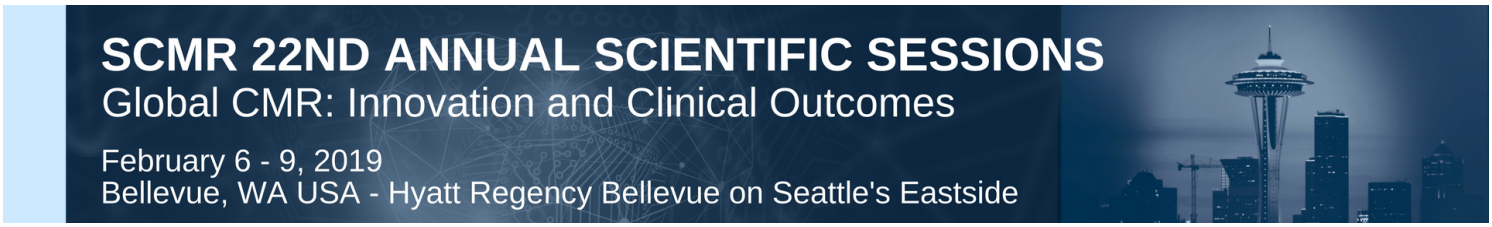

SUBMISSION PREVIEW

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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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Submission Status: Complete

Participant(s)

Jessica A. Martinez, MSc
Graduate Student Researcher
Radiological Sciences
University of California, Los Angeles

Role: Presenter
Age Range
Profession

Kevin Moulin, PhD
Post-doctoral Fellow
Department of Radiological Sciences, Stanford University, Stanford, CA
Stanford University

Role: Author Only
Age Range
Profession

Ashley E. Prosper, MD
MD
Department of Radiological Sciences
University of California, Los Angeles

Role: Author Only
Age Range
Radiologist
Profession
Radiologist

Daniel B. Ennis, PhD
Associate Professor
Department of Radiology, Stanford University, Stanford, CA
Stanford University

Role: Author Only
Age Range
Engineer
Profession
Engineer

Topic

Miscellaneous - Scientific Sessions

- Basic Science

Format Type

- Scientific Sessions Only

Presentation Type

- Oral or Poster

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

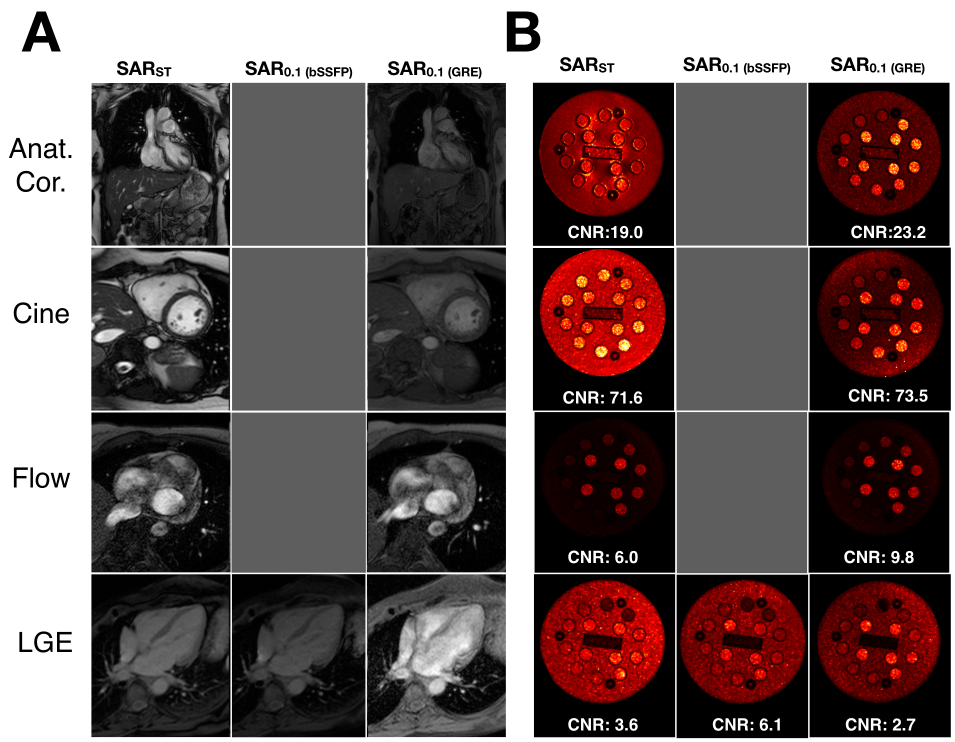
This work provides feedback for both clinicians and device manufacturers on how to achieve a cardiac MRI protocol for patients with AIMDs. A protocol with SAR≤0.1W/kg was achievable with limited impact on image quality, thus it can be used for clinical evaluation.

Funding from NIH NHLBI R21 HL127433,Abbott

Uploaded File(s)

Images

Fig. 1



Example images **(A)** and SNR and CNR results **(B)** for four of the main cardiac sequences. Gray indicates that the modified sequence did not reach the SAR limit, thus no images were acquired.

Table(s)

Table 1.

	Sequence Base			RF Pulse Mode			Repetition Time (ms)		Flip Angle (°)		
	SAR_{ST}	$SAR_{0.1}$		SAR_{ST}	$SAR_{0.1}$		SAR_{ST}	$SAR_{0.1}$	SAR_{ST}	$SAR_{0.1}$	
Cor. Anat.	b-SSFP	GRE		Normal	Normal		681	1435	70	15	
Cine	b-SSFP	GRE		Normal	Normal		39	55	77		
Flow	GRE	GRE		Normal	Low SAR		41	42	30		
LGE*	b-SSFP	b-SSFP	GRE	Normal	Low SAR	Normal	700		65	45	15

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.

	Whole Body SAR (W/kg)			Likert Score (AU)		
	SAR_{ST}	$SAR_{0.1}$ *(b-SSFP)*	$SAR_{0.1}$ *(GRE)*	SAR_{ST}	$SAR_{0.1}$ *(b-SSFP)*	$SAR_{0.1}$ *(GRE)*
Cor. Anat.	1.29±0.19		0.02±0.01	4.00±0.50		3.00±0.48
Cine	1.66±0.18		0.02±0.00	4.00±0.71		3.00±0.57
Flow	0.23±0.03		0.08±0.01	4.00±0.48		4.00±0.70
LGE	0.29±0.04	0.10±0.04	0.06±0.01	3.00±0.47	2.00±0.52	3.00±0.67

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

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Keywords

Keyword One:
Safety

Keyword Two:
Cardiac Implantable Electronic Devices

Keyword Three:
Guidelines