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focal. The peculiar shape of this "hyperconvex subdural hematoma" may serve as a clue to the correct diagnosis because the arachnoid membrane surrounding it can be stretched and ballooned more easily than the dura mater. Epidural hematomas are usually more fusiform. Finally, when a hyperconvex extraaxial hematoma contains a fluid level, the diagnosis of acute subdural hematoma should be considered.

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Physiologic Changes During High Field Strength MR Imaging

I read with interest the recent article by Kido et al. [1] concerning the physiologic changes during high field strength MR imaging, and I think that certain aspects of this paper need further clarification and explanation. In addition, I would like to offer some constructive criticism.

Kido et al. indicated that "the temperature increases and other physiologic changes observed during MR scanning . . . at RF powers of 0.2 and 0.8 W/kg were small and of no clinical concern." It should be noted that the investigators based their comments about temperature on measurements obtained from the axilla of their normal volunteers.

The purpose of the study was "to quantify changes in body surface temperature." However, the axilla is an unacceptable site for temperature measurement since it is not representative of surface (or skin) temperature, primarily because it is not an exposed surface, and the tissues of the upper arm radiate to one another. In thermophysiologic studies, numerous sites have been selected for assessments of changes in surface or skin temperature, but the axilla has never been one of them [2].

The authors also should realize that measurements obtained via contact techniques, such as the thermistor probe used in their study, are subject to considerable error because of the variations in skin temperature caused by pressure exerted from the device [3]. Conventional thermistors are also unacceptable for measurement of temperatures during exposure to RF radiation because the wire leads can distort the field and produce heating by electromagnetically induced currents [4]. High-resistance thermistors connected to leads with electrical conductivity characteristics that are about the same or less than the electrical conductivity of the surrounding medium (i.e., tissue) must be used [4]. It does not suffice to simply disconnect the thermistor during the MR scan and then connect it when the temperature measurements are taken, as was done in this study.

Nothing was mentioned about the environmental conditions (e.g., room temperature, relative humidity, airflow) in which these experiments were performed or whether the patients were allowed to adjust or "equilibrate" to these conditions. This is particularly important because temperature responses can be altered dramatically in relation to environmental changes. Were the environmental conditions controlled and the same for each subject in this study?

It was unclear whether the subjects undergoing the head scans had MR performed with a transmit/receive "head coil," as is usually the case in the clinical setting, or with the body coil. The indicated pulse parameters and specific absorption rates (i.e., up to 0.06 W/kg) suggest that the head coil was used; in that case, only a localized absorption of RF power occurs. The coil should be specified, particularly since the changes in temperature measured from the axilla cannot reveal to any substantial degree what is happening within the head coil. Because of the aforementioned issues, the significance of the information provided by this study is questionable.

Kido et al. indicated that their results (i.e., changes in axillary temperatures of 0.1°C for the 0.0 W/kg group, 0.2°C for the 0.2 W/kg group, and 0.5°C for the 0.8 W/kg group) were consistent with a study performed by Schaefer et al. [5] on RF radiation-induced heating. However, Schaefer et al. reported an average change in body temperature (measured in the esophagus) of only 0.3°C during a 20-min exposure at a specific absorption rate of 4.0 W/kg (approximately five times the level used in the study by Kido et al.). How can these results be considered comparable?

Another minor point, the bar graph in Fig. 1 does not appear to indicate the reported temperature changes of 0.1, 0.2, and 0.5°C for the subjects in the 0, 0.2 and 0.8 W/kg groups (i.e., the bars do not "line up" with the temperature scale).

The topic of temperature responses to MR imaging performed at specific absorption rates above the level recommended by the U.S. Food and Drug Administration (whole-body average specific absorption rate of 0.4 W/kg) is extremely important and has significant safety and economical implications. For these reasons, it is vital that investigations examining temperature changes resulting from the absorption of high RF power be conducted in a manner that is physiologically meaningful (i.e., measurements should be obtained at sites that are representative of skin and/or body temperatures) and clinically relevant (i.e., if transmit/receive surface coils are used, temperatures should be measured from the tissue that is contained within the coil). Only then will a thorough understanding of the thermal effects of RF radiation from MR imaging be understood so that safe levels of exposure and thresholds for adverse effects can be determined.

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Reply

We have attempted to answer the questions posed by Dr. Shellock in sequence. First, the axillary site was chosen as a compromise for measurements of body temperature and local surface temperature. Our primary concern was acceptance by the patient.

As mentioned in the article, the thermistor probe does behave as an RF receiver and cannot be used during RF exposure. The thermistor was not connected to the electronic circuit until approximately 1 min after each exposure, and the thermistor had a thermal response of T1/2 of approximately 1 sec. We never observed a rapid decrease in temperature during the measurements, and patients never reported that the thermistor felt warm (as they did when the thermistor was connected to the circuitry). We certainly agree that continuous monitoring of surface and core temperature should be performed, but we did not have access to that technology.

The environmental temperature was maintained between 20.0°C and 24.4°C, and air flow was maintained in the scanner by a fan. Humidity was not monitored, but conditions always were considered comfortable. To minimize the impact of changes in environmental temperature on our data, we used the prescan measurements as a baseline.

The head coil was used for the head scans and, as suggested, should not have contributed to axillary surface heating. Even the body scans should not have contributed significantly to axillary surface temperature as the RF pulses were positioned over the lower half of the abdomen.

The purpose of the study was to look for clinically significant changes. We thought that small, transient changes in local surface temperatures were not of clinical significance, and we were interested primarily in sustained increases in "body" temperature. It is unlikely that increases in local surface temperature are important as patients did not report local sensations of heat or burning.

The data from Schaefer and our study are consistent in that neither study shows clinically significant changes in temperature.

The data in Fig. 1 are plotted to three significant figures. Because the experimental accuracy was only 0.1°C, the numerical values in Table 2 were rounded off to the nearest 0.1°C.

We agree with Dr. Shellock that further studies should be performed, especially if more sophisticated monitoring capabilities are available to that group.

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Abbreviated Reports

MR Imaging of Pontine Tuberculoma

Tuberculomas account for up to 30% of all intracranial masses in endemic areas [1]. In more developed nations, however, CNS tuberculoma is rare, occurring mainly among immigrants [2, 3]. Brainstem tuberculomas are particularly unusual; only 8% of all intracranial tuberculomas are located in this region [4]. Imaging techniques are important in defining the extent of these lesions, directing biopsy procedures, and evaluating response to treatment. To our knowledge, this is the first reported case of a brainstem tuberculoma documented by MR imaging.

Case Report

A 63-year-old woman presented on August 15, 1985, with a 3-month history of progressive hemiparesis, dysarthria, and dysphagia. Neurologic examination revealed mild dysarthria, left-sided motor trigeminal and peripheral facial palsy, an immobile left soft palate, deviation of the tongue to the left on protrusion, and a mild left-sided hemiparesis without sensory deficit. Mild left-sided dysdiadochokinesia was found on cerebellar testing. CT with IV contrast showed a 1-cm lesion in the pons with marked enhancement (Fig. 1A).

MR was performed with a 0.35-T unit and showed a mass of decreased intensity on T2-weighted images that was 15 mm in diameter (Fig. 1B). This lesion was surrounded by a large zone of increased intensity on T2-weighted images, indicating edema, which extended through much of the pons into the cerebellar and cerebral peduncles (Fig. 1C). The fourth ventricle was slightly compressed and posteriorly displaced. The findings were thought to be due to an infectious process, most likely tuberculosis.

Five days after admission, the patient underwent stereotactic biopsy of the pontine lesion under CT guidance. Two 2-mm fragments of tissue were obtained and showed noncaseating granulomas composed of histiocytes, lymphocytes, and giant cells. Special stains showed rare acid-fast bacilli. The diagnosis of tuberculoma was subsequently confirmed by cultures, and antituberculous therapy was

A B C

Fig. 1.—63-year-old woman with pontine tuberculoma.
***A*, CT scan after infusion of contrast shows 1-cm lesion in pons.**
***B*, Sagittal MR image (TR = 1.0 sec; TE = 28 msec) shows a focal mass of decreased signal intensity.**
***C*, Axial MR images (TR = 2.0 sec; TE = 56 msec) show extension of edema in cerebellum.**