ORIGINAL ARTICLE

KNOWLEDGE OF COMPUTED TOMOGRAPHY EXPOSURE PARAMETERS AND COMMON RADIOLOGICAL EXAMINATION DOSES AMONG RADIOGRAPHERS IN TEACHING HOSPITALS IN NORTHERN NIGERIA

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ABSTRACT

OBJECTIVE: To assess the knowledge of radiographers regarding computed tomography (CT) exposure parameters and doses associated with common radiological examinations. **MATERIALS AND METHODS:** A Prospective cross-sectional study was carried out amongst radiographers in all the teaching hospitals in Northern Nigeria. A self-administered, structured and validated questionnaire was used in this study. The questionnaire consisted of 21 questions in multiple choice formats, divided into three sections. Data were analyzed using Statistical Package for Social Sciences (SPSS) program (version 20.0; SPSS Inc., Chicago, IL, USA). Descriptive statistics were employed to generate mean percentages and frequencies. Mann Whitney U-test was used to compare between knowledge of CT exposure parameters and common radiological examination doses with highest academic qualification. A p-value of <0.05 was considered significant. **RESULTS:** Out of the 150 questionnaires distributed, one hundred and fifteen (76.7%) were correctly filled and returned. The results show that only 13% (n=15) of the radiographers had excellent knowledge of the CT exposure parameters. Majority of them, 35.7% (n=41) had very good knowledge while 22.6% (n=26) and 13% (n=15) had good and fairly good knowledge respectively. About 15.7% (n=18) were found to have poor knowledge. Regarding the knowledge of common radiological examination doses, 21.7% (n=25), 9.6% (n=11) and 4.3% (n=5) of the radiographers had excellent, very good and good knowledge. The majority amounting to 64.3% (n=74) were found to have poor knowledge. There was no significant difference in the knowledge of the radiographers about CT exposure parameters and doses from common radiological examinations based on highest academic qualification. **CONCLUSION:** There was good knowledge of CT exposure parameters among radiographers but the knowledge of common radiological examination doses was generally poor. However, there was no statistical significant difference in knowledge of CT exposure parameters and common radiological examination doses among radiographers in teaching hospitals in Northern Nigeria based on highest academic qualification.

Keywords: Computed tomography, Exposure parameters, Radiographers, Radiation doses, Radiological examinations

Introduction

Radiation awareness and protection of patients have been basic responsibilities in diagnostic imaging since the discovery of x-rays in late 1895 and the first reports of radiation injury in1896.[1] In recent years

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there have been significant advancements in equipment that uses either x-rays to form images, such as fluoroscopy or computed tomography (CT),[2] or the types of radiation emitted during nuclear imaging procedures such as positron emission tomography (PET).[3] Such advancement has inevitably improved the standard of care including dose reduction for patients and made most of the imaging modalities diagnostic tool of choice for a host of medical indications.

Nevertheless, some of the imaging procedure like CT is associated with high radiation doses which of serious concern most especially as is being increasingly used in medical practice worldwide.[4] It is fast becoming the largest contributor to population dose from medical exposures.[5] Although the overall benefits of it use as imaging tool outweigh the associated risks of radiation, there is growing concern over the adverse biological effects of ionizing radiation on living organisms. A 2009 National Council on Radiation Protection and Measurements publication, "Ionizing Radiation Exposure of the Population of the United States", reported a sevenfold increase in radiation exposure to the population of the United States from medical radiation since the early 1980s.[6]

Moreover, doses from diagnostic imaging have the potential to cause detriments of a stochastic nature, these include; cancer in the exposed individual or genetic mutations, which can be passed on to future offspring of the affected individual.[7] The probability of these stochastic detriments occurring is determined by the age of the patient, the anatomical region being exposed and the amount of the dose involved.[7] Also, many have reported that radiographers and patients are not very aware of the radiation doses of common radiological examinations and that there is a lack of communication between radiographers and patients relating to radiation and its possible effects.[8,9,10] Such lack of awareness by the radiographers can be extremely dangerous when high dose examinations are conducted without optimization, resulting in a potentially significant biological lifetime risk for patients. The radiation hazard can be particularly relevant for young patients and especially children, whose high biological susceptibility and long life expectancy tend to increase the likelihood of the effects of not only cancer but also other non-cancerous diseases.[11]

The new Council Directive 2013/59/EURATOM of the 5th December 2013, this concerns belaying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation, is poised to strengthen this need for change, imposing on all professionals an ever greater duty of care to properly justify and optimize each radiological procedure.[12]

In view of that, radiographers need to be knowledgeable about the various means in controlling CT exposure parameters such as tube potential, tube current, slice thickness, pitch and the type of detector used.[13] In addition, to ensure optimization, radiographers must adjust CT parameters to match the presenting indication, region being scanned and patient size, as not all examinations require the highest level of detail.

Thus, concern is increasingly being raised regarding the potential harm that CT may have on populations especially if CT parameters are used inappropriately, given its carcinogenic potential.[14] Hence, it is necessary for radiographers who are the primary users of CT to have adequate knowledge of its exposure parameters. This will enable them to select appropriate exposure parameters that will strike a balance between image quality and radiation doses for wide range of investigations. This in turn will cut down the potential radiation risk associated with the use of ionizing radiation. Therefore, the aim of this study is to evaluate radiographer's knowledge about CT exposure parameters and common radiological examination doses in Northern Nigeria.

Materials and Methods

The study adopted a prospective cross-sectional survey design using a self-administered, structured and validated questionnaire after acquiring approval from ethical committee. The questionnaire consisted of 21 questions in multiple choice formats and divided into three sections;"A"captured demographic features of the respondents,"B''captured radiographer's knowledge regarding CT exposure parameters and "C" captured radiographer's knowledge regarding common radiological examination doses. The reliability was ensured through a pilot survey amongst radiographers from University of Maiduguri teaching hospital (n=15) who were randomly selected. Moreover, a test - retest method was used. After a

14-day interval, the same radiographers who were selected earlier were asked to answer the same questionnaire. The reliability of the questionnaire is within Crombach's Alpha coefficient of 0.731.

The study included all radiographers working in teaching hospitals with CT machine in Northern Nigeria.

A Stratified simple random sampling was used where the study site was stratified into three based on the available geopolitical zones. These include; Northeast, Northwest and North central. Each of the state in each of the three geological zones was treated as cluster. Three clusters were randomly selected from each geopolitical zone making a total of nine clusters. No cluster houses more than one teaching hospital. Therefore, the teaching hospital in each cluster represents the cluster. The clusters selected were; University of Maiduguri teaching hospital, Abubakar Tafawa Balewa University teaching hospital and Federal teaching hospital Gombein northeast. Aminu Kano teaching hospital, Ahmadu Bello University teaching hospital and Usman Danfodio University teaching hospital in northwest. Also, Jos University teaching hospital, Benue State University teaching hospital and University of Abuja teaching hospital in North-Central.

Statistical analysis was carried out using Statistical Package for Social Sciences (SPSS) Program (version 20.0 SPSS Inc.,Chicago, IL, USA). Normality of the data was tested using the Kolmogorov Smirnov test. Descriptive statistics was used to generate mean percentages and frequencies. Mann Whitney U-test was used to compare between knowledge of CT exposure parameters and common radiological examination doses with highest academic qualifications, a p-value of <0.05 was considered significant.

Results

A total of one hundred and fifteen (n=115, 76.7%) radiographers from teaching hospitals in Northern Nigeria participated in the study. Majority of the respondents 66.1% (n=76) were males while the remaining 39.9% (n=39) were females. More than half of the respondents 52.2% (n=60) had less than two years of CT experience while 47.8% (n=55) had 12 years working experience with CT experience of 2 years and above. Majority of the respondents 89.4% (n=101) had bachelor degree as highest academic qualification, 10% (n=11) had master's degree while 0.9% (n=1) had diploma (Tab. 1).

S/N	Highest Academic Qualification	Frequency (n)	Percentage (%)
1	B.Rad	101	89
2	MSc	11	10
3	DCR	1	1
	Total	112	100

Table 1: Percentage distribution of highest academic qualification of participants.

Majority of the participants 98.2% (n=111) thought further education in the area of optimization of CT exposure parameters would be beneficial while some of the respondents 1.8% (n=2) thought further education in optimization CT exposure parameters is not necessary. About one-third of the participants 31.5% (n=35) had excellent confidence in altering the CT exposure parameters correctly, while striking a balance between image quality and radiation dose. Only 4.5% (n=5) indicated poor confidence in altering CT exposure parameters correctly (Tab. 2).

How would you rate your confidence to alter the CT scan exposure parameters correctly, considering image quality and radiation dose?	Frequency (n)	Percentage (%)
Excellent	35	31.5
Very good	31	27.9
Good	31	27.9
Fairly	9	8.1
Poor	5	4.5
Total	111	100

Table 2: Frequency distribution of confidence level of the respondents regarding change in CT exposure parameters

Furthermore, the respondents were evaluated, given a score of 1 for each correct answer and a score of 0 for incorrect or missing answers; the scores were converted over hundred and graded. The total mean score for CT exposure parameters was 56.16 0ut of 100 with average grade of good. While, the total mean score of the common radiological examination doses was 33.05 0ut of 100 with average grade of fairly good. A total of 22.6% (n=26) of the respondents had good knowledge of CT exposure para-meters, 35.7% (n=41) and 13% (n=15) had very good and fairly good

Question	True	False	Total
Regarding the reduction in kVp for CT angiography procedure (n=all other parameters being kept constant) Reduces the radiation dose	71.9% (n=82)	28.1% (n=32)	100% (n=114)
Regarding the reduction in kVp for CT angiography procedure (n=all other parameters being kept constant) Reduces the image contrast	65.5% (n=74)	34.5% (n=39)	100% (n=113)
Regarding the reduction in kVp for CT angiography procedure (n=all other parameters being kept constant) Increases the image Noise	56.6% (n=64)	43.4% (n=49)	100% (n=113)
Regarding the reduction in kVp for CT angiography procedure (n=all other parameters being kept constant) Increases the vessels enhancement	55.5% (n=61)	44.5% (n=49)	100% (n=110)
Regarding the tube Current, Tube Current has linear relationship with Radiation dose	86.8% (n=99)	13.2% (n=15)	100% (n=114)
Regarding the tube Current, Reducing the tube current by 50% increases the noise by two fold	74.8% (n=83)	25.2% (n=28)	100% (n=111)
Regarding the pitch (n=table movement per rotation/total nominal beam width); Higher table speed result in slice sensitivity profile and thus, effective slice thickness, reducing the z-axis resolution	74.8% (n=83)	25.2% (n=28)	100% (n=111)
Regarding the pitch (n=table movement per rotation/total nominal beam width); For single slice helical CT, the higher the pitch, the lower the dose	69.8% (n=74)	30.2% (n=32)	100% (n=106)
Decreasing the gantry rotation time (n=seconds), Decreases the patience dose	58.6% (n=65)	41.4% (n=46)	100% (n=111)
Decreasing the gantry rotation time (n=seconds), Increases the Image noise	60% (n=66)	40% (n=44)	100% (n=110)
Regarding slice thickness (n=selected beam width/collimation), Increasing the slice thickness increases the spatial resolution	64.6% (n=73)	35.4% (n=40)	100% (n=113)
Regarding slice thickness (n=selected beam width/collimation), Increasing the slice thickness decreases the patient dose	60.4% (n=67)	39.6% (n=44)	100% (n=111)
Regarding slice thickness (n=selected beam width/collimation), Decreasing the slice thickness reduces partial volume artifact	74.8% (n=80)	25.2% (n=27)	100% (n=107)
Regarding reconstruction parameters choosing, A smoothing reconstruction kernel, increases the visualization of noise	66% (n=68)	34% (n=35)	100% (n=103)
Regarding reconstruction parameters choosing, Wider window settings, reduces not only the image contrast but also the visual perception of noise	78.9% (n=82)	21.2% (n=22)	100% (n=104)

Table 3: Percentage distribution of knowledge of CT exposure parameters.

knowledge respectively. While 13% (n=15) had excellent knowledge and 15.7% (n=18) had poor knowledge. About 64.3% (n=74) of the respondents had poor knowledge in identifying the common radiological examination doses of various body parts. About 21.7% (n=25) of the radiographers had excellent while 4.3% (n=5) and 9.6% (n=11) had good and very good knowledge in stating the common radiological examination doses as shown in (Tab. 5) below.

	Grades of Knowledge					
Variables	Excellent	Very Good	Good	Fairly Good	Poor	Total
CT exposure parameters	13% (n=15)	35.7% (n=41)	22.6% (n=26)	13% (n=15)	15.7% (n=18)	100% (n=115)
Common radiological examination doses	21.7% (n=25)	4.3% (n=5)	9.7% (n=11)	13% (n=15)	64.3% (n=74)	100% (n=115)

Table 5: Frequency distribution of grades of knowledge of participants.

Variables	Highest academic qualification	N	p-Value
CT exposure parameters (score of respondents)	B.Rad MSc	101 11	0.431
Common radiological examination doses (score of respondents)	B.Rad MSc	101 11	0.385
CT exposure parameters (Grade of respondents)	B.Rad MSc	101 11	0.421
Common radiological examination doses (Grade of respondents)	B.Rad MSc	101 11	0.373

Table 6: Comparison of knowledge of participants based on highest academic qualification.

The average dose is based on considering chest x-ray as 1 u

Doses (mSv)	CXR	Abdominal Radiograph	L/S Radiograph	Mammogram	Abdominal CT	Abdominal USS	Abdominal MRI	Barium Meal
0	1.0% (n=1)	0.0% (n=0)	0.0% (n=0)	1.1% (n=1)	2.2% (n=2)	80.7% (n=75)	75.5% (n=71)	0.0% (n=0)
0-1	30.3% (n=30)	5.2% (n=5)	5.4% (n=5)	29.8% (n=28)	0.0% (n=0)	3.2% (n=3)	2.1% (n=2)	5.4% (n=5)
1	13.1% (n=13)	12.5% (n=12)	12% (n=11)	10.6% (n=10)	1.1% (n=1)	0.0% (n=0)	4.3% (n=4)	3.2% (n=3)
1-3	13.1% (n=13)	15.6% (n=15)	14.1% (n=13)	9.6% (n=9)	4.3% (n=4)	4.3% (n=4)	2.2% (n=2)	2.2% (n=2)
4-5	6.1% (n=6)	12.5% (n=12)	9.8% (n=9)	12.8% (n=12)	4.3% (n=4)	2.2% (n=2)	3.2% (n=3)	16.1% (n=15)
10-15	5.1% (n=5)	10.4% (n=10)	9.8% (n=9)	7.4% (n=7)	14% (n=13)	2.2% (n=2)	1.1% (n=1)	7.5% (n=7)
20-30	3.0% (n=3)	9.4% (n=9)	8.7% (n=8)	20.2% (n=19)	11.8% (n=11)	2.2% (n=2)	3.2% (n=3)	19.4% (n=18)
40-60	5.1% (n=5)	5.2% (n=5)	9.8% (n=9)	1.1% (n=1)	22.6% (n=21)	0.0% (n=2)	5.3% (n=5)	11.8% (n=11)
70-100	18.2% (n=18)	20.4% (n=20)	21.7% (n=20)	4.3% (n=4)	5.4% (n=5)	2.2% (n=2)	1.1% (n=1)	24.7% (n=23)
100-200	4.0% (n=4)	5.2% (n=5)	5.4% (n=5)	1.1% (n=1)	19.4% (n=18)	0.0% (n=0)	1.1% (n=1)	4.3% (n=4)
>200	1.0% (n=1)	3.1% (n=3)	3.3% (n=3)	2.1% (n=2)	15.1% (n=14)	2.2% (n=2)	1.1% (n=1)	5.4% (n=5)
TOTAL	100% (n=99)	100% (n=96)	100% (n=92)	100% (n=94)	100% (n=93)	100% (n=93)	100% (n=94)	100% (n=93)

Table 4: Percentage distribution of knowledge of common radiological examination doses

Discussion

Having sufficient knowledge of exposure parameters and the trade-offs that are related to the patient's dose and image quality is a fundamental skill for radiographers. In the absence of sufficient knowledge, it is recommended that radiographers should participate in yearly ionizing radiation and safety training, which has been proven to enhance knowledge and awareness regarding radiation risks.[9]

Out of the one hundred and fifty (150) questionnaires distributed to nine (9) teaching hospitals in three geo-political zones of Northern Nigeria, One hundred and fifteen (115) were correctly filled and returned, given a return rate of 76.7%. This result revealed that the majority of the respondents 66.1% (n = 76) were males while about 39.9% (n = 39) were females. This may be due to low level of girl-child education in Northern Nigeria as reported by Abdulkareem (2015), which put the girl child education at 46%.[15] The poor girl-child education could be due to so many factors such as religious misunderstanding, cultural practices, poverty, early marriage, illiteracy, and inadequate school infrastructures.[16]

Moreover, More than half of the respondents 52.2% (n = 60) had less than two years of CT experience while 47.8% (n = 55) had 12 years and above working experience with CT experience of 2 years and above.This is in agreement with the study of Foley et al, (2013) in Ireland, who stated that almost two fold differences in median number of years of experience exist between radiologist and radiographers.[17] The experience gap in years could be due to the fact that, most of the respondents were intern radiographers who were still in their internship training program. Additionally, lack of enough CT machine in other hospitals could be part of the reason. Moreover, most of the CT machines in the participating hospitals were faulty due to lack of proper maintenance. Despite the gap in experience level there is no statistical difference in the mean score of the questions answered.

Regarding highest academic qualification, the result revealed that majority of the respondents 89.4% (n = 101) had Bachelor degree as highest academic qualification, 10% (n = 11) had Master's degree while 0.9% (n=1) had diploma. This shows that majority of radiographers in Northern Nigeria had bachelor's degree due to the fact that, there are no institutions running post-graduate courses in the entire Northern Nigeria at the time of this study. Another discouraging factor which may hinder their furtherance of educationin the hospital setting is that bachelor degree is the highest academic/professional qualification recognized in the scheme of services for radiographers, hence other higher academic qualifications (MSc, PhD) were not considered valuable for any level promotion.

Pertaining further education, majority of the participants 98.2% (n = 111) thought further education in the area of optimization of CT exposure parameters would be beneficial while few of the respondents 1.8% (n = 2) thought further education in optimization of CT scan exposure parameters is not necessary. This could be due to their low level of experience and also, considering the fact being survey questionnaire, the respondents may hardly give their true intuition. This finding is in comparison with the study of Foley et al., (2013) where majority of both Radiologists (79%) and Radiographers (86%) stated further education in the area of optimization of CT scan parameters is beneficial.[17]

However, the findings also revealed that, 22.6% (n = 26) of the respondents had good knowledge of CT exposure parameters, 35.7% (n = 41) and 13% (n = 15) were very good and fairly good respectively. While 13% (n = 15) were excellent and a significant number 15.7% (n = 14) were poor. This corresponds to the study of Foley et al., (2013) and Rawadeshdeh et al., (2018) who reported the CT exposure parameters were well understood by majority of Radiographers (54.1%). This could be due to the fact that, most of the respondents had the theoretical background of the CT exposure parameter from their undergraduate studies considering their low level of experience. Literarily, the peak voltage, kVp controls the overall energy of the x-ray photons, so any alteration will influence the number of photons penetrating the body tissue, with a resultant effect on both radiation dose and image noise.[18] While most CT systems operate at a standard 120 kVp, increasingly alternative values from 80-140 kVp are available.[17] Several studies highlight the optimization potential of appropriate kVp selection, especially for patients below a certain size and also during angiographic studies,[19-20] given the added advantage of increase vessel attenuations with lower tube voltage.[21] Considering the above mentioned facts, this study revealed that 43.4% (n = 49) of the radiographers did not associate reduction in kVp with image noise, which is of concern, although this could be due to the belief that automated tube current modulation (ATCM) systems will automatically increase the tube current to compensate for any change in kVp to ensure the image noise is maintained at a consistent level. Foley et al, (2013) also reported similar to finding with 40% of radiographers.[17] Therefore, appropriate manipulation of the above mentioned CT parameters can significantly alter the visibility of the noise within the CT images and lower the radiation dose.

Conversely, our finding from this survey showed a poor knowledge of radiographers 64.3% (n = 74) about common radiological examination doses for various body parts under different imaging modalities. Only 21.7% (n = 25) of the radiographers were excellent in stating the common radiological examination doses. In addition, none of the radiation dose delivered by the imaging modalities was 100% correctly estimated by the respondents. This is in line with the study of Rawashdeh et al., (2018) in Jordan who reported that the question answered correctly most often was for the chest DRLs, with 4 out of 54 participants able to give a close estimation of the recommended DRL of 545 mGy cm; With the pass mark being 50%, only nine participants out of 54 had passed this section. This is indicative of the poor knowledge amongst radiographers regarding the dose, DRLs and organ sensitivity and highlights an issue that requires more attention.[9] However it is in contrast with the findings of Gunalp et al, (2013) where overall a total of 41.4% of all participants and 46.3% resident doctors underestimated the radiation doses.[22] Also, Ramanathan, (2015) in Canada reported that there is overall significant underestimation of dosage and cancer risk from common examinations.[23] This implies that, there is tendency of radiation misuse and underutilization of alternative radiation free methods by the practicing radiographers. Also, Lee et al, (2016) in Hong Kong revealed that knowledge of radiation doses of investigation is generally inadequate among radiologist and particular poor in non-radiologist with overall accuracy of 40% for radiologist and 16% for non-radiologist.[24]

Analyzing the present study in detail, it is surprising that only 26.1% (n = 30) of the participants were correct in identifying the radiation dose of the most commonly performed postero-anterior chest examination (CXR) in radiology department. Concerning radiation dose of abdominal CT as stated in literatures, majority of the respondents 74.9% (n = 77) underestimated the relation dose. Perhaps, the study shows that none of the respondents were able to complete this section of the questionnaire without making any mistake.

Comparing the knowledge of CT exposure parameters and common radiological examination doses with academic qualification, it is found that there was no significant difference in the scores of CT exposure parameters between radiographers with bachelor degree and master degree as highest academic qualification (p <0.05). Similarly, the difference in scores of common radiological examination doses among radiographers with bachelor's degree and master degree was not statistically significant. This isin line with the study of Rawashdeh et al., (2018) in Jordan who reported none of the participants were able to provide a close estimation of all three routine examinations doses regardless of their experience and academic degree.[9] This Might be due to the less gap in experience among the respondents

Conclusion

There was good knowledge of CT exposure parameters amongst radiographers; poor knowledge of radiological examination doses. However, there was no statistical significant difference in knowledge of CT exposure parameters and common radiological examination doses among radiographers in teaching hospitals in Northern Nigeria based on highest academic qualification.

RECOMMENDATION

There should be ongoing education in dose optimization for radiographers at all level.

Radiographers must adopt CT parameters to optimize patient dose and image quality.

Specific action such as regular training courses for both undergraduate and postgraduate students as well as for working radiographers must be considered to ensure patient safety during radiological examination.

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