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Knowledge and practice of computed tomography exposure parameters amongst radiographers in Jordan

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ABSTRACT

Objective: To investigate the knowledge and practice of computed tomography (CT) radiographers working in Jordan.

Materials and methods: This Institutional Review Board (IRB) approved study disseminated a questionnaire via social media and recruited 54 Jordanian CT radiographers. The questionnaire comprised 36 questions divided into four sections: demographics; an evaluation of knowledge regarding CT exposure; modifications to CT exposure for paediatric patients; dose units and diagnostic reference levels (DRLs). Descriptive and inferential statistics including Chi-square tests, Mann–Whitney U tests, independent samples t-tests and Kruskal–Wallis H tests were employed. Statistical significance was considered below $p < 0.05$.

Results: The 54 participants had various qualifications, with the majority holding a Bachelor's degree (n = 35, 64.8%) and the rest holding a Diploma (n = 19, 35.2%). In order to pass the questionnaire, participants needed to score 13 correct answers. The overall number of radiographers who correctly passed the questionnaire was 48 (88.9%). None of the participants correctly stated all the DRL values for chest, abdomen and brain CT. However, four out of 54 respondents (7.4%) knew the chest DRL value, three (5.6%) participants correctly estimated the abdominal DRL value but only two (3.7%) knew the DRL for the brain.

Conclusion: Good general knowledge was found amongst radiographers regarding the relationship of each exposure parameter to the image quality and patient dose. However, there was poor knowledge of diagnostic reference levels and the order of the organ radiation sensitivity. The need for CT radiographers to undertake further education that focuses on radiation exposure in CT is highlighted.

1. Introduction

Computed tomography (CT) has experienced rapid advances over the last decade in terms of both use and technology [1,2]. It is fast becoming the diagnostic modality of choice for a wide range of diseases and is surpassing conventional imaging in many abdominopelvic examinations [1,3]. In neurological imaging, CT for trauma and stroke evaluation is essential due to its fast sub-centimetre image reconstruction [4,5]. Despite the fact that CT has undeniable value in producing high-quality two- and three-dimensional images, the use of ionizing radiation remains a concern [6]. The radiation dose used in most CT examinations is creeping upwards and is significantly higher than it was a decade ago [6]. Thus, it is important that radiographers are actively involved in minimizing the radiation dose while maintaining or improving the image quality. CT scanning accounts for more than 10% of the procedures for diagnostic radiology and nearly two-thirds of the collective radiation dose [7]. The radiation risks associated with CT exceed those of other imaging modalities utilizing ionizing radiation. For example, the dose from CT of the chest is 100–1000 times greater than a conventional chest x-ray [1]. A single CT scan is equivalent to one year's exposure to both natural and man-made radiation [8]. It has been estimated that around 30% of those who undergo CT scans will be examined at least 3 more times in the future [1,2]. Moreover, the possibility of acquiring fatal cancer increases up to 1 chance in 2000 as the CT examination's effective dose approaches 10 mSv and more [6].

In CT there is a strong relationship between the image quality and

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radiation dose. Using too low a dose can come at the expense of good image quality [9,10]. The exposure parameters that radiographers manipulate, namely the mAs, kVp, pitch and slice thickness, have a direct impact on the image quality and patient dose. The mAs and the kVp have a direct relationship with the patient dose [11]. On the other hand, pitch and slice thickness have an inverse relationship to the dose. So, by increasing the mAs and kVp and by decreasing the pitch and slice thickness, the quantity of x-rays will increase and the image quality will increase, but the patient dose will also increase [12].

A relatively recent feature added to most CT scanners is automated tube current modulation (ATCM) [9,13]. ATCM helps to optimise the dose by modifying the mAs according to the thickness of the body part being scanned whilst maintaining the same image quality throughout the procedure [12,13]. One study reported that radiographers lack knowledge about the appropriate application of ATCM. Although the majority of radiographers were aware of the general purpose of the ATCM, over 50% were unaware that ATCM increases the dose, for example, to the patient in the pelvic region [9]. As such, 38% of radiographers were unaware that improper positioning of the patient within the gantry would affect the performance of the ATCM [14]. This is concerning especially since it is estimated that inappropriate use of CT scan parameters can vary the radiation dose up to 41% [15]. Similarly, another study found that almost 50% of radiographers assumed that ATCM should not be used with patients with metallic implants, which is an inaccurate assumption since ATCM would still assist in dose reduction [9].

Diagnostic reference levels (DRLs) are radiation dose values for specific x-ray examinations that should not be consistently exceeded for average sized patients if good radiographic practice is in place. According to previous studies, the establishment of the diagnostic reference levels (DRL) has contributed to a 50% reduction in the dose delivered to patients [16,17]. Radiographers are the front line for delivering the radiation dose and should use their informed judgment regarding each examination protocol requested by medical practitioners [18]. In order to implement the principle of keeping the dose as low as reasonably achievable, radiographers should have sufficient knowledge of the relationship between each exposure parameter and the image quality [12,14]. They should also be knowledgeable about the DRLs recommended for common examination [9]. The aim of this study is to assess the knowledge and practice of computed tomography (CT) radiographers working in Jordan.

2. Materials and Methods

2.1. Patient demographics

This study was approved by an Institutional Review Board (IRB) committee at the Jordan University of Science and Technology, Jordan. Data was collected via an online survey (Google survey) that was distributed using the Facebook social media network. No identifying personal information was collected. The study involved radiographers with different levels of experience in CT. Eligible participants were recruited through non-probability sampling techniques; convenience and snowball sampling. A power analysis using Cohen's formula (1992) indicated that a sample of 54 would give an 85% chance of detecting correlations of $\pm$ 0.223 at $p \leq 0.05$.

2.2. Questionnaire

The proposed questionnaire consisted of 38 mandatory questions in English. It was divided into four sections to assess the knowledge and practice of radiographers. The first section collected demographic information about the participants' work experience. The second section evaluated the radiographers' knowledge of exposure parameters including kVp, mAs, pitch, slice thickness and ATCM, as well as the relationship between exposure parameters, image quality and patient dose. The third section focused on practice in paediatrics. It presented two paediatric cases to assess whether the radiographers were able to modify the exposure parameters based on the patients' age and weight. The last section was about the dose and assessed knowledge of the recommended DRL and radiation doses. Multiple formats of questions were used, including short answers, open-ended questions and true/false questions.

2.3. Validation of the questionnaire

In order to finalise the study tool, a panel of three experienced radiographers and three medical imaging lecturers from Allied Medical Sciences of Jordan University of Sciences and Technology reviewed the questionnaire methodologically. Piloting of the tool confirmed that the content was appropriate for CT radiographers and the questions were not ambiguous. Based on suggestions from the selected panel, modifications were made related to the structure and arrangement of the questions.

The reliability was ensured through a pilot survey that was conducted and distributed to university students (n = 10) who were randomly selected. Moreover, a test–retest method was used. After a 10-day interval, the same students who were selected earlier were asked to answer the same questionnaire.

2.4. Statistical analysis

For analysis of data, the Statistical Package for Social Sciences software, version 20.0 (SPSS Inc., Chicago, IL) was used. Initially, all the information gathered via the questionnaire was coded into variables. Normality of the data was tested using the Kolmogorov–Smirnov test. Both descriptive and inferential statistics involving the Chi-square test, Mann–Whitney *U* test or independent samples t-tests and Kruskal–Wallis H test were employed. For each test, a p-value equal to or less than 0.05 was considered statistically significant.

3. Results

A total sample of 54 radiographers was obtained. There were 35 (64.8%) participants that held a Bachelor degree and 19 (35.2%) with Diplomas. The duration of experience in the CT field varied from less than 3 months to a maximum of 20 years. There was a relatively even mix of genders, with 30 (55.6%) participants being female and 24 (44.4%) being male. In addition, those with less than 5 years' experience were greater in number (n = 34, 62.2%) than degree holders with more than 5 years' experience (n = 20, 37.8%).

Within the full sample of 54 radiographers, 57.4% reported that they have sufficient knowledge and skills to change parameters without degrading the image quality. However, only 35.2% of radiographers reported applying modifications in their daily practice, meaning that they used the manufacturer's pre-set values or the set departmental protocol.

3.1. CT knowledge

Out of the 26 questions that were scored to assess radiographers' knowledge, 18 questions investigated the participants' knowledge regarding basic parameters in CT. The six main parametric factors the questionnaire assessed were kVp, mAs, noise, pitch, slice thickness and ATCM. In order to pass the questionnaire, participants needed to score 13 correct answers. The overall number of radiographers who correctly answered the questions regarding CT exposure parameters was 48 (88.9%) out of 54. Those radiographers achieved a score of ($\geq$9) out of 18. Further values are explained in Table 1.