ASSESSMENT OF RADIOGRAPHERS KNOWLEDGE ON MANIPULATIONS OF COMPUTED TOMOGRAPHY PARAMETERS IN KANO STATE

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Abstract
Background: Image quality in Computed Tomography (CT) is obviously influenced by many of its technical parameters. Continuous development in CT technology over the years has led to an improved clinically relevant image. Image assessment methods through image processing and reformatting options now provide the diagnostic answer to most clinical tasks e.g in cardiac imaging in which motion is inevitable. These advancements are as a result of complex interactions of CT parameters and CT Radiographers play a central role in CT parameter manipulation in any CT practice.

Objective: To assess the knowledge of CT parameters and the effects of their manipulations among CT-Radiographers in all radio-diagnostic centers in Kano

Methods: This is a questionnaire-based study. Responses from consenting CT-radiographers were evaluated using a validated questionnaire to assess Radiographers Knowledge of CT-parameters in Kano from March –November 2017. Questions concerning CT parameters, their manipulation and influence on image quality were asked.

Results: Radiographers had basic knowledge of CT parameters. However, there is relative variation in Radiographers knowledge of complex CT parameters and their anticipated effect on image quality. A number of discrepancies were identified with regards to the influence of CT parameters, their manipulation and the resultant effect on image quality characterization. Academic knowledge and professional year of practice were found to be associated with Radiographers confidence in manipulating CT parameters. However, age and gender were found to be slightly related to them.

Conclusions: Radiographers had considerable knowledge of CT parameters. However, further theoretical knowledge on the effect of CT parameters on image quality is recommended through update courses.

Keywords: Radiographer, Knowledge, CT-parameter.

Introduction:

Computed tomography (CT) scan uses highly collimated x-rays of different intensities from different angles of a scanned object to produce cross-sectional images through a complex computer process[1,2,3]. It is the largest single source of medical exposure in the western countries accounting for almost 60% of the radiation exposure from imaging modalities[4]. Despite being a larger contributor to medical exposure to ionizing radiation, CT scan continues to be popular due to its capabilities.

Fundamentally, Image quality (IQ) in CT is described by several performance parameters: high-contrast spatial resolution, low-contrast resolution, temporal resolution, CT number uniformity and accuracy, noise and artifacts. Incidentally, these parameters are influenced not only by the CT system performance but also by the operator's selection of protocol e.g tube voltage, tube current, slice thickness, pitch and scan time [4,5,6]. Advancements in detector's technology, efficiency, image reconstruction, and processing have led to the introduction of complex techniques such as organ perfusion, three-dimensional angiography and virtual colonography with exceptionally short scanning times[7]. These complex procedures have been primarily due to the flexibility of CT parameters and IQ is obviously influenced by most of these parameters which have now resulted in the adaptation and formulation of different assessment methods[7,8].

Manufacturers of CT systems use different methods in defining image quality in their user interface[6,9,10]. General Electric (GE) uses a concept known as the noise index with reference to the standard deviation of pixels values in a specific size water phantom that is comparable to patient attenuation[11]. Toshiba allows two ways to prescribe image quality in their Sure Exposure Automatic Exposure Control (AEC) algorithm: Standard Deviation and Image Quality level[11]. Like GE's Noise Index, Sure Exposure also compares the patient's scanogram data to that of the standard deviation attenuation coefficient of a specific water phantom[6,9,11]. Philips uses a reference image from a satisfactory patient statistical data stored in the system with which image quality for future exams is to be matched[9,11]. Siemens uses Quality Reference mAs to define the effective mAs (mAs/pitch) required to produce a specific image quality in an 80 kg patient for an adult (20 kg for pediatric cases) for a given protocol [9,10].

Several factors affect how well the CT system performs this task; e.g spatial resolution, low contrast resolution, linearity, noise, and artifacts are some of the factors that affect image quality[5,7]. Spatial resolution is determined almost entirely by the number of rays in each projection, and the spacing of the detectors, low contrast resolution is determined solely by image noise and inherent tissue contrast with respect to x-ray beam attenuation[12]. Image noise is affected by tube current, scan time, tube voltage, patient size, and pitch in a helical scan, slice thickness and reconstruction algorithm[7,8,13]. In all these parameters, the only parameter that is not in the control of CT radiographer is the patient size or weight[14,15].

Generally, there is a tradeoff between noise and spatial resolution. For example, if a bone reconstruction algorithm is utilized to decrease structural blurring and thus increase spatial resolution, image noise increases which degrades the soft tissue resolution[7,8]. Noise can also be reduced by increasing the slice thickness, using a softer reconstruction kernel and by moving the arm out of the scanned volume for abdominal CT scan or constrained of large breasts in front of the thorax rather than on both sides in the thoracic and cardiac region [9,14].

Literature has shown that the inter-connections of these parameters with their subsequent effect on image quality are poorly assessed objectively among Radiographers who are primarily scheduled to handle, manipulate and produce CT images especially in the study area. The present study intends to assess the knowledge of CT radiographers' regarding CT parameters and their relationship with image quality.

Materials and Methods

A cross-sectional questionnaire-based study was conducted from March - November 2017 in all radio-diagnostic centers having functional CT-equipment in Kano, North-west Nigeria. All Radiographers working in any radio-diagnostic center having functional CT scan were recruited. Three radio-diagnostic centers satisfied these criteria namely: Aminu Kano Teaching Hospital, Mecure radio-diagnostic center, and Providian radio-diagnostic center. Full ethical approvals (NHREC/21/08/2008/AKTH/EC/1990) from the human research and ethics committees of each center were sought. An existing questionnaire from the American Board of Radiology, Kentucky[11] was used and adapted to suit the study situation. The questionnaire was assessed for reliability using test-retest reliability. A Cronbach's alpha of 0.73 was obtained. The questionnaire was fielded, responses were retrieved, analyzed and presented in figure and tables. Responses in proportions were expressed as frequency and percentages. These were done using Microsoft Excel for Windows 2010.

Table 1: Distribution of respondents according to age.

Age	Frequency	Percentage %
20-25years	5	14.7
26-30years	19	55.9
31-45years	9	26.5
46-55years	1	2.9
Total	34	100.0

Respondents were also categorized according to their academic qualifications as seen in (Table 2).

Table 2: Distribution of Respondents according to academic qualifications.

Qualification	Frequency	Percentage %
Diploma in Rad. (DIR)	0	0
B.RAD / BSc. (RAD)	31	91.2
M.RAD	3	8.8
PhD in RAD	0	0
Total	34	100.0

Results

A total of 40 questionnaires were issued, 34 were received, representing a response rate of 85%. Males had the highest frequency of 25(73.5%) while females were 9 (26.5%). Respondent's age ranged from 20-55 years with the highest respondents in 26-30 years category having a frequency of 19 (55.9%) and lowest age category 46-55 years having a frequency of 1 (2.9%) (Table 1).

On decision regarding choice of protocol to employ prior to CT scanning examination, 25(73.5%) of the responding radiographers indicated they single-handedly decide which protocol to employ, while the remaining stated they do so in conjunction with a physicist and/or Radiologist (Table 3).

Table 3: Frequency of Respondents Regarding Decision on Choice of CT Protocol.

Specialist Consulted	Frequency	Percentage %
Radiographer	25	73.5
Radiologist	1	2.9
Physicist	8	23.5
Total	34	100

Respondents were asked to rate their confidence in altering CT parameters correctly while considering radiation dose to their patient on a scale of 5 ranging from (1=excellent - 5=poor). The highest response was 3=good having a frequency of

19(55.9%), the least is 1=excellent with a frequency of 1(2.9%) as seen in (Table 4).

Table 4: Distribution of respondent confidence in manipulating CT protocol.

Scale	Frequency	Percentage (%)
Excellent	1	2.9
Very Good	12	35.3
Good	19	55.9
Fair	2	5.9
Poor	0	0
Total	34	100

The distribution of respondents on the common factors (i.e Anatomic region, patient size, and Clinical Indication) known to warrant the modification of CT protocol was also documented as seen in Table 5

Table 5: Distribution of respondents based on factors that led to the modification of the CT protocol

Factors	Frequency	Percentage
Anatomic Region, Patient Size & Anatomical Region	28	82.4
Clinical Indication	6	17.6
Anatomic Region	0	0
Patient Size	0	0
Total	34	100

Questions regarding effect of noise setting, its effects and modifications were also documented from across respondents. The distribution of the response was tabulated (Table 6)

Table 6: Participants responds to the effects of noise.

Noise /Noise setting		Response	Frequency	Percentage (%)
Readers tolerate more noise in pediatric patient.		True^{+}	21	61.8
		False^{-}	13	38.2
Less noise in obese patient.		True^{-}	19	55.9
		False^{+}	15	44.1
Lower mAs index shall be used if patient size is extreme		False^{-}	10	29.4
		True^{+}	24	70.6
The non-contrast phase of abdominal require the same noise setting of contrast		True^{-}	11	32.4
		False^{+}	23	67.6
A decrease in tube voltage	Increase image noise & Reduce image contrast	False^{-}	11	32.4
		True^{+}	23	67.6
	Increase vessel enhancement	False^{-}	12	35.3
		True^{+}	22	64.7

KEY: $^{+}$= Correct Response, – = incorrect response

Regarding pitch of the CT scanner, 11(32.4%) of the respondents do not believe that pitch may affect image quality and contrast. Also, 23(67.6%) do not believe that an increase in pitch will increase effective slice thickness and reduce the z-axis resolution. Only 9(26.5%) of respondents stated that spiral artifact is reduced at lower pitch setting as seen in (table 7)

Table 7: Respondents Distribution Regarding effects of pitch, image quality, and contrast.

Effect of pitch	**Response**	**Frequency**	**Percentage (%)**
pitch may affect image quality & contrast	False$^-$	11	32.4
	True$^+$	23	67.6
increased pitch increases slice thickness and spatial resolution	False$^+$	23	67.6
	True$^-$	11	32.4
Spiral artifact is reduced at a lower pitch	True$^+$	9	26.5
	False$^-$	25	73.5

KEY: += Correct response, –= incorrect response

Discussion

Knowledge assessment takes priority over checking competency, particularly in professions that are completely mediated by technology[16]. Studies have shown that the combination of practical and theoretical knowledge leads to significant changes, a better outcome and enables the radiographer to be more competent and confident in his/her profession[14,17]. Relevant studies and international recommendations have all agreed that the development, design, and modification of any CT protocol should be done with the inputs of radiologist, CT radiographers and medical physicist[11,14,18]. This measure will definitely promote the exchange of ideas between the three specialists to incorporate clinical, technical and physical concepts with the aim of improving better diagnostic outcomes while ultimately prioritizing patient's safety. However, in the present study, up to 73.5% of the radiographers indicated they single-handedly determine the choice and modifications of CT protocols independently. However, 2.9% of the respondents reported that such decisions were made in conjunction with a radiologist and 23.5% also includes medical physicists in this process. These acts can be explained by the level of Radiographers confidence in manipulating CT protocols as seen in table 4. Just 5.9% of the respondents indicated they have fair confidence while as high as 94.1% of the respondents indicated they have an excellent to a good confidence in manipulating CT protocols prior to an examination.

A high percentage of the respondents about 82.4% indicated they alter their CT parameters based on clinical indication. This may explain that CT Radiographers are conscious of their patient's level of exposure to unnecessary doses of ionizing radiation, thus in keeping with the wider international principle of radiation protection; the As Low As Reasonably Practicable (ALARP) principle. The present study is thus in agreement with the works of Goldman in 2007 and McNitt-Gray in 2006 all in the United States (US)[5,19]. They both agreed and recommended that varying parameters according to study indication has already been demonstrated to permit significant reductions in radiation dose. This is especially obvious for procedures with high inherent contrast, in such instance, high image quality is not required, such as coronary artery calcium detection, kidney stone protocols, lung nodule follow-up, identification of emphysema in a lung or sinus examinations[3,6,19].

The tube potential controls the overall energy of the X-ray photons as any change in kVp affects the number of photons penetrating the body tissues with resultant effects on both radiation dose and image noise. An increased tube potential improves both the tube output and penetrating power and image quality is directly proportional to the amount of radiation used[21,22]. In the present study, about 32.4% of respondents highlighted that reductions in kVp may not increase the image noise. This is similar to the findings (though less in proportion) reported in the works by Foley *et al*., in 2013 in the US which stated that 40% of radiographers stated that reduction in kVp has no associate increase with image noise[11].

Studies have highlighted that optimization of tube potential is appropriate, especially for patients below a certain size[23,24,25]. Lack of understanding of the effects of tube potential will obviously limit the potential available for optimization. Most CT systems operate at a standard of 120 kVp but increasingly alternative values from 80–140kVp are available[12,24]. In the present study, 64.7% of respondents agreed that lower tube voltages result in increased vessel enhancement during angiographic examinations. This is an indication that a significant percentage of respondents in the study area are aware of this effect and in line with previously established facts.

Surprisingly, 64.7% of respondent radiographers incorrectly responded that tube current has a linear relationship with image noise. In fact, image noise is approximately inversely proportional to the square root of the tube current[12,26,27]. This relationship is worthy of note because noise remains the largest enemy of an acceptable CT- image especially among obese patients that have high-fat content which can generate higher scatter radiation that can lead to high image noise[7,11,19]. Attempt to optimize patient doses by CT- Radiographers is most Radiographers desire. However, the knowledge and relationship of tube current with image noise must be understood and applied in other to maximize the optimization potential. Again emphasis on the need for professional update courses on CT parameters and its effects among others is greatly needed.

On the effect of pitch, increasing helical pitch increases the effective slice thickness and increase in partial volume artifact and decreases spatial resolution. However, increasing pitch enables CT radiographers to cover a greater longitudinal area within the same scan time or cover the same longitudinal area in less scan time. This is important when the patient cannot hold their breath or more coverage is needed within a single helical scan as in coronary CT. However, in the present study, the result has shown that 32.4% of the respondents do not believe that, pitch may impact image quality and contrast. Again similar percentage of the respondents are not aware that by increasing pitch and slice thickness, spatial resolution isn't increased. Interestingly, as high as 73.5% of respondents stated that spiral artifact is reduced at lower pitch setting. This finding is not in agreement with the works of Foley *et al*. in 2013 in the US which stated that almost all CT radiographers know that pitch affects image quality and contrast. An increased pitch reduces patient dose. However, this study is in agreement with Foley et al 2013 finding on spiral artifact reduction in helical CT when a lower pitch is used [11]. An explanation for this may be simply due to two reasons. First, is that CT scanners were installed in the entire study locality not long ago, with the earliest installed scanner; 4 slice CT scanner installed just 2009. Secondly, few Radiographers who first handled the gadget were not adequately trained as they "learned on the job". The immediate patronage by physicians and surgeons for the services created a surge in demand of CT services. This might have not allowed the few CT-Radiographers on the ground to forge ahead for further training. Hence CT applications and parameters are just gradually being understood by practitioners through experience rather than coaching. Secondly, up to 91.2% of CT radiographers in the study area are first degree holders of Radiography. Expectedly, these respondents have less practical experience of the influence of applied CT parameters and its effect on image quality when compared to their counterparts in the US whom have been operating and utilizing CT scanners for over 3 decades. Obviously, advanced CT applications and its parameters are better appreciated and understood by experts that have spent years of learning, operation and practice and have also applied many modification models to various CT-protocols and parameters. As time passed, much should be expected from the CT-Radiographers within the study area especially if update courses are prioritized.

The practice of Radiography requires a Radiographers to be versatile and flexible especially in the modification of his technique and protocol as patients come in different conditions. The present study has been able to assess and report that Radiographers have adequate knowledge of basic CT parameters. They are always cautious of clinical Indication, anatomic region and patient size in deciding which protocol and technique to adopt or modify. The present study is limited to the theoretical/anticipated effect of manipulation of CT parameters on image quality. Incorporation of an objective image quality assessment into the study would have provided a basis for a generalized conclusion but this will mean adopting a different research design (non-questionnaire based).

Conclusion:

Based on the present study's findings, basic CT-parameters were understood by most radiographers and usually manipulate the parameters in anticipation of maximizing image quality. A number of deficiencies were noted regarding CT parameters manipulation and the anticipated effect on image quality. Academic and professional update courses are two key areas that will improve radiographers' level of knowledge and application of basic and complex CT parameters in maximizing best patient outcomes (image quality, less radiation dose, less scan time). Hence, refresher courses, workshops and short-term training courses on CT- application, parameters and their effects will definitely enhance radiographer's knowledge in computed tomography.

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