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Case Report

MRI-Induced Second and Third Degree Burns to Hands Bilaterally: A Case Report

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Abstract

Magnetic resonance imaging (MRI) has become an essential tool in medicine that provides important diagnostic information that would otherwise not be obtained using other techniques (i.e. CNS disorders, joint damage, etc.). According to statistics collected for 2013 by the Organization for Economic Co-operation and Development (OECD), 106.8 MRI exams were ordered per 1,000 populations in the United States for 2013 alone. Review of the Manufacturer and User Facility Device Experience (MAUDE) database in 2010 by the FDA found 419 thermal injuries to be associated with MRI over a 12 year period, including 1st, 2nd, and 3rd degree burns. The purpose of this case report is to raise awareness of the potential for painful thermal injuries caused by MRI exams using the case of a 37 year old male patient who received 2nd and 3rd degree burns to both thumbs and the right index finger. Most adverse events from MRI have been found to be due to improper patient positioning or improper equipment use. Therefore, it is imperative that patients, clinicians and technicians are all familiar with the potential for thermal injuries incurred from MRI exams. Possible mechanisms for MRI induced thermal injury will be discussed with a focus on ways to prevent such injuries.

Keywords: Magnetic Resonance Imaging; MRI; MRI thermal injury; MRI adverse events; MRI burns

Case Presentation

A 37 year old male presented to the emergency room with a 3-4 day history of increasing pain and swelling in his right upper extremity. The physical examination was normal apart from mild tenderness to palpation along the swollen segment as well as surrounding paresthesia and a weakened right grip strength. Pulses and painless range of motion remained intact. A duplex ultrasound with Doppler discovered a venous thrombus extending from the jugular vein to the subclavian, axillary and terminating in the brachial veins at the elbow. The patient underwent pharmacomechanical thrombectomy. This lead to improvement in the pain and swelling of the extremity. Due to an absence of a traumatic event or family history of clotting disorders as potential etiologies, the patient underwent an MRI to explore thoracic outlet syndrome as the underlying cause. Although the MRI indicated the presence of thoracic outlet syndrome, the patient sustained 2nd and 3rd degree burns to his extremities. Detailed examination discovered third degree burns on the left and right thumb bases as well as blisters on the left thumb and right index finger. These injuries required debridement and split thickness skin grafts which were well taken and are currently being followed by plastic surgery on an outpatient basis.

Discussion

Previous literature has attributed MRI induced thermal injuries to one of three possible mechanisms: 1) direct electromagnetic induction in a conductive loop, 2) induction in a resonant conducting loop, and 3) electric field resonant coupling with a wire known as the "antenna effect" [1-3]. When a patient undergoes an MRI, a strong magnetic field is generated using superconductive magnets. As the patient passes through the bore of the machine, radiofrequency (RF) coils apply a pulse to hydrogen atoms in the area being imaged. This pulse creates an RF field that provides energy to the atoms that is ultimately sensed by the RF coils and relayed to a computer in order to generate an image. However, the RF field is also capable of inducing currents in conductive material that can lead to thermal injury. The first mechanism, electromagnetic induction, involves current generated by the RF field in a formed "closed loop" [3]. These closed loops can result from any cross points involving conductive material such as cables crossing other cables, cables looping across themselves, cables touching the patient more than once or the cables contacting the RF coil more than once. Importantly, closed loops can even form in the absence of cables via skin-to-skin contact such as between extremities (i.e. hand to leg) as skin itself is conductive [3]. As the current in the closed loop encounters the area of highest resistance, sufficient heat is generated to damage tissue. In special cases, closed loops may actually have specific values of inductance and capacitance due to certain shapes that enable them to exhibit "resonance" with the MRI machine. This resonance further increases the ability of the loop to concentrate current resulting in even greater heating. However, the existence of a resonant conducting loop during imaging would be extremely coincidental clinically [3]. The third possible mechanism, the "antenna effect", occurs in scenarios where wires of a certain length can serve as an antenna upon exposure to pulses from the RF coils. In these wires, resonance is produced with antinodes of maximum amplitude at each end. As a result, the ends of the wire generate sufficient heat that is capable of causing injury [3]. Some have suspected this mechanism specifically in cases of pulse oximeter wires causing severe burns on the hands and fingers [4,5].

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The American College of Radiology (ACR) released a Guidance Document on MR Safe Practices for 2013 that recognizes these thermal effects and provides recommendations for prevention. Recommendations that specifically address the mechanisms for injury discussed above include very simple and reasonable steps such as removing all unnecessary or unused electrically conductive material external to the patient, placing thermal insulation between the patient and electrically conductive material, placing leads or wires far from the RF coils in the inner wall, ensuring patient tissue does not form conductive loops by minimizing skin-to-skin contact in the areas being imaged, and utilizing cold compresses or ice packs for electrically conductive leads that need to contact the patient during imaging, in unconscious or unresponsive patients with attached leads, or for areas of concern such as tattooed areas. There are also established MR Conditional labeling and safety guidelines that provide magnetic field strengths that were tested with various implants. Finally, the patient should be continually monitored during the procedure for any sudden sensations of overheating or discomfort.

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