For all the IPGs and leads studied, the IPG input impedance is relatively negligible compared to the lead's impedance and hence can be considered as a short circuit at the 1.5 T MRI frequency of 63.87 MHz. Because the input impedances of the IPGs are all relatively low, a system composed of any of the studied IPGs and any of the transvenous leads approved as MR-Conditional will have very similar RF impedance to a system composed of an MR-Conditional labeled IPG and the same lead, and therefore both systems are expected to exhibit similar RF-induced electrode heating behavior.