Magnetic Resonance Imaging-guided Focused Ultrasound Ablation Procedure of Facet Joint of Patient with MRI Non-conditional Pacemaker

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Introduction

Magnetic Resonance Imaging-guided Focused Ultrasound (MRgFUS) is a minimally-invasive thermal treatment modality that utilizes a phased-array ultrasound transducer embedded inside the MRgFUS patient table integrated with the MRI scanner. During MRgFUS treatment, ultrasound energy is selectively focused within target tissues causing localized thermal ablation.

Methods

Clinical Presentation

- 80 year old male with history of chronic axial lower back pain.
- The patient's past medical history was significant for coronary artery disease, hypertension, and symptomatic sinus bradycardia (50 bpm and 2:1 block), which led to placement of a dual chamber transvenous pacemaker system in 2015 (Assurity DR 2240 pulse generator, Model 1642T right atrial lead, Model 1646t right ventricular lead, all MRI non-conditional, St Jude Medical, Memphis, TN). The patient was not pacemaker-dependent.
- Prior to the MRgFUS treatment, a risk-benefit analysis was carried out given the MRI non-conditional CIED system, and the decision was made to proceed with treatment. The risk-benefit analysis was performed in accordance with our established CIED/MRI practice procedure, which has been used to safely scan over 3000 patients for diagnostic indications. This practice involves a coordinated team of radiologists, cardiologists, MRI physicists, cardiology nursing staff, and MRI technologists.
- Listed below are our institutional established CIED/MRI practice procedures which had to be modified to account for the specific requirements of the MRgFUS treatment. Where the procedure remained the same “Yes” is indicated and where it needed to be altered “No” is indicated.

- Cardiology pacing nurse present for entire procedure. Programs the pacemaker to DOO mode at 80 bpm prior to treatment. No change in heart rate monitored with no response to sensor input
- Patient positioned on MR table outside of the scanner room and subsequently transferred into scanner room where the table is docked to MR scanner
- This was not possible for this MRgFUS Procedure for 2 reasons:
  1. Following completion of pre-treatment quality assurance (QA) testing of MRgFUS system the table needs to remain docked to the MR scanner (undocking would necessitate repeating the QA)
  2. Prior to starting the treatment (with the patient position on the table) the transducer has to be registered with the 3D anatomic position of the MR scanner which requires automatic execution of MR sequences with the whole body SAR of 1.73 W/kg, exceeding our practice safety limit of 1.5 W/kg
- Transducer calibration scans were performed on the QA phantom
- the patient was walked slowly into the MR scanner room and was guided into the feet-first supine position with his back located above the transducer, the table was then slowly advanced to isocenter
- the cardiology nurse continually monitored electrocardiography, pulse oximetry, and blood pressure
- all MRI was performed in the Normal scan mode
- Physics assisted the MRI technologist in adjusting sequence parameters to limit whole-body SAR to 1.5 W/kg (as verified by real-time SAR monitor)

Results

Pre-planning sequences acquired in axial, sagittal and coronal planes with SAR of <1.2 W/kg for each sequence (Table 1). This was achieved with adequate image quality

Procedure time was 2½ hours with 22 individual sonication (treatment doses 40-60 W)
- Treatment was monitored in axial plane using real-time MR thermometry with 6s temporal resolution (SAR < 0.01 W/kg)
- Vendor recommendation is to use First-level controlled mode for MR thermometry, which was not possible in this case. Upon testing using multiple sonication in a phantom, the quality of MR thermometry acquired in the Normal mode was comparable to that of 1st level mode
- Post-treatment T2 weighted sequence was acquired to assess treatment effects (edema) around treated joints (SAR <1.12W/kg). This was achieved with adequate image quality

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Discussion

- We report a first case of MRgFUS ablation of lumbar facet joints in a patient with refractory low back pain and MRI non-conditional pacemaker.
- More than 1.8 million people in the United States have pacemakers or implantable cardiac defibrillators. Facet joint degenerative changes and pain often occur in older demographics, including those with confounding cardiac morbidities, including a substantial number with CIEDs.
- Therefore, an appropriate risk-benefit analysis for such cases is of paramount importance. CIEDs from multiple manufacturers have been specifically engineered and are labeled as MRI-conditional.
- The key to this MRgFUS case was the successful integration of the existing CIED/MRI practice to this interventional procedure.
- In this present case study, the patient maintained stable vital signs and cardiac function throughout the procedure and there were no changes in pacemaker function or in pacing threshold post MRgFUS facet joint ablation.

Conclusions

This study reports a successful MRgFUS lumbar facet joint ablation in a patient with a non-conditional pacemaker. By careful use of our MRI CIED protocol , we demonstrated that the MRgFUS ablation treatment of facet joints can be performed and going forward can be offered to patients with CIEDs on a case-by-case basis.

Disclosures: MRgFUS use for facet joint treatment is an off-label use in the United States.

References


Table 1: Details of MRI sequences and image acquisition that were used during the MRI guided focused ultrasound procedure and the corresponding whole-body SAR values for each image sequence

<table>
<thead>
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<th>Sequence Description</th>
<th>SAR (W/kg)</th>
<th>MRgFUS Safety Criteria</th>
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<tr>
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<td>Yes</td>
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