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Experimental and numerical assessment of MRI-induced temperature change and SAR distributions in phantoms

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I. INTRODUCTION

During an MR procedure, most of the transmitted RF power is transformed into heat within the patient's tissue and implants as a result of resistive losses which is referred to as the specific energy absorption rate (SAR) (1). The European committee for electrotechnical standardisation (CENELEC) has mandated that all scanners must measure the specific absorption rate of radiofrequency in patients and develop system safeguards to ensure that the limits set out IEC 60602-3-33 are not exceeded. Accurate estimation of SAR is critical to safeguard in unconscious/sedated patients, patients with compromised thermoregulation, implant patients, pregnant patients and neonates who require an MRI procedure. The increased static field strength and RF duty cycle capabilities in modern MRI scanners means that systems can easily exceed safe SAR levels for patients (2). Advisory protocols routine used to establish QA protocols do not have advise on the testing of SAR levels in MRI and this is not routinely measured in annual medical physics QA. There is increasing need to verify the manufacturers SAR estimations.

II. AIM

Aim of this research is to develop a protocol to verify the SAR delivered to a patient's head. There are a number of experimental approaches to verify SAR however these methods broadly fall into three categories; phantom, mathematical modelling and MR thermography. To ensure these methods are accurate for actual MRI coils, however, it is necessary to compare to experimental results. To determine the RF power deposition and its thermal effects in tissue we will use a T1 doped MR phantom in 4 channel head coil where the only source of heat is the radiofrequency fields produced by the imaging coil. The temperature changes in the phantom will be determine using three independent measures, external calorimetric infra-red thermometry, thermal imaging and MR thermometry

III. METHODS

SAR is is equivalent to the heating source created by the electric field in the tissues. The SAR is defined

$$SAR = \frac{\sigma}{\rho} E^2 [W/kg]$$

where σ is the conductivity of the tissue [S/m], ρ is the density of the tissue kg/m, and E is the electric field (rms) [V/m]. The tissue heating effects will vary over the whole body with the greatest effects at the periphery and least in centre. As there is no negligible contribution from thermal conduction in our SAR assessment and our phantom is a nonperfused material the SAR at discreet points in the observation plane we can determined by the following equation

$$SAR \approx c \frac{\Delta T}{\Delta t} [W/kg]$$

where (J/kg K) is the specific heat of the phantom, [K] is the temperature rise, and [s] is the exposure time. The specific heat and emissivity of the phantom based on our material properties of dissolving agar (7 g/L), NaCl (10 g/L), and CuSO₄ (1 g/L) in distilled water are 3850 J/kg K and 0.97, respectively. The T1 properties of the phantom were determined at room temperature using a STIR sequence over times ranging from 50- 2000ms.

IV. RESULTS

A baseline STIR sequence was followed up by a standard Brain protocol acquisition was applied over the whole phantom. This included localizer, T2 axial TSE, FLAIR axial TSE, T1 sagittal and Flair Sagittal. Post a standard brain protocol a further STIR sequence was acquired. The highest temperature rise was at the periphery of the sequence with ΔT of 3 degrees and less than 1 degree overall.

V. DISCUSSION

We have developed an open source phantom that can in dependently verify the temperature rise associated with SAR.

REFERENCES

1. Shellock FG. Radiofrequency energy-induced heating during MR procedures: a review. *J Magn Reson Imaging*. 2000;12(1):30-6.
2. Crook N et al., A review of the safety implications of magnetic resonance imaging at field strengths of 3 Tesla and above. *Radiography*. 2009;15(4):351-

Conflict of Interest: the authors have no conflict of interest to disclose

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