MR Imaging–related Electrical Thermal Injury Complicated by Acute Carpal Tunnel and Compartment Syndrome: Case Report

Magnetic resonance (MR) imaging is generally considered a safe procedure. Contraindications include the presence of foreign objects in or on the body, which may be subject to electromagnetic fields associated with the MR system. Most of these objects are well known and are routinely screened for prior to the procedure. The authors report an unusual adverse event that appears to have been caused by a unique combination of factors involving an identification bracelet, an item not previously known to present any risks. To the authors’ knowledge, this is the first report in the literature of a severe electrical thermal burn that required surgical intervention. Identification bracelets may need to be removed or padded to prevent direct contact with the patient’s skin during all MR imaging examinations for patients unable to communicate, such as those requiring sedation or general anesthesia.
Magnetic resonance (MR) imaging is generally considered a safe procedure. Contraindications include the presence of foreign objects in or on the body, which may be subject to electromagnetic fields associated with the MR system. Such objects are routinely screened for prior to the procedure (1). We report an unusual adverse event that appears to have been caused by a unique combination of factors involving an identification bracelet, an item not previously known to present any risks.

Identification bracelets may need to be removed or padded to prevent direct contact with the patient’s skin during MR imaging examinations for patients unable to communicate, such those requiring sedation or general anesthesia.

Case Study

A 61-year-old male patient was referred to our facility to undergo a lumbar spine MR imaging study. His past medical history was significant for chronic lower back pain, moderate obesity (body weight, 128 kg; body mass index, 40), hyperlipidemia, coronary artery disease, and obstructive sleep apnea. The patient also had severe claustrophobia for which he required anesthesia during the MR imaging study. The attending neurosurgeon insisted the study proceeding without general anesthesia.

The patient underwent preprocedural medical evaluation and preparation according to the hospital’s standards. For the MR imaging study, general anesthesia was induced and maintained by means of an intravenous infusion of propofol (200 μg/kg/min) and sevoflurane (1 MAC [minimum alveolar concentration]). The patient’s airway was secured. In a supine position, he was placed in the MR imager head first (Fig 1). Pressure points over the face, head, and limbs were inspected and padded with cotton blankets or towels as necessary. Monitoring cables were also padded to avoid direct skin contact. The patient was positioned into a standard 1.5-T MR imaging system (Intera, software version 2.6.3.3; Philips Healthcare, Best, the Netherlands). A spinal coil (Spinal CTL sense coil, eight channels; Philips Healthcare) was placed under the patient’s lumbar area. The patient was wearing a cotton hospital gown and sweatpants. The MR imaging study continued for 70 minutes with an uneventful clinical course (Table 1).

After emerging from general anesthesia in the recovery room, the patient complained of severe pain under his identification bracelet (LB2; Laserband, St Louis, Mo) (Fig 2), located on his right wrist, as well as pain over the index, middle, and ring fingers (2). The identification bracelet was immediately removed, and an area of redness under it was noted. In the recovery room the patient was treated with intravenous analgesics (ketorolac, 30 mg; fentanyl, 50 mg; ketamine, 20 mg, times three doses) with only a partial response. He was referred to the emergency department for further evaluation. At repeated examination approximately 2 hours after the conclusion of the MR imaging studies, a blister (2 × 3 cm) was noted in the area under the identification bracelet’s former location, along with pain in the hand and wrist, with numbness in the fingers over the median nerve distribution. The right wrist was immobilized in a wrist splint. The patient was admitted for observation under the care of the hand service, as these findings were consistent with an acute carpal tunnel syndrome with a wrist burn that if progressed would need urgent decompression. The patient was serially evaluated overnight and remained stable. At examination the following morning, the carpal tunnel symptoms had worsened, with severely diminished sensation in the anatomic distribution of the median nerve, weakness of the abductor pollicis brevis, and a positive Tinel sign at the carpal tunnel with concomitant development of a volar forearm compartment syndrome with pain on passive extension and active flexion of the volar forearm musculature and an elevated compartment pressure in the forearm of 74 mmHg (Fig 3).

Intraoperative findings (Fig 4) were significant for a median nerve that over subsequent irrigation and debridement procedures became progressively pale and edematous, and with muscle necrosis in the pronator quadratus (the deepest muscle and closest to bone and the postulated entry point). This was characteristic of an electrical burn injury, which preferentially damages nerve and muscle tissue because of their lower resistance. Furthermore, the muscle adjacent to the bone likely received a second injury from the increased heat generated by the bone’s high resistance to electricity.

The patient underwent two repeated irrigation and debridement procedures of his forearm wound. There was no

Implication for Patient Care

- Identification bracelets may need to be removed or padded to prevent direct contact with the patient’s skin during MR imaging for patients unable to communicate, such those requiring sedation or general anesthesia.

Advance in Knowledge

- Identification bracelets may contribute to thermal and electrical burns during MR imaging.
Heating tends to be problematic primarily for conductive objects that have an elongated shape such as electrodes, leads, guidewires, and certain types of catheters (4). There are also reports of excessive heating or burns caused by iron oxide–based tattoos and transdermal patches with metal components, such as testosterone (eg, Androderm), nicotine (eg, Habitrol, Nicotrol), scopolamine (eg, Trasderm Scop), and clonidine (Catapress-TTS) patches (5–7).

Currents may be induced by two oscillating fields: the pulsed magnetic-gradient field and the pulsed radiofrequency (RF) field. These fields’ intensities vary with time and may induce an electromotive force in a conductive loop. Heating will result from current flowing through the loop, and it is proportional to the resistance in the conductive medium (3). The pulsed magnetic-gradient field is produced by a large gradient coil that encloses the RF coils, which are sometimes located in the vicinity of the patient to be imaged. The risk of excessive heating is related to the proximity of the transmit RF coil to the patient’s tissue, as well as to the frequency and the power of the RF used.

In this case, the patient sustained a thermal injury on the volar mid-to-ulnar side of the wrist, which likely represented an entry point for the electrical current. The presence of progressive acute carpal tunnel syndrome with a compartment syndrome is not consistent with a small ulnar thermal burn. For a thermal burn to cause carpal tunnel syndrome and compartment

**Table 1**

<table>
<thead>
<tr>
<th>Step</th>
<th>Sequence</th>
<th>TR/TE*</th>
<th>No. of Images</th>
<th>Specific Absorption Rate (W/kg)</th>
<th>Acquisition Time (min:sec)</th>
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<tr>
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<td>Three plane</td>
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<td>3</td>
<td>1.3</td>
<td>12:32</td>
</tr>
<tr>
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<td>TSE</td>
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<td>8</td>
<td>3</td>
<td>12:33</td>
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<tr>
<td>STIR</td>
<td>TR</td>
<td>2500/70</td>
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<td>3</td>
<td>12:42</td>
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<td>1.7</td>
<td>12:46</td>
</tr>
<tr>
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<td>FSE</td>
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<td>2.2</td>
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</tr>
<tr>
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</tr>
<tr>
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<td>16</td>
<td>2.0</td>
<td>13:02</td>
</tr>
<tr>
<td>T2-weighted FSE axial</td>
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<td>1.5</td>
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<td>44</td>
<td>1.7</td>
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<tr>
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<td>4000/100</td>
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<td>1.7</td>
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<td>T1-weighted sagittal post</td>
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<td>2.6</td>
<td>13:27</td>
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<tr>
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<td>44</td>
<td>3</td>
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<td>18</td>
<td>2.6</td>
<td>13:42</td>
</tr>
</tbody>
</table>

Note: Total acquisition time was 70 minutes. FS = fat suppression, FSE = fast spin echo, STIR = short inversion time inversion-recovery, TR = time inversion recovery, TSE = turbo spin echo.

* TR/TE = repetition time (msec)/echo time (msec).
The exact mechanism causing the injury in this case is unclear. The MR imaging coils, imager, and monitoring system were inspected by the radiology department and the manufacturer, and no fault was found. A detailed report was submitted to the U.S. Food and Drug Administration and to Philips Healthcare (8,9). Review of the imaging protocol did not show any unexpected energy deposition. The presence of a foreign body in the patient was excluded. Prior to the imaging examination, the patient’s pressure and contact points were padded and isolated from direct contact with the MR imager bore or to different parts of the patient’s body, minimizing the chance of creating a loop as described by Knopp et al (10).

The monitoring equipment did include an oxygen saturation probe and electrocardiographic electrodes, but they and their associated cables were placed on different parts of the patient and were not in proximity to the injured limb.

At clinical examination immediately following the incident, we found that the blister (or the postulated exit/entrance point of the electrical current) appeared in the area under the barcode print in the identification bracelet (LJB2; Laserband) (2). Further investigation revealed that the toner used to print the identification bracelet barcode contained
40%–50% iron oxide (11). We suggest that the initial snug placement of the identification bracelet around the wrist at admittance, along with the patient’s wrist anatomy and the addition of sweat, created a conductive loop. We postulate that this in turn caused a flow of electrical current into the arm throughout the procedure (electromagnetic induction). Additional risk factors such as long acquisition time and location of the RF coil in proximity to the wrist may also have played a role.

We recommend having a high index of suspicion during the recovery time because the clinical signs and symptoms may be initially nonspecific during emergence from sedation or general anesthesia. In this case, prompt clinical attention and close observation with frequent clinical examination, which led to early intervention, prevented a more severe injury to the upper extremity from impending compartment syndrome.

The hospital quality assurance committee recommendations that followed this incident were to remove or pad the identification bracelets from direct contact with the patient’s skin during all future MR imaging examinations for patients requiring sedation and general anesthesia.

References