De-fibrillation in an MRI Environment

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Introduction

Magnetic Resonance Imaging (MRI) is routinely performed to evaluate, diagnose, and detect multiple conditions in different parts of the anatomy. While imaging subjects (humans and animals) in an MRI scanner, it may sometimes be necessary to de-fibrillate in order to restore a normal sinus rhythm or to resuscitate in the event of cardiac arrest. Since defibrillator equipment is inherently incompatible with the MRI's magnetic field, it has been necessary to remove the subject from the MR environment and perform the de-fibrillation in a separate room. This relocation procedure consumes valuable time while the subject is in a critical state. We present here a procedure for de-fibrillating an animal subject successfully inside the MR environment.

Methods

Cardiac MRI studies on swines and canines are routinely performed to study and improve real-time MRI guided intervention in the heart [1 2]. In our case, the proposed de-fibrillation technique was utilized during such studies when the animal went into ventricular tachycardia. All studies and experiments were performed on a Siemens 3.0T Verio scanner (Siemens HealthCare, Erlangen, Germany).

The de-fibrillation procedure was made possible by locating the defibrillator unit outside the 5-gauss line of the MR environment. De-fibrillation pads were placed on the animal and connected to the defibrillator unit via an extension cable. The pads, cables, and connectors were all non-ferrous. The defibrillator pads used were TZ Medical LifeLinks pads with attached radiotransparent element and lead wires. A custom 30-foot extension cable was manufactured by TZ Medical for this purpose. The patches had adhesive backing for contact with the subject. One patch was adhered to the left anterior of the animal, and the other adhered to the right posterior. These were placed in a flanking position with respect to the chest, so that the heart would be in the path of an imaginary line drawn between the two pads. The posterior patch had no interference issues, but the anterior patch had to be placed in order to be clear of the ECG leads on the anterior of the animal.

The animal's vital signs were monitored during MRI scans. If a life-threatening problem was observed, the scan was stopped, and the scanner table moved from the isocenter to the home position. The defibrillator pads were then quickly placed (on an already shaved and prepped area), and a de-fibrillator charge delivered. Once the animal recovered to a normal sinus rhythm (from the de-fibrillation energy and other drugs including epinephrine and adenosine as required), the patches were removed and the table moved back to the isocenter for continuation of scanning (after localizing again to account for animal motion from the de-fibrillation). No scans were performed with the defibrillator patches adhered to the animal, in order to avoid the risk of heating. Figures 1a & 1b show the animal on the scanner table with anterior de-fibrillation pad adhered (red arrow). The posterior pad is not shown. Figure 2 shows three sequential still frames of animal movement during defibrillator charge delivery. Figure 3 shows an overlay of the three frames from Figure 2.

Results

During four separate scanning sessions, de-fibrillation charges were delivered to swine subjects. In two of these sessions, the animal recovered to normal sinus rhythm, and normal scanning was resumed. In the other two unsuccessful resuscitation attempts, it was determined that the animal expired due to other complications. Charges ranging from 120J to 200J were applied. With the table retracted to home position, the defibrillator pads were located 2 feet from the front of the scanner bore. When the charge was delivered, no movement of the defibrillator wires or patches was observed, and no adverse affects from the magnetic field were observed. A clean ECG signal was obtained from the defibrillator pads, and appeared to be unaffected by the static magnetic field of the scanner. The defibrillator unit did not report any error conditions before or after the charges were delivered. In one session, up to eight sequential charges were delivered in a single de-fibrillation attempt without any errors.

Conclusion/Discussion

The de-fibrillation equipment and procedure made it possible to successfully de-fibrillate an animal subject in the MR environment without removing it from the scanner table, and without any observed problems.

Acknowledgments

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References

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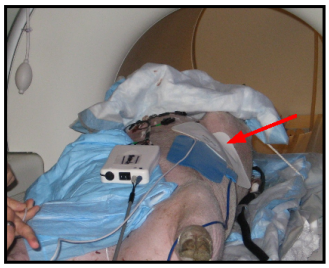

Figure 1a. Inferior view of animal.

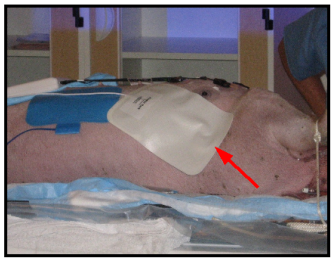

Figure 1b. Left view of animal.

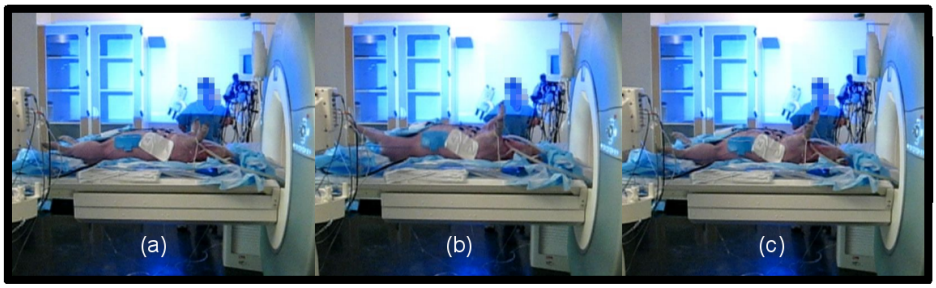

Figure 2. Still frames of animal movement during charge delivery.

Figure 3. Overlay of still frames from Figure 2 a, b, c.