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ESTIMATION OF SPECIFIC ABSORPTION RATE (SAR) IN AN 1.5 TESLA MAGNETIC RESONANCE IMAGING (MRI) SCANNER USING COMMON BRAIN SEQUENCES

Radiology

Esther C. Igboanugo – BSc – MIT (Intern), Department of Radiology, SRM Medical College Hospital & Research Centre, SRM Institute of Science &Technology, Potheri, Kattankulathur – 603 203, Tamil Nadu, India.

Victor R. Lazar* – Tutor, Department of Radiology, SRM Medical College Hospital & Research Centre, SRM Institute of Science &Technology, Potheri, Kattankulathur – 603 203, Tamil Nadu, India. *Corresponding Author

Binitha.B – BSc – MIT (Intern), Department of Radiology, SRM Medical College Hospital & Research Centre, SRM Institute of Science &Technology, Potheri, Kattankulathur – 603 203, Tamil Nadu, India.

Kingsly.D – BSc – MIT (Intern), Department of Radiology, SRM Medical College Hospital & Research Centre, SRM Institute of Science &Technology, Potheri, Kattankulathur – 603 203, Tamil Nadu, India.

Ananthi.M – Assistant Professor, Department of Radiology, SRM Medical College Hospital & Research Centre, SRM Institute of Science &Technology, Potheri, Kattankulathur – 603 203, Tamil Nadu, India.

ABSTRACT

The purpose of present study is to identify the routine Magnetic Resonance Imaging (MRI) brain sequences that might give higher Specific Absorption Rate (SAR) values in patients. The measurement of SAR quantifies the possibility of tissue heating due to the deposition of Radio Frequency (RF) waves. This study was performed using Siemens, Magnetom, Essenza 1.5 Tesla scanner. The brain scans were performed using fluid attenuated inversion recovery (FLAIR), diffusion weighted imaging (DWI), gradient echo (GRE), spin echo (SE) and fast spin echo (FSE) sequences in fixed order. The measured values showed higher SAR values for SE and FSE sequences and minimal SAR values for other sequences. This study identified that the RF deposition on patients is not controlled by the type of sequences, but determined by the internal parameters of the respective sequences.

KEYWORDS

MRI – Magnetic Resonance Imaging, SAR – Specific Absorption Rate, RF - Radio Frequency, FLAIR – Fluid Attenuated Inversion Recovery, DWI – Diffusion Weighted Imaging, GRE – Gradient Echo, SE – Spin Echo, FSE – Fast Spin Echo

INTRODUCTION

Magnetic Resonance Imaging (MRI) is an imaging modality that uses homogenous magnetic fields (main magnetic B_0 field), varying magnetic fields (gradient magnetic fields) and Radio Frequency (RF) fields to acquire MR images. The biological effects of the above fields (non-ionizing) in MRI are much safer when compared with Computed Tomography (CT), Fluoroscopy and General Radiographic Imaging modalities, which use ionizing radiations. The biological effect of RF is the only major concern in MRI which can result in RF energy deposition on patients, resulting in general/localised tissue heating effects[3]. Hence the effects of RF are automatically monitored by the MRI scanner through the Specific Absorption Rate (SAR) tool. The purpose of this study was to measure the amounts of RF deposited to patients using the SAR tool, during an MRI brain scan for five common MRI brain sequences.

MATERIALS AND METHODS

Twenty one patients were prospectively analyzed during routine MRI brain scans. Siemens, Magnetom Essenza 1.5 Tesla MRI scanner with Volume Head coil and Head first positioning were used for this study. The patient's weight was measured prior to the MR scan and respectively entered in the MRI scan protocol. The order of MRI sequence acquisition were kept constant for all the 20 patients and the default clinical brain sequences were used without any modifications (Table 1 & Figure 1). The order of acquisition were: (i) Localizer, (ii) FLAIR, (iii) DWI, (iv) GRE, (v) SE and (vi) FSE sequence respectively. The SAR values were recorded immediately after each sequence using the SAR tool from the MRI console system. The acquired data were recorded and processed in Microsoft Office Excel 2007 software.

Table.1: List of MRI sequences and their parameters used in the study

PARAMETERS	FLAIR	DWI	GRE	SE	FSE
Number of images	22	22	22	22	22
Averages	1	4	1	1	1
Field of view (mm)	230	230	230	230	230
Slice thickness (mm)	5	5	5	5	5
Time of acquisition (min:sec)	2:26	2:12	1:59	1:30	1:47
Repetition time (ms)	9000	4200	700	450	5000
Echo time (ms)	87	119	26	10	90
Inversion time (ms)	2500	-	-	-	-
Turbo factor	17	-	-	-	15
Echo train per slice	7	-	-	-	20
Band width (Hz/px)	190	892	200	144	172

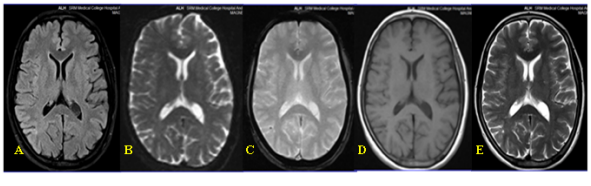


Figure 1: Acquired images of (A) FLAIR, (B) DWI, (C) GRE, (D) SE & (E) FSE

RESULTS

The comparison between depositions of RF in Head with relation to all sequences described a pattern of maximum values for SE, followed by FSE, FLAIR, DWI and GRE sequence (Figure 2). Comparison between RF power and all sequences was also observed to be higher in SE sequence followed by FSE, FLAIR, DWI and GRE sequence

(Figure 3). The comparison between total SAR (%) deposit and all sequences was also observed to be higher in SE sequence followed by FSE, FLAIR, DWI and GRE sequence (Figure 4).

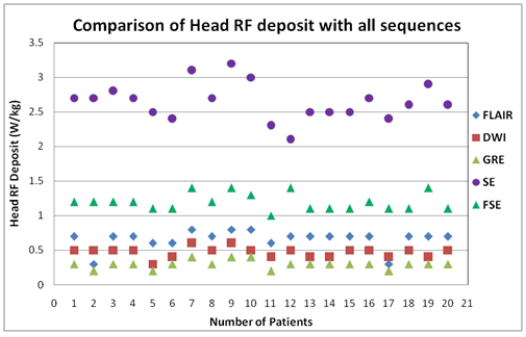


Figure 2: Scatter plot describing the comparison of Head RF deposit in relation to all acquired sequences.

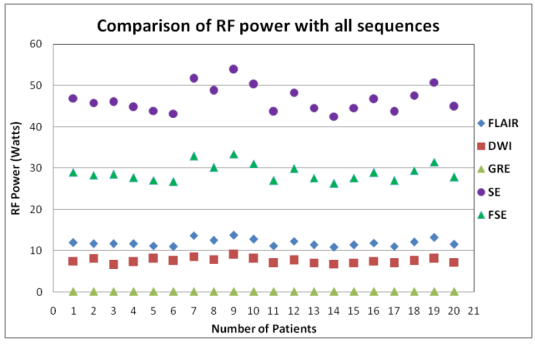


Figure 3: Scatter plot describing the comparison of RF power applied in all acquired sequences.

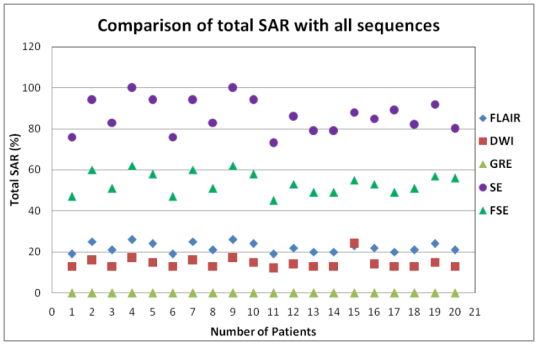


Figure 4: Scatter plot describing the comparison of total SAR deposit, in relation to all acquired sequences.

DISCUSSION

SAR is indeed an important parameter when considering the amount of RF deposited in a patient during any MRI examination. In previous study, SE, particularly FSE, delivered more RF power which resulted in higher SAR and more tissue heating while gradient echo technique resulted in lower SAR and less tissue heating[1]. The numerical values of partial-body and local peak SAR was also studied to ensure that absorbed RF do not produce any harmful health effect on patients[2]. During MR procedures, the majority of the RF power transmitted for imaging or spectroscopy (especially for carbon decoupling) is transformed into heat within the patient's tissue as a result of resistive losses. The exposure to RF radiation may produce various physiological effects including those associated with alterations in visual, auditory, endocrine, neural, cardiovascular, immune, reproductive, and developmental function[3]. The specific absorption rate (SAR) increases with the radial dimension of the patient[4].The SAR distribution due to human head exposure to radio frequency radiation during MRI revealed areas with increased values[5]. Diffusion coefficients have shown significance on estimating accurate SAR values as a standardized method[6].

CONCLUSION

SE images exhibited higher SAR for all patients when compared with FSE, FLAIR, DWI and GRE consistently. In general SE sequences are believed to give reduced SAR due to their application of minimal RF pulses. But, the current result describes higher RF deposition to patients in SE sequence when compared with all the other sequences. The possible reasons for high SAR in SE sequence for clinical imaging can be due to: (i) the use of T_1 weighted image that employs decreased repetition time (Table 1), which may result in reduced time for tissues to dissipate the absorbed RF energy and (ii) the use of high RF power (Figure 3).

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