SUBMISSION PREVIEW

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Cardiac MRI Exams with Very Low SAR (0.1 W/kg) for Patients with Active Implantable Medical Devices

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Topic
Miscellaneous - Scientific Sessions
  • Basic Science
Background

MRI-Conditional active implantable medical devices (AIMDs), such as pacemakers or deep brain stimulators (DBS), are approved for MRI exams by the FDA, but include SAR limits as low as 0.1W/kg\(^1\). For typical cardiac MRI exams, the conventional limit is SAR≤2W/kg. Therefore, modified MRI sequences must be implemented to meet the device’s SAR limit. Previous work proposed a workflow to modify non-cardiac MRI exams to meet a specific SAR target while minimizing the impact on image quality\(^2\). The objective of this project was to use the same workflow to modify a cardiac protocol to achieve a target SAR≤0.1W/kg. The resulting images were then assessed against those acquired with conventional sequences.

Methods

Cardiac MRI exams were performed at 1.5T(Avanto,Siemens) in healthy subjects under an IRB approved protocol(N=10,7 females,3 males,81±45kg,66±7bpm). A standard cardiac MRI protocol(SAR\(_{ST}\)), consisted of localizers, cor/sag/ax anatomical, cine, late gadolinium enhancement(LGE), and flow imaging. SAR\(_{ST}\) was modified to achieve a SAR≤0.1W/kg(SAR\(_{0.1}\))\(^2\). The RF pulse mode, number of slices and flip angle were modified in a systematic manner following a previously derived workflow. If SAR\(_{0.1}\) could not be achieved, then the sequence base was changed from bSSFP to GRE. Protocol modifications are shown in Table1. The scanner reported SAR was recorded during each exam. Images were scored by an expert radiologist on a 5-point Likert scale blinded to the imaging protocol. The scale accounted for both (i) clinical acceptability and (ii) image quality index using 1(extremely poor), 2(poor), 3(borderline good), 4(good) and 5(excellent). In addition, ten repeated image acquisitions were acquired in a T1/T2 phantom (Model 130,QalibreMD) to calculate voxel-wise SNR maps. CNR analysis was performed by comparing a single slice with ROIs in regions where T1 values were similar to myocardium(950±23ms) and late enhanced scar(406±94ms)\(^3\).

Results

Results are reported for cor. anatomical(cor anat), cine, flow imaging and LGE. Table2 shows the SAR and the 5-point Likert score recorded for both protocols. On average the SAR for SAR\(_{ST}\) was significantly higher than SAR\(_{0.1}\)(0.88±0.68W/kg vs 0.05±0.03W/kg,p-value<0.05). Image quality was higher, but not significantly for SAR\(_{ST}\) compared to SAR\(_{0.1}\)(3.9±0.8 vs 3.1±0.7,p>0.05). Example images are shown in Fig1A; SNR maps and CNR values are shown in Fig1B. The SNR value for the phantom region corresponding to myocardium was 53±59 for SAR\(_{ST}\) and 34±24 for SAR\(_{0.1}\). CNR values were maintained(SAR\(_{ST}\):25±32,SAR\(_{0.1}\):27±32,p>0.05).

Conclusion

This work provides feedback for both clinicians and device manufacturers on how to achieve a cardiac MRI protocol for patients with AIMDs. A protocol with SAR≤0.1W/kg was achievable with limited impact on image quality, thus it can be used for clinical evaluation.

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Uploaded File(s)

Images
Fig. 1
Table(s)

Table 1.

<table>
<thead>
<tr>
<th>Sequence Base</th>
<th>RF Pulse Mode</th>
<th>Repetition Time (ms)</th>
<th>Flip Angle (°)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>SAR_{ST}</td>
<td>SAR_{0.1}</td>
</tr>
<tr>
<td>Cor. Anat.</td>
<td>b-SSFP</td>
<td>GRE</td>
<td>Normal</td>
</tr>
<tr>
<td>Cine</td>
<td>b-SSFP</td>
<td>GRE</td>
<td>Normal</td>
</tr>
<tr>
<td>Flow</td>
<td>GRE</td>
<td>GRE</td>
<td>Normal</td>
</tr>
<tr>
<td>LGE*</td>
<td>b-SSFP</td>
<td>b-SSFP</td>
<td>GRE</td>
</tr>
</tbody>
</table>

Parameters modified for each sequence. * Refers to sequences that could be modified to reach 0.1 W/kg for both b-SSFP and GRE.

Table 2.

<table>
<thead>
<tr>
<th>Whole Body SAR (W/kg)</th>
<th>Likert Score (AU)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>SAR_{ST}</td>
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<tr>
<td>Cor. Anat.</td>
<td>1.29±0.19</td>
</tr>
<tr>
<td>Cine</td>
<td>1.66±0.18</td>
</tr>
<tr>
<td>Flow</td>
<td>0.23±0.03</td>
</tr>
<tr>
<td>LGE</td>
<td>0.29±0.04</td>
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</tbody>
</table>
Median Whole-Body SAR and Likert scale for four of the main cardiac sequences. Gray indicates that the modified sequence did not reach the SAR limit, thus no data was acquired.

References


Keywords

Keyword One:
Safety

Keyword Two:
Cardiac Implantable Electronic Devices

Keyword Three:
Guidelines