International Journal of E-Health and Medical Communications
Volume 12 • Issue 1 • January-March 2021

Data Mining of MR Technical Parameters:
A Case Study for SAR in a Large-Scale MR Repository

Adriana Murraças, University of Aveiro, Portugal

Paula Maria Vaz Martins, School of Health Sciences, University of Aveiro, Portugal

Carlos Daniel Cipriani Ferreira, Perspectum Diagnostics, Ltd, Oxford, UK & Institute of Nuclear Sciences Applied to Health (ICNAS), University of Coimbra, Portugal

Tiago Marques Godinho, University of Aveiro, Portugal

Augusto Marques Ferreira da Silva, University of Aveiro, Portugal

ABSTRACT

Exposure to radiofrequency (RF) energy during a magnetic resonance imaging exam is a safety concern related to biological thermal effects. Estimation of the specific absorption rate (SAR) is done by manufacturer scanner integrated tools to monitor RF energy. This work presents an exploratory approach of DICOM metadata focused in whole-body SAR values, patient dependent parameters, and pulse sequences. Previously acquired abdominopelvic and head studies were retrieved from a 3 Tesla scanner. Dicoogle tool was used for metadata indexing, mining, and extraction. Specifically weighted pulse sequences were related with weight, BMI, and gender through boxplot diagrams and effect size analysis. A decrease of SAR values with increasing body weight and BMI categories is observable for abdominopelvic studies. Head studies showed different trends regarding distinct pulse sequences; in addition, underage patients register higher SAR values compared to adults. Male individuals register marginally higher SAR values. Metadata recording practices and standardization need to be improved.

KEYWORDS

Cliff's Delta, Data Mining, Dicoogle, Effect Size, Large Repository, Magnetic Resonance, Pulse Sequences, Specific Absorption Rate

INTRODUCTION

The imaging modality of magnetic resonance (MR) involves the absorption of radiofrequency (RF) energy by the human body, comprising one of the main patient safety concerns during the exam due to heating risk of tissues. Monitoring RF absorption is achieved by the estimation of specific absorption rate (SAR) expressed in watts per kilogram (W/kg) (Hartwig, 2015).

Several studies deal with SAR values over computational simulations, but the usage of the ones obtained in real patient in everyday MR practice are hardly ever analyzed. Guidelines and reviews address SAR as dependent of the patient weight, introduced by the MR technologist, but are not specific in what way weight influences SAR. The only way to assess SAR during the MR exam is to trust in the methods applied by the manufacturers, that return an output of an estimated SAR that can limit acquisition conditions according to guideline values.

DOI: 10.4018/IJEHMC.2021010102

In this respect, the scope of this article is to present an exploratory approach of whole-body SAR values reported by the equipment and stored in DICOM metadata. It uses a large metadata repository acquired in a 3 Tesla scanner. Such repository was indexed in an open source platform named Dicoogle. Data was organized, selected, and characterized. Abdominopelvic and head studies were selected for further analysis as well as specifically weighted pulse sequences for each study type. Whole-body SAR values were related with categorical patient weight, categorical BMI, and sex. This study also deals with statistical analysis regarding large data repositories.

The objectives of this work are, on one hand, related with SAR values and, on the other hand, with data itself. Specifically, assess the scenario regarding whole-body SAR values reported by the MR scanner and acquired in real patients, looking for trends or patterns regarding human physical factors (patient weight, BMI, and sex) and image acquisition parameters (pulse sequences). Simultaneously, dealing with a large repository of MR metadata, given its specific constrains such as data handling, data diversity, and data statistical analysis.

This article is organized as follows. The Background section includes the presentation of the problem, related nomenclature and reference to relevant literature on the topic. Section of Methods describes the applied approach, including a flowchart, regarding three separated topics: Data acquisition, organization, and preparation; Data characterization; and Data representation and statistical analysis. Section of Results is divided into three matters: Weight and BMI: abdominopelvic studies; Weight and BMI: head studies; and Sex: abdominopelvic and head studies. Discussion section examines the observed results, referring to comparative literature when reasonable. Ending with Conclusion section, where the main findings, limitations and future scope are addressed.

BACKGROUND

Magnetic resonance (MR) is a widely used imaging modality with superior soft tissue contrast and flexible tools for diagnosis, physiological, and functional applications (Kim & Kim, 2017; Kraff & Ladd, 2016). In Europe, for the countries for which data is available, there was a general increase between 2011 and 2016 in the number of MR scans conducted relative to population size (Eurostat, 2019).

MR image acquisition does not use ionizing radiation and comprises an interaction between three types of magnetic fields with the human body: a high static magnetic field (B_0), three gradient magnetic fields (G_x, G_y, and G_z), and a radiofrequency (RF) field (B_1) (Hartwig, 2015). The timing of application of gradients and RF pulses is determined in a MR pulse sequence (pSq). There are two fundamental types of MR pSq: spin echo (SE) and gradient echo (GRE); other MR sequences are variations of these, with different parameters added on (Bitar et al., 2006). MR is considered a safe technology but is not hazard-free.

The magnetic fields involved in image acquisition can cause dangerous biological effects for the patient if the hazards are not taken into consideration (Hartwig, 2015; Stralka & Bottomley, 2007). Specifically, the RF power deposition is linked with thermal effects, due to tissue heating caused by direct absorption of energy and induced currents. The safety aspects regarding RF exposure are regulated via international government and industry guidelines published by ICNIRP (International Commission on Non-Ionizing Radiation Protection, 2014), FDA (Food and Drug Administration, 2014), and the IEC (International Electrotechnical Commission), ensuring patient safety and compliance with safe exposure levels (Hartwig, 2015). In the IEC standard, whole-body SAR limits are specified for the three MR operating modes: normal (< 2 W/kg), 1^{st} level controlled (< 4 W/Kg) and 2^{nd} level controlled (> 4 W/kg). Other SAR limits are defined for different body regions and for localized SAR estimations (Fiedler, Ladd, & Bitz, 2018).

Monitoring RF energy absorption is achieved by estimation of the specific absorption rate (SAR), measured in watts per kilogram (W/kg). SAR is used in safety standards and guidelines and represents a convenient and current way to control possible temperature increases (Formica & Silvestri, 2004;