Case report

TWO CASES OF MRI-INDUCED SKIN BURNS

PRIMERA OPEKLIN NA KOŽI PRI MAGNETNO RESONANČNEM SLIKANJU

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ABSTRACT

Purpose: The purpose of this paper is to present two cases of MRI-induced skin burns.

Materials and methods: Both cases were imaged using a GE Optima™ MR450w 1.5T scanner. A combination of anterior and posterior arrays were used. In both cases, patients were placed in the headfirst prone position.

Results and discussion: In the first case, there was a red area on the skin and a white blister appeared after 15 minutes. A closed conducting loop was created in the patient's body, which caused increased local temperature at the junction of her thighs. We could prevent this by using insulation, such as foam pads, which is one of eight steps for preventing MRI-induced skin burns. In the second case, there were red spots on the skin of the left and right thighs at the contact of the scrotum where a white blister appeared after 15 minutes. This could not have been prevented, even if we considered all the steps for preventing MRI-induced skin burns.

Conclusion: I reported a case of burns on a small area of skin at the junction of the patient's thighs, which we could have prevented by using insulation pads, and a case of burns on the skin at the contact of the scrotum, which we could not have prevented, even if we considered all the steps for preventing MRI-induced skin burns. However, we could have stopped the increase in the degree of the burn by recognising early signs.

Key words: MR imaging, burns, safety, radiofrequency waves, heating

IZVLEČEK

Namen: Namen tega članka je predstaviti dva primera opeklin, ki sta nastala pri MR slikanju.

Metode in materiali: Oba primera smo slikali z magnetnoresonančnim tomografom GE Optima 450w 1,5T. Uporabili smo sprejemno tuljavo za trup (ang. anterior array) in hrbtenico (ang. posterior array). Oba pacienta sta ležala na hrbtu z glavo proti tomografu.

Rezultati in razprava: V prvem primeru se je med slikanjem pojavila rdečina, na kateri je čez 15 minut nastal še bel mehur. V pacientkinem telesu se je ustvarila prevodna zanka, ki je povzročila lokalno segrevanje na notranji strani stegen in posledično je na tem mestu nastala opeklina. Temu bi se lahko izognili z namestitvijo izolativne blazinice, kar je eden od osmih korakov, ki jih lahko upoštevamo za preprečitev opeklin med MR slikanjem. V drugem primeru sta se rdečini pojavili na koži levega in desnega stegna ob skrotumu, na katerih je čez nekaj minut nastal bel mehur. Temu bi se težko izognili, tudi če bi upoštevali ukrepe za preprečitev opeklin.

Zaključek: Predstavil sem primer opeklin, ki so nastale zaradi manjšega stika kože na stegnih, ki bi jih lahko preprečili z namestitvijo blazinice med stegni, ter primer opeklin na koži stegen ob skrotumu, ki ju ne bi mogli preprečiti, lahko pa bi, ob razumevanju mehanizma nastanka le-teh in v komunikaciji s pacientom, prepoznali zgodnje znake ter preprečili poglabljanje stopnje opekline.

Ključne besede: MR slikanje, opekline, varnost, radiofrekvenčni pulzi, segrevanje

INTRODUCTION

Since magnetic resonance imaging (MRI) has been used, there has not been any scientific proven cases of relevant long-term adverse effects on body cells or organisms (1).

Modern magnetic resonance scanners, which are used for clinical purposes, use a very strong static-magnetic field, additional gradient magnetic fields and short high-frequency waves from radiofrequency (RF) fields to excite protons. RF waves are transmitted by the coil/array that induces high-frequency current in tissues (2). Using the energy from the impulses, the average magnetisation of proton is distorted. We can only achieve this if the frequency of radiofrequency waves is identical to the frequency of core precessing in the magnetic field, and if these cores are perpendicular to the static-magnetic field. We can control the angle of magnetisation through the appropriate power and duration of RF waves. In MRI, we most often angle the magnetisation of the cores to 90 degrees so that it precesses around the axis of the static-magnetic field with Larmor frequency. That is how magnetic current in an RF array is adjusted and thus electrical voltage is induced. At 90 degrees, electrical voltage is at its highest, as it has the widest possible projection at the surface when it is perpendicular to the static-magnetic field (3).

Most of the RF energy that is used for MRI is transformed into heat within the patient's tissue. Energy absorption in MRI is measured in specific absorption rate (SAR); it is the power absorbed per mass of tissue (W/kg). Higher body temperature of the patient due to RF wave exposure also depends on the patient's thermoregulation system, the duration of exposure, the energy accumulation rate and the environment where the patient is during the imaging process (4).

Soon after MR was introduced for clinical purposes, the first articles appeared on risks due to increased temperature in the imaging process (5, 6). It has been proven that the local temperature can increase and result in burns during MRI. Most injuries occur with patients who were attached to life function monitoring devices and whose skin was in contact with sensors or conductors (7). The human body is a conductor and therefore burns can occur even if there are no implants or active electrical devices. A closed conducting loop in the patient's body can thus be created if a patient lies with his hands clasped or if a thumb is touching a thigh (8).

Organ shape and layers of insulating fat can have an impact on how the induced electrical voltage flows. This may lead to increased local temperature (9). Knopp et al. described a case in which a closed conducting loop was created through the torso and legs. The contact area between the calf muscles comprised two adjacent skin layers that consisted of approximately 2 mm of subcutaneous fat. They assessed that the average power absorbed in a layer of subcutaneous fat of 1 cm3 was 1.5 W, which was enough to cause RF-induced burns. In this area, the local temperature could reach up to 43oC, which does not cause immediate pain, but is sufficient to induce tissue necrosis. Initially, third-degree burns are painless, as pain receptors under the skin are destroyed first (10). Friedstad Jonathan et al. described an unusual case of two third-degree burns that occurred on the ring finger of the right hand and on the left forearm during MRI (11).

AIM

The aim of this paper is to present two cases of MRI-induced skin burns, raise awareness and introduce measures to prevent such complications.

METHODS

Both cases were imaged using a GE Optima™ MR450w 1.5T scanner. A combination of anterior and posterior arrays was used.

Case 1:
MRI of low-grade liposarcoma of an 82-year-old patient's rectus femoris muscle. We performed a protocol for soft tissue tumour that includes T1, T2, T2 pulse sequences with signal saturation from fat (FS) and a diffusion-weighted sequence in the axial plane and axial, coronal and sagittal T1 FS sequence after the application of a contrast agent. The patient was placed in the headfirst prone position during the examination. The patient stated at the end of the process that she felt heat between the thighs.

Case 2:
MRI of the rectum of a 74-year-old patient. We performed a standard rectal protocol that comprised a T2 sagittal sequence, paraxial (imaging plane planned through the cancer-infected rectum area) and paracoronal (imaging plane perpendicular to the paraxial plane) plane, followed by a diffusion weighted sequence in the paraxial plane and a T2 sequence for lymph node display in the axial plane. The patient was placed in the headfirst prone position during the examination. After the examination, the patient stated that he felt heat in the testicle area.

RESULTS AND DISCUSSION

Case 1:
There were no peculiarities during the examination, except at the end the patient complained about the increased temperature between her thighs. At the junction of her thighs, there was a red area on the skin and a white blister appeared after 15 minutes (Image 1). The female patient was referred to a surgeon who cared for the wound and provided her written instructions on how to care for the burn.

Image 1: Photograph of the medial side of the thigh with burns on both sides

The MR images (Image 2) show that the local temperature increased and caused the burns at the junction of the patient's thighs. It is stated in the results of the examination that, compared with the previous MR examination a subcutaneous fat oedema was evident, which probably contributed to the higher conductivity of this area.

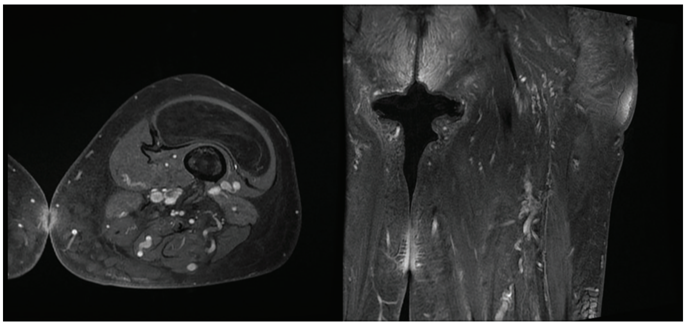

Image 2: Left, T1 image of a saturated signal from the adipose tissue after the application of the contrast agent in the axial plane. Right, T1 image of a saturated signal from the adipose tissue after the application of the contrast agent in the coronal plane.

During MRI, a conducting loop was created in the patient's body, which is schematically presented in Image 3. As the result of magnetic induction in the body (L_{array}), an electric voltage, which is influenced by the resistance of the individual tissue (R_{skin}), flows through patient's body. The entire resistance of the loop is presented with R_{array}. In border areas between fat, skin and air, an electrical charge is created according to a similar principle as in an ordinary electric capacitor. Capacitance is dependent on a distance between the tissues and the ability to accumulate electrical charge in an individual tissue (R_{skin}). In our case, it is the border between the fat and the skin. A virtual capacitor with C_{air} is also created between the skin of left and right thighs. In the worst-case scenario, the capacitance is high enough to create an electrical current through every tissue, meaning it can increase the temperature in border areas and cause burns (8).

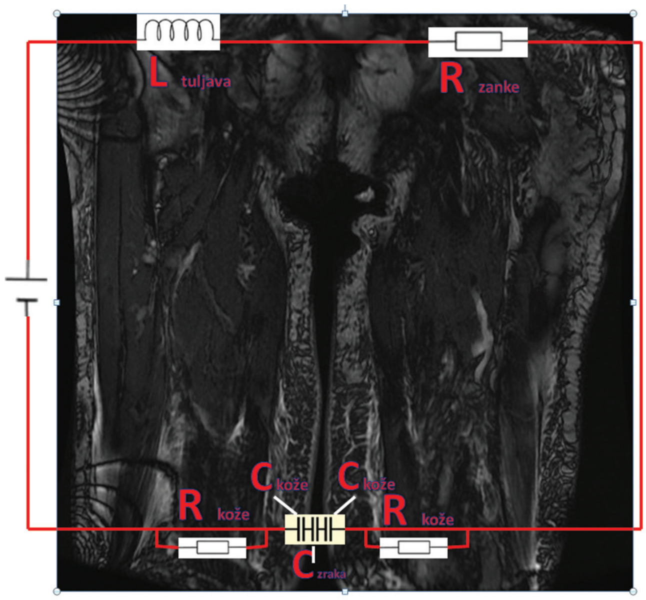

Image 3: Schematic diagram of a closed conduction loop that appeared in the patient's body in the process of MRI. Loop induction (L_{array}), loop resistance (R_{array}), skin resistance (R_{skin}), skin capacitance (C_{skin}), air capacitance (C_{air})

We could prevent this by using insulation between the thighs, such as foam pads, at least 1 cm thick, which would prevent the creation of a closed conduction loop.

With an increase in the number of MR examinations and better MR scanners there is also an increase in the number of burns reported. Skin damage is the most common reason for a report of an unwanted event (Hardy and Weil, 2010). For this reason, the ISMRM (International Society for Magnetic Resonance in Medicine) prepared a poster that everyone can print for free and hang in the MR diagnostic clinics and that systematically describes steps to prevent MR burns.

1. We systematically check for implants or other metal objects in the patient's body, and everything that is unknown to us is deemed MR Unsafe.
2. We systematically check that every object that enters the MR space is MR Safe or MR Conditional; we always check that all conditions for MR safety have been met. All metals, including non-ferromagnetic metals, can heat up and cause burns.
3. Before the examination, every patient strips down to their underwear and puts on a cotton hospital robe.
4. For examination, we prepare the patient so that there is no skin contact (hands on the hips, crossed arms or legs).
5. While preparing the patient, we use insulation foam pads on skin to skin contact spots, skin to conductors and skin to a scanner wall spots.
6. We prevent loops on array conductors and other medical devices.
7. Imaging is done on a normal operative level, using the lowest possible SAR.
8. We continuously observe and listen to patients to ensure that everything is all right. We are aware of any signs of increased temperature. Sedated patients are connected to a life function monitoring device that is MRI Conditional (12).

Case 2:

There were no peculiarities during the examination, except at the end the patient complained about increased temperature

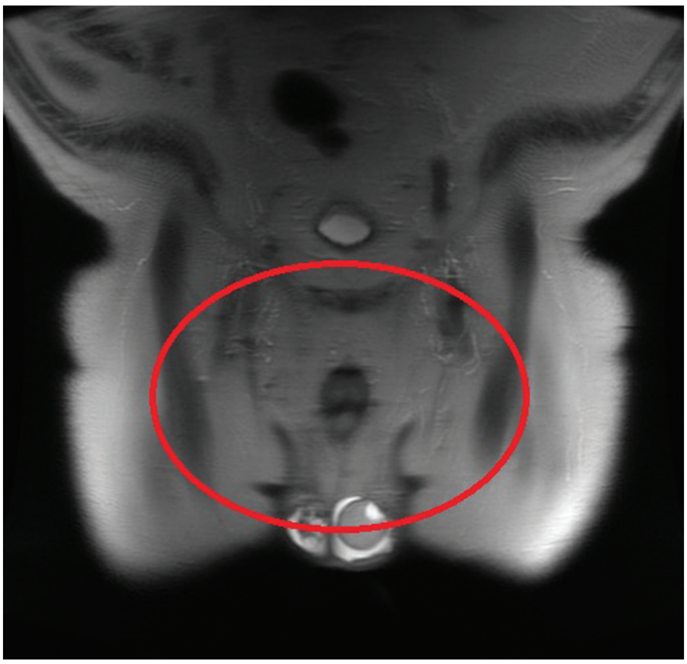

Image 4: Localiser in the coronal plane. The red line indicates the trajectory of the closed conducting loop.

on the skin around his thighs, in the scrotum area. There were red spots on the skin of the left and right thighs at the contact of the scrotum where a white blister appeared after a few minutes. We cared for the wound and provided him instructions for cooling the wound.

This could not have been prevented, even if we considered all the steps for preventing MRI-induced skin burns. A similar case occurred in Sweden, but was not described in literature. The skin burn appeared under the breast where an air pocket formed in the inframammary fold and a closed conduction loop was created around it.

CONCLUSION

With an increase in the number of MR examinations and better MR scanners around the world, a growing number of cases of MRI-induced burns can be expected. The aim of this article is to present an example of burns on a small area of skin at the junction of the patient's thighs, which we could have prevented by using insulation pads. Another example shows the occurrence of skin burns at the contact of the thighs and scrotum, which we could not have prevented. However, by communicating with patients, understanding the mechanism behind the burns and by recognising early signs, we could have stopped the increase in the degree of the burn.

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