Surface-coil heat concentration in MR as a possible exacerbating factor in retrobulbar neuritis: is this a local "hot bath test"?

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Letters

Surface-Coil Heat Concentration in MR as a Possible Exacerbating Factor in Retrobulbar Neuritis: Is This a Local "Hot Bath Test"?

The recent article by Shellock and Crues [1] is most informative. The authors acknowledge that little is known about the thermophysiologic consequences of MR imaging in the clinical setting and that certain thermal-sensitive tissues (i.e., the eye) may not tolerate localized heating. The following case illustrates a possible untoward effect.

A 29-year-old nurse experienced her first episode of right retrobulbar neuritis 3 years ago and recovered. A second episode occurred 1 year later, producing residual visual deficit. A third episode occurred 1 year after the second and responded rapidly to corticosteroids. A fourth episode occurred recently, with evidence of optic atrophy, reduced vision, an enlarged blind spot, and Marcus-Gunn pupil. CSF was normal. MR imaging (0.3 T) with sagittal, axial, and coronal pulse sequences was performed by using a surface coil on the right eye and was normal. During the entire examination, the local eye pain intensified two- to fourfold. After completion of the examination, it took 4 hr to return to her usual baseline discomfort.

The cause for this augmented pain is unclear. MR is not thought to be biologically hazardous; however, small amounts of heat are generated during the pulse sequences. Surface coils tend to concentrate this energy into a smaller area. Inasmuch as it is known that a rise in temperature, to as little as 0.5° C, can induce symptoms in multiple sclerosis (as a result of Na/K flux in myelin), could the aforementioned occurrence of intense focal eye pain represent a focal "hot bath test" (Uhthoff phenomenon)?

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Reply

In approximately 30% of patients with multiple sclerosis, short-term visual impairment develops in conjunction with physical activity, elevated body temperature, or emotional stress [1–4]. This phenomenon, known as the Uhthoff symptom, reportedly has been provoked by increases in body temperature of as little as 0.5°C.

Dr. Weintraub has suggested that the intense local eye pain observed in a patient during MR imaging with a 0.3-T MR scanner and an "eye surface coil" may have been due to RF radiation-induced heating that, in turn, elicited the Uhthoff symptom.

Our investigation [5] on tissue heating produced by MR imaging with a head coil showed that the largest change in skin temperature was 2.1°C and that there was no significant increase in body temperature. In another, recently published study [6], we found that patients undergoing high-field-strength (1.5 T) MR imaging with a head coil had an average increase in corneal temperature of 0.5°C; the highest temperature recorded was 1.8°C. Again, there was no significant increase in body temperature found during this experiment (unpublished observations).

These changes in surface temperature were not considered hazardous to the skin or ocular tissues [5, 6]. Furthermore, the recorded changes in body temperature (measured in the sublingual pocket, which is a good representative site of internal temperature, particularly during MR imaging with a head coil) were not within the range capable of inducing the Uhthoff symptom in susceptible patients. Although the contribution of elevated surface temperatures in causing the Uhthoff symptom is unknown, internal heating appears to be required to produce this response [2–4].

Although the scenario presented by Dr. Weintraub may be theoretically possible, it is unlikely that the normal operation of a 0.3-T MR scanner produced sufficient heating to evoke the Uhthoff symptom. We think that emotional stress may have been responsible; however, the actual cause remains to be determined.

Dr. Weintraub mentioned that "surface coils tend to concentrate this (RF) energy into a smaller area." We want to emphasize that only transmit/receive (not receive-only) surface coils produce a localized RF power deposition that causes the heating of tissue contained within the coil [5, 6]. It has been our experience that temperature changes associated with MR imaging by means of the body coil combined with conventional surface coils are similar to imaging with the body coil alone (unpublished observations); mostly surface (i.e., skin) heating occurs, with only slight changes in body temperature.

A comprehensive MR imaging safety survey currently is being conducted by Frank Shellock (Cedars-Sinai Medical Center) and Emanual Kanal (Pittsburgh NMR Institute) under the auspices of the Society for Magnetic Resonance Imaging. It is hoped that any incidents similar to the one described by Dr. Weintraub will be brought to our attention in this survey, in which case, we will follow up on this issue in a future letter to *AJNR*.

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Technique for RF Isolation of a Pulse Oximeter in a 1.5-T MR Unit

Monitoring sedated or unstable patients during radiographic procedures is a time-consuming but obligatory part of a radiologist's activity. During MR studies, patients are effectively out of sight, and a means of continuous monitoring becomes necessary. Digital oxygen transducers or pulse oximeters can be used to monitor arterial hemoglobin saturation and pulse rate noninvasively. These portable machines frequently are used during surgical procedures, but their operation in a 1.5-T MR unit is limited by their emission of RF radiation, which interferes with the formation of MR images. I have designed a simple technique for RF isolation of a standard pulse oximeter for use in a 1.5-T MR unit.

In standard pulse oximeters, two light-emitting diodes (LEDs), red and infrared, are used to generate dual light beams that are recorded by a photodetector. The relative amount of each color absorbed by the pulsing arterial blood indicates the amount of arterial hemoglobin saturation (Nellcor Inc., Product Information Division, Haywood, CA). A disposable LED sensor is attached to the patient's finger or toe, and its short electrical line is connected to a second electrical line that leads directly to a preamplifier. The final electrical connection is between the preamplifier and the oximeter. My colleagues and I have found it most convenient to place the preamplifier and the oximeter outside the magnet room and to run the electrical line from the LED through a copper pipe in the wall of the magnet room into the main console room. With the LED attached, the patient's hand or foot is wrapped completely in aluminum foil as is the entire electrical line leading to the copper pipe. The part of the copper pipe exposed in the magnet room is also completely wrapped with aluminum foil. The preamplifier and the oximeter are outside the RF-shielded magnet room and need not be wrapped.

A 1.5-T unit will not interfere with the operation of a standard pulse oximeter, but the RF energy emitted from the LED, electrical wire, preamplifier, and oximeter will interfere with the formation of an MR image. I underwent several trials with a pulse oximeter attached to my finger but without the aluminum-foil RF shielding. During these trials, oxygen saturation and heart rate remained accurate during routine MR examinations. No discernible image could be obtained during these studies ("salt and pepper" images) as long as the unshielded oximeter was used. Once the aluminum foil was applied, the images were free of artifact. At our institution, we routinely use a Nellcor N-200 pulse oximeter, which emits a broad spectrum of RF radiation but which has two peaks at 6 and 96 MHz (personal communication, S. Souza, C. Dumoulin, General Electric Corporate Research & Development Center, Schenectady, NY). The wire from the LED is passed directly through a copper pipe in the wall of the magnet room into the control room because we have been unsuccessful with the use of electrical filters in the penetration panel.

In more than 35 clinical studies, we have seen no complications with the use of aluminum foil, and the image quality has been indistinguishable from studies in which the oximeter was not used. Tolerance by the patients has been excellent.

Pulse oximetry is a simple, noninvasive, and reliable method of detecting arterial oxygen saturation, and it rapidly has become an essential tool in monitoring sedated and anesthetized patients. A simple method of RF shielding by using aluminum foil will allow the routine use of a pulse oximeter in a 1.5-T MR unit.

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