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Assessment of the knowledge of CT technologists regarding radiation protection and computed tomography parameters in Libya

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Abstract:
To evaluate the knowledge of CT technologists about radiation protection as well as CT parameters and their impact on image quality and patient dose. This cross-sectional descriptive-analytic study was performed in 11 government hospitals from different cities, Libya, was conducted between April and September 2025, using a valid and reliable online questionnaire consisting of 18 questions assigned to 150 CT technologist. Each questionnaire contained demographic characteristics along with CT parameters including mAs, pitch, scan time, automatic tube current modulation, image construction technique and effects of these parameters on image quality and radiation dose. There were statistically significant differences in the level of knowledge among CT technologists regarding radiation protection and specialized training, with 73% reporting that they had not received any training in this regard. As for knowledge of the device's parameters and their relationship to image quality and patient dose, 74% of them reported that they had not received any training on this subject, and the results showsa significant difference in the mean mAs (1.09±0.288, $P<0.005$), pitch(1.21±0.409, $P<0.005$), ATCM (1.39±0.490,$P<0.05$)and image reconstruction(1.15±0.339, $P<0.005$). The overall familiarity of CT technologists about radiation protection and scan parameters which affecting image quality, dose or both was found insufficient. In this case, retraining update courses should be offered frequently to augment and refresh the knowledge of technologists. which can contribute to reducing exposure for patients, CT staff and community at the same time.

Keywords: CT scan, Radiation Protection, CT Parameters, Image Quality.

تقييم معرفة تقنيي التصوير المقطعي فيما يتعلق بالحماية من الإشعاع عوامل التصوير المقطعي في ليبيا

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الملخص
لتقييم معارف تقني التصوير المقطعي حول الحماية من الإشعاع، بالإضافة إلى عوامل التصوير المقطعي وتأثيرها على جودة الصورة وجرعة الإشعاع للمريض. أُجريت هذه الدراسة الوصفية التحليلية المقطعية في 11 مستشفى حكوميًا في مدن مختلفة بليبيا، بين أبريل وسبتمبر 2025، باستخدام استبيان إلكتروني صحيح وموثوق، يتكون من 18 سؤالًا موجهًا إلى 150 تقني تصوير مقطعي. تضمن كل استبيان خصائص ديموغرافية، بالإضافة إلى عوامل التصوير المقطعي، بما في ذلك الملي أمبير، ودرجة الصوت، وزمن المسح، وتعديل تيار الأنبوب التلقائي، وتقنية بناء الصورة، وتأثير هذه

العوامل على جودة الصورة وجرعة الإشعاع. وُجدت فروق ذات دلالة إحصائية في مستوى المعرفة بين تقني التصوير المقطعي فيما يتعلق بالحماية من الإشعاع والتدريب المتخصص، حيث أفاد 73% منهم بعدم تلقيهم أي تدريب في هذا الصدد. فيما يتعلق بمعرفة عوامل الجهاز وعلاقتها بجودة الصورة وجرعة المريض، أفاد 74% منهم أنهم لم يتلقوا أي تدريب حول هذا الموضوع، وتُظهر النتائج فرقًا كبيرًا في متوسط ألمللي أمبير (1.09±0.288، P <0.005)، ودرجة التباين (1.21±0.409، P <0.005)، وعوامل التحكم التلقائي في تيار الأنبوب (1.39±0.490، P <0.05)، وإعادة بناء الصورة (1.15±0.339، P <0.005). وُجد أن الإلمام العام لتقني التصوير المقطعي بالحماية من الإشعاع وعوامل التصوير المقطعي التي تؤثر على جودة الصورة أو الجرعة أو كليهما غير كافٍ. في هذه الحالة، ينبغي تقديم دورات تحديث إعادة التدريب بشكل مستمر لتعزيز وتحديث معرفة التقنيين، مما يمكن أن يُسهم في تقليل التعرض للمرضى وتقني التصوير المقطعي والمجتمع في الوقت نفسه.

الكلمات المفتاحية: التصوير المقطعي، الحماية من الإشعاع، عوامل التصوير المقطعي، جودة الصورة.

Introduction

Computed tomography (CT) is an X-ray imaging technique that has revolutionized modern medicine. Due to the high accuracy, speed, non-invasiveness, and higher image resolution than conventional radiographic imaging, this method is gaining attraction in diagnosing and monitoring disease processes. Developing technologies, such as multi-detector CT (MDCT), have led to a growing demand for CT examinations [1,2]. On the other hand, CT is a significant source of radiation production and is associated with a considerably higher dose than other radiological procedures, accounting for nearly 50% of medical radiation exposure; for example, a chest CT scan delivers a dose of ionizing radiation 100–1,000 times greater than a corresponding chest X-ray examination [3].

Radiation exposure at high doses increases the risk of cancer over a lifetime, and this risk is estimated to be significantly higher in children than in adults due to their increased sensitivity to radiation [4]. As a result, patient doses must be kept as low as possible while maintaining an acceptable level of image quality. To achieve this goal and protection from ionizing radiation, adherence to the ALARA (as low as reasonably achievable) principle is essential [5]. The exposure parameters that are utilized in CT examination, such as tube current-time product (mAs), peak kilovoltage (kVp), slice thickness, pitch, and automatic tube current modulation (ATCM), directly affect the radiation dose and image quality [6]. The kVp and mAs directly correlate with the dose, such that a reduction of about 46% in tube current and 17% in kVp results in a reduction of about 70% in dose [7]. Slice thickness and pitch, on the other hand, are inversely related to patient dose [8]. There are various combinations of these parameters for CT users to choose from, some of which are pre-determined by the manufacturer.

As reported, nearly half of radiology technologists followed the device's recommended protocols and made no modifications [9]. However, manufacturer-recommended protocols and default settings may be optimized for medium-sized patients and provide the optimal image quality without optimizing patient dose [10]. Thus, radiology technologists must employ the most appropriate protocols for the patient's size, the organ, and the area being studied to obtain an acceptable image quality with the optimum amount of radiation exposure possible according to the ALARA principle [11]. Due to the constant evolution of CT scan technology, radiology technologists must constantly improve and update their knowledge.

In Libya, radiology students must complete four years of university study before they can graduate as radiology technologists. In the workplace, graduates with little job experience work with radiography devices, namely "radiographers" and graduates with high job experience work with CT devices, namely " CT technologists". This study aims to determine the level of knowledge of CT technologists regarding radiation protection, scan parameters in Libyan hospitals. This study was descriptive and analytical in nature, avoiding bias in data and results, unlike some studies that followed a methodology of reviewing previous studies.The findings of this study can be used to formulation of proper training courses for improving required skills and knowledge around CT exposure parameters for radiology technologists, and develop new strategies for optimizing CT examinations and minimizing radiation doses to patients, CT staff and community.

Methods

Study design and setting

This study was cross-sectional on a descriptive and analytical approach in the computed tomography units. The population sample consisted of radiology CT technologists from eleven government hospitals located in different cities in Libya and was conducted from April to September 2025. Using a valid and reliable online questionnaire with 18 questions, the questionnaires were distributed to 150 CT technologists. Each questionnaire included questions about demographic characteristics, radiation protection and CT parameters; mAs, pitch, and automatic tube current modulation (ATCM) as well as the effects of these parameters on image quality and radiation dose.A questionnaire was conducted entitled assessment of the knowledge of CT technologists regarding radiation protection and computed tomography parameters. The sample size was set to be 150 participants. For the statistical procedures, descriptive statistics were applied, and for the data collection, self-administered questionnaires were used. A validated, self-administered questionnaire was designed with 18-item questions. It was shared with the subjectsthrough an online platform (Google form) and responses were collected from 100 participants. Study participants were CT technologists who specialize and qualified in medical imaging and radiology technology

Data collection procedure

18-item questions were divided into two sections., the first section concerning general information comprised (3) independent questions regardingsocio-demographic data of respondents, level experience and availability of training opportunities related to radiation protection. The second section included (15) specific questions related to knowledge on CT scan parameters, such as mAs, pitch, tube rotation speed and ATCM, availability of training opportunities for CT technologists related to reducing radiation dose. Questions were answered by "yes" or "no" or by indicating an option from the multiple-choice answers, with a few open-ended questions as well.Basically, the questionnaire administered to participants became a point of reference for our analysis to observe and establish patterns and relationships in the data acquired.

Data analysis

The data were collected and statistically analyzed by using SPSS software which stands for social sciences software (SPSS version 27). Descriptive statistics were used to summarize demographic data and survey responses (frequency, percentage, mean, standard deviation). Inferential statistics including Chi-square goodness fit test was employed to examined the statistically significant differences of sample distribution cross variable categories., *P*-value <0.05 was considered statistically significant

Results

Table 1. Shows the demographic and characteristics of participants

Variable	**n=100(%)**
Gender	
Male	**66(66)**
Female	**34(34)**
Age group (years)	
21-30	**50(50)**
31-40	**20(20)**
41-50	**13(13)**
51- 61	**12(12)**

The questionnaires were completed by 100 out of 150 CT technologists, resulting in a 67% response rate., The demographic data displayed in (Table 1) pointed out that the group of participants was mainly male, making up 66% of the total respondents. The age distribution reflects the fact that the professionals' ages were mostly concentrated on the younger side, with the 21-30 years' age range comprising 50% of all the respondents. This demographic profile indicates a young workforce in CT technologists, which could potentially reflect their levels of expertise and the nature of the training they might have undergone or required.

Table 2. This table shows the Level of experience

level of years	**n (%)**
>5	**42(42)**
5-10	**14(14)**
More than 10 years	**44(44)**

Table 2. Shows the demographic characteristics of survey participants according to experience. the survey revealedthat42% of participants had less than five years of experience, 14% had experience ranging between five and ten years, while 44% had experience of more than 10 years. diversification of experiences is a good thing, and it helps the credibility of the finding.

Table 3. Shows percentage (n) of answers related to radiation protection of participants.

No	**Question**	Answer		**Mean ± SD**	***P*-value**
1	Attended a training course in radiationprotection, practice?	Yes No	27 73	1.34±0.476	**< 0.005**

Availability of training opportunities related to radiation protection (Table 3) indicates that 73% of respondents reported that they had not received any formal training in radiation protection during their professional practice. Even though more than half 27% were familiar with the topic through previous training, the significant difference between these two categories., mean (1.34±0.476, *P*<0.05) points to a very large extent of professionals lacking basic knowledge. Inadequate training may contribute to poor knowledge, which in turn contributes to excessive radiation exposure of patients and the use of suboptimal or even ill-considered techniques.

Table 4 Total answers of CT technologist about different CT parameters (Mean ± SD., *P* value).

Questions	Answer	N	Mean ±SD	*P*-value
1. Are you familiar with the radiation dose in computed tomography?	Yes No	60 40	1.4±0.492	**< 0.05**
2. Does training affect the level of awareness of CT technologists regarding radiation doses?	Yes No	93 7	1.07±0.256	**< 0.05**
3. The importance of offering radiation protection courses to CT technologists.	Yes No	93 7	1.07±0.256	**< 0.05**
4. Have you participated in any training related to the strategies to reduce radiation dose during CT scanning?	Yes No	26 74	1.74±0.441	**< 0.05**
5. Does mAs affect the radiation dose?	Yes No	91 9	1.09±0.288	**< 0.05**
6. Does Pitch affect the radiation dose?	Yes No	79 21	1.21±0.409	**< 0.05**
7. Does value of DLP affect the radiation dose?	Yes No	74 26	1.26±0.441	**< 0.05**
8. Does the length of the CT scan area affect the dose, either increasing or decreasing it?	Yes No	87 13	1.13±0.338	**<0.05**
9. Does tube rotation speed (scan time) affect the value of the radiation dose.	Yes No	83 17	1.17±0.378	**< 0.05**
10. Does reducing the amount of data needed to create a high-quality image contribute to reducing the dose?	Yes No	60 40	1.4±0.492	**0.046**
11. Does automatic tube current modulation reduce the dose to the patients.	Yes No	61 39	1.39±0.490	**0.028**
12. Is there a relationship between improving the quality of imaging and patient safety?	Yes No	89 11	1.11±0.314	**< 0.05**
13. Are you using specific protocols for each age group for each test?	Yes No	71 29	1.29±0.456	**< 0.05**
14. Do you think that the experiences of CT technologists contribute to reducing radiation doses?	Yes No	87 13	1.13±0.338	**< 0.05**
15. Does the use of modern technologyin CT contribute to reducing the dose for the patient?	Yes No	85 15	1.15±0.339	**<0.05**

Factors affecting radiation doses: The performance regarding the technical parameters specifically influencing doses, as visible from the stated results showed the various but statistically significant effects on the radiation doses, knowledge about the effect of mAs(Mean ± SD: 1.09±0.288, *P*<0.05), pitch (Mean± SD: 1.21±0.409, *P*-<0.05) , tube rotation speed (Mean ± SD: .117±0.378, *P*<0.05)and dose length product(Mean± SD: 1.13±0.338, *P*<0.05). This information is extremely important because it confirms that CT technologist is responsible for implementing the necessary measures to improve radiation safety in their routine practices and are expected to protect patients from unwanted exposure.

Protocol adherence and experience impact: Regarding the adherence to protocol, the responses showed (Mean±SD:1.29±0.456, *P*<0.05) that indicates the need for better compliance with age-appropriate protocols, it'sespecially crucial in this case due to the increased radio-sensitivity of pediatric patients. Furthermore, the views of the CT technologists experienced a significant dose reduction (Mean±SD: 1.13±0.338, *P*<0.05). There is a statistically significant difference in frequency distribution between categories of variable with (P<0.01).and the use of advanced technology (image reconstruction)., (Mean±SD: 1.15±0.339, $P<0.05$) were perceived positively. This points to general acknowledgment by the participants of the necessity that experience and the progress in technology play in overcoming the problem of reducing exposure to patients.

Discussion

Computed tomography (CT) has become an essential diagnostic tool used in the diagnosis of many diseases, contributing to saving many lives thanks to the accurate diagnostic information it provides, as well as reducing the cost of diagnosis and saving time. Despite its benefits, patients are potentially exposed to high doses of radiation, and the harmful effects of ionizing radiation can lead to genetic mutations and cancer [12]. The radiation dose from CT scans can be reduced by 50% without compromising the ability to distinguish normal anatomical features [13-14]. Similarly, the effective dose has been found to vary greatly from one examination to another; for example, the effective dose for a routine digital head CT scan was measured at 2 millisieverts, while it was found to be 31 mSv for a multiphase abdominal and pelvic scan [15].

This study identified significant variations in knowledge pertaining to various aspects of radiation science among CT technologists who operate in diagnostic radiology departments from eleven governmental hospitals established in different cities of Libya. Major topics for consideration were: One, principles of radiation protection and qualitative approaches to compliance with the guidelines for the practices in use of ionizing radiation. Two, management of radiation doses during CT examinations. Three, specialized training opportunities for radiology staff, especially the CT technologists.This professional group in this study consists mainly of young people (age 21 and 30 years), who can be described as a group of active CT professionals interested in change. The younger generation of professionals may be more receptive and quicker to learn new techniques and protocols, but their lack of experience compared to their more seasoned counterparts may require them to undergo a comprehensive initial training program and possibly more time in the mentorship and training process in radiation dose management. The balanced representation of women in the practice of this specialty is of great importance to female patients, especially children, as their presence reduces anxiety and stress and contributes to creating conditions conducive to the safe performance of diagnostic radiological examinations. Therefore, this issue deserves mention in discussions about workforce diversity in the profession and its importance in general. There should be developing training programs within an organization relevant to the safe and effective application of diagnosis or treatment. One especially scary outcome from this study is that 73% of CT technologists who participated in the study did not undergo any formal training in radiation protection at all, while around 74% of participants argued that they did not undergo any particular training about managing radiation dose during their employment. The main goal of the training was to safely and effectively implement medical practice where radiation was used as part and parcel of the diagnosis or treatment. The findings indicate a serious lack of training for radiation protection for CT technologists in Libyan hospitals in general and state that there are no short-term training courses in radiation protection and associated sciences. This deprivation of training leads to unsafe work practices and non-compliance with available radiation protection. The educational program of some of these practitioners on radiation dosage, despite all the experiences with radiation, remains a big problem for the safety of the patients. The finding suggests that this is not purely some individual's shortcoming, since there is ignorance in regard to the protection of radiation and the importance of reducing radiation doses in general, especially when it comes down to healthcare institution decision-makers allocating their annual budgetwithout paying attention to training programs. Well and adequately entertaining courses during the academic development of the radiation science students, including but not limited to radiation physics, radiation protection, and radiation biology, form the basis of imparting certain theoretical concepts of radiation protection and reduction methods, which the students will step into practice with their professions. Thus, potentially some very skilled technicians, mostly based on experience, might continue doing things the way they did before due to lack of education and training; however, they might not be privy to advanced dose optimization measures, thus causing patients to receive higher doses.

This concern is underscored by the International Atomic Energy Agency (IAEA), which, along with bodies such as the International Commission on Radiological Protection (ICRP), provides recommendations and guidelines to ensure that radiation exposure is justified, optimized, and kept as low as reasonably achievable (ALARA). Central to the implementation of these recommendations is comprehensive training in radiation protection. Such training ensures that healthcare professionals understand the risks associated with ionizing radiation, are proficient in the use of protective measures, and can appropriately balance diagnostic or therapeutic gain against potential harm. Given the evidence of individual variability in radiation sensitivity, the complexities of modern imaging and treatment modalities, and the evolving landscape of radiation dosimetry and monitoring technologies, the importance of effective training cannot be overstated.There are differences in the understanding of those important parameters of computed tomography in image production that are statistically significant in relation to the ongoing debate about their effects on image quality and on possible radiation dose exposures to patients as a result of insufficient knowledge and understanding of these parameters for generating really good diagnostic images while keeping a relative balance between quality and radiation dose, especially in children. It was found that CT technologists lack appropriate knowledge, which manifests itself in the absence of training opportunities in the area of applying radiation dose reduction methodologies in a disciplined scientific manner. 61% of CT technologists reported that they were aware of the importance of using automatic control of CT parameters such as automatic tube current modulation (ATCM), but 39% did not adjust CT parameters according to the patient's age, indicating a lack of understanding of the potential for dose reduction.It is useful to use a system that precisely controls the parameters, and therefore ATCM may be useful in significantly reducing radiation exposure[16]. Similarly, because the contrast of each anatomical region varies between organs, it is critical to select the appropriate protocol to achieve the best image quality [17].

Pitch., both noise and dose are pitch dependent in helical CT. Approximately 79%., ($P < 0.05$) of subject agreed that dose decreases as the CT pitch increases. The effective mAs proportional to dose is the tube current-time product/pitch. To compensate for the noise increases associated with increasing the pitch or decreasing the rotation time, manufacturers of CT systems include mechanisms that adjust the tube current so that mAs increases almost proportionally to the increase in pitch. As a result, while effective mAs remain constant, both noise and dose remain constant. The results of this study revealed that the knowledge of CT technologists regarding effective mAs was 91%. There was a significant difference in knowledge between the CT technologists regarding pitch and mAs effects on patient dose and image noise ($P < 0.05$). Scanning time: 83% of study participants are fully aware of the relationship between scan time and the radiation dose to which the patient is exposed, as scanning time directly influences the radiation dose deposited during CT examinations. Longer exposure times whether due to protocol design, patient movement, or unnecessary repetition—increase the cumulative dose. Protocol optimization, including the use of faster scanning techniques and motion correction algorithms, can reduce total exposure without compromising image quality.

The length of scan area., the radiation dose to which a patient is exposed during a CT scan is influenced by a complex interaction between technical parameters, procedural choices, and the practices and experience of the specialist, including the length and area of the scan. 74% of study participants reported that adjusting the length and area of the scan is important and contributes to reducing radiation dose.Therefore, the length of the examination area should be minimized to cover only the area of clinical interest. Excessive scanning i.e., imaging beyond the necessary anatomical boundaries contributes significantly to an increase in the dose length product (DLP) and effective dose [18]. Poor awareness or technical limitations may lead technologists to perform longer scans than are necessary for diagnosis, exposing patients to unnecessary radiation.

The ACR recommends that the lead radiologist, lead CT technologist and medical physicist should converge to design all new or modified protocol settings [19]. Computed tomography technologists have a significant responsibility and ethical obligation to determine and design protocols that take into account the patient's size, age, and anatomical characteristics. Taking into account the characteristics of the anatomical area being studied and adjusting protocols can help reduce the patient's dose, especially in examinations with high internal contrast that do not require high image quality, such as sinus or urinary tract examinations. Due to the varying contrast between organs in each anatomical region, it is necessary to select the appropriate protocol to obtain the best image quality. 71% (mean1.29 ± 0.456:$P<0.05$) of CT technologists reported that they use protocols based on the region and age of the patient. Similarly, because the contrast of each anatomical region varies between organs, it is critical to select the appropriate protocol to achieve the best image quality [20].

Majority of study participants (85%) they agreed that modern and advanced technology does help decrease the radiation dose while the quality of image remains intact. Advances in modern technology are now more progressive and feature innovations such as automatic tube current adjustment, iterative reconstruction algorithms, and real-time dose monitoring, which can reduce the patient dose significantly but without compromising on the diagnostic quality. This will also have further integration into the capabilities of artificial intelligence and machine learning in medical imaging field [21].

The positive view of technologist's experience and advanced CT techniques in reducing radiation dose is encouraging. This shows that the profession values expertise and technology in keeping patients safe. This recognition can help promote knowledge sharing, mentorship programs, and the use of new technologies that reduce doses, such as iterative reconstruction and automated exposure control. The results highlight significant variation and, therefore, the urgent need to address weaknesses in clinical practice methodologies. Knowledge of radiation dose metrics and the factors influencing patient exposure is essential for technologists operating CT equipment. CT scans typically deliver higher doses of ionizing radiation compared to conventional radiography, increasing the potential for both deterministic and stochastic effects. Radiologic technologists are responsible for selecting scan parameters such as kilovoltage (kVp), tube current (mAs), exposure time, pitch, DLP, amount of data and standardized protocols, all of which directly impact patient dose, CT staff and community. The results of this research are similar to those obtained in previous studies, lending credibility to our study and indicating that the patterns we see are not mere coincidences or exceptions, but have become part of a general body of evidence in this field. This is reassuring and allows our study to once again prove that it is an important contribution to improving the quality of healthcare and promoting the role of specialized academic dialogue in spreading a culture of radiation safety.

Limitations

In a way, the study was limited to 11 hospitals in different cities in Libya, thereby compromising the extent to which results can be generalized for the larger population. Nevertheless, the rather small sample size has offered important insight into the knowledge of CT technologists regarding principles of radiation protection, methods of radiation dose management, and levels of safe radiation use in current clinical practice

Conclusion

Based on the results of this study, there are concerning gaps in CT technologists' knowledge of radiation protection guidelines and methods of reducing radiation dose. These may have a significant impact on patient, CT staffs and community doses and limit the potential for improving the quality of clinical practice.

Recommendations

1. We recommend to development to better the quality of educational programs for students studying radiology so that the curriculum covers all aspects related to radiation science, such as radiobiology and radiation protection, as well as international and local guidelines governing the use of ionizing radiation in medical applications.
2. We recommend continuing medical education and training for all staff in order to get current innovations, scientific, and technical advancements that are necessary in their respective fields

Disclaimer

The article has not been previously presented or published, and is not part of a thesis project.

Conflict of Interest

There are no financial, personal, or professional conflicts of interest to declare.

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