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Estimation of Radiation Dose for Adults Patient during Computed Tomography Examinations

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Abstract **Original Research Article**

This study designed to evaluate the patient doses and the radiation related factor, and helps to improve Occupational awareness to ionizing radiation hazard from CT procedures and the impotent of radiation protection protocols to achieve ALARA principle. Four CT machines were used to collect data in Khartoum state, and a quality control tests were performed to the machines prior any data collection. Comparing the demographic and radiographic information from CT brain among male and female for age and BMI the age data shows the males was older than female and the body mass index data it's almost similar for both gender. The radiographic data the mA was higher for female than male while the DLP CTDIvol and effective dose was higher for male. Comparing the demographic and radiographic information from CT chest among male and female we found that the Ma for female was higher than male, while the dose length product and computed tomography dose index per volume was higher for male, the effective dose the male was higher than that from female. Comparing the dose parameters among the two exams for all hospitals for brain the CTDIvol, DLP and ED was 77.44 ± 30.51, 2142.3 ± 3309.17 and 4.49 ± 6.94 respectively, while for chest was 40.47 ± 38.58, 963.23 ± 624.77 and 13.48 ± 8.74. And when compared with diagnostic reference level and other countries found that the CTDIvol was lowest at present study between all studies except the study from UK 2013. The main dose variations in the same CT unit could be attributed to the different techniques, which justify the important of use radiation dose optimization technique and technologists training. Dose reduction strategies must be well understood and properly used.

Keywords: *CT, effective dose, Chest, Brain, dose length product*.

INTRODUCTION

The computed tomography (CT) is the best technology that gives high-resolution anatomical images of patients. CT images represent transverse slices, which are obtained by an X-ray tube rotating around the human body, today with increasing attention surrounding computed tomography (CT) from radiologic society and the public, with more accurate dose information becomes available for many studies, and to estimate the biological effect from CT procedures [1,2]. CT has become one of the most main source of medical exposure, reports show that the risk of developing malignant diseases due to radiation exposure from CT is significant [3]. Many factor contribute to CT burden such as CTDIvol witch indicate the dose output of CT unit to a standard-size object. It is also effective in characterizing CT system output for axial coverage protocols this will lead to fail in representing fully account for each patient attributes and protocols [4]. Another factor is DLP dose-length-product expressing the total radiation dose excess [5]. In CT procedure to improve clinical practices dose measurements for each patient is recommended although a high exposure per examination related with increasing the number of people who are exposed the risk of individual patient is low never the less it may have related to many cases off cancer resulting from exposing to radiation during CT procedure. Reputed CT examination, using of inappropriate exposure factor and increasing scan volume all this factor attributed to increase patient dose [6].

The first role in the principle of radiation protection for medical imaging is the need to balance between the benefit and risk of any patient exposure which called justification [7]. So, it is essential that, the technologist should understand the radiation risks associated with radiological examinations, and the relation between these risks and the patient's information gender and age [8, 9]. The main concerning is then due to the significant radiation dose delivered to the radiosensitive organs, thyroid, eye lens and breast because they will be irradiated during radiological procedures of the cervical spine, head and chest [9-11].

METHOD AND MARTIAL

This study was designed to evaluate the patient doses and the radiation related factor, the collected data included, sex, and age, tube potential, tube current–time product settings, pitch, slice thickness and total slice number, in addition, I also recorded all scanning parameters, as well as the CT Dose Index volume (in milli sievert) and dose-length product (in milli sievert-centimeters). All these factors have a direct influence on radiation dose. The entire hospital was passed successfully the extensive quality control tests performed by Sudan atomic energy commission and met the criteria of this study. Four CT machines were used to collect data during this study. These machines are installed in four private radiological departments. All quality control tests were performed to the machine prior any data collection.

Table-1. Show specification of computed tomography machines in the all hospitals

Hospitals	Manufacture	Model	Detected Type
Hospital A	GE Healthcare	Light Speed 8	8 slice
Hospital B	Toshiba	Aquilion 64	64 slice
Hospital C	Toshiba	Aquilion 64	64 slice
Hospital D	Siemens	Sensation	16 slice

CT dose measurement

Radiation dose indicators $CTDI_{vol}$ and DLP can be obtained from a dose summary page, which includes information about the CT exam. $CTDI_{vol}$ does allow the comparison of scan protocols or scanners and is useful for obtaining benchmark data to compare techniques, but it's not so good for estimating patient dose. DLP, an indicator of the dose imparted to the patient, is calculated by multiplying $CTDI_{vol}$ times the scan length. In addition to being affected by the issues associated with $CTDI_{vol}$, DLP can be problematic in a limited scan range [12].

Calculation of Effective dose

CT scanners record the radiation exposure as a DLP in mGy.cm. and by Multiply this by Conversion Factor (CF) to convert it to effective dose in mSv.

RESULTS

CT scanning has been recognized as a high radiation dose modality, when compared to other diagnostic X-ray techniques, since its launch into clinical practice more than 30 years ago. Over that time, as scanner technology has developed and its use has become more widespread, concerns over patient radiation doses from CT have grown and the statistical methods were used to represent the results; mean, median, STD, minimum, maximum and 3rd quartile.

Table -2. Show the demographic data and radiographic information for all patients from CT scan for from brain examinations

Variables	Mean	Median	STD	Min	Max	3d Quartile
Age	48.78	47	20.47	18	86	67
BMI	25.83	25.83	4.03	19.81	42.92	27.55
mA	209.11	225	64.71	92	318	252
DLP mGy.cm	2142.3	1497.7	3309.17	151.50	26636	1742
CTDIv mGy	77.44	75.40	30.51	21.80	155	81
ED mSv	4.49	3.14	6.94	0.32	55.93	3.66

kV= 120

Table -3. Show comparing the demographic data and radiographic information for male and female patients from CT scan for from brain examinations

variables	Male					Female				
	Mean	STD	Min	Max	3d Quartile	Mean	STD	Min	Max	3d Quartile
Age	52.63	19.122	18	85	69.50	43.22	21.22	18	83	66
BMI	25.60	3.68	19.81	39.44	27.09	25.68	4.46	20.06	42.97	27.73
mA	205.73	69.17	92	318	255.75	238.71	42.32	112	300	262.25
DLP mGy.cm	2232.68	3791.54	400.30	26636	1778.45	2206.39	3235.17	158	19537	1630.5
CTDIv mGy	78.97	31.38	21.80	155	79.50	76.24	34.36	38.88	143.10	81
ED mSv	4.69	7.96	0.84	55.93	3.73	4.63	6.79	0.33	41.03	3.42

kV= 120

Table- 4. Show the demographic data and radiographic information for all patients from CT scan for from Chest examinations

Variables	*Mean*	*Median*	*STD*	*Min*	*Max*	*3d Quartile*
Age	48.88	47.50	20.64	18	85	67
BMI	27.13	27.05	4.16	19.53	39.52	30.57
mA	182.04	188	55.12	60	300	225
DLP mGy.cm	963.23	784.09	624.77	158	3313	1529.5
CTDIv mGy	40.47	19.40	38.58	40.02	239	77
ED mSv	13.48	10.97	8.74	2.22	46.38	21.42

kV= 120

Table -5. Show comparing the demographic data and radiographic information for male and female patients from CT scan for from brain examinations

	Male					*Female*				
variables	*Mean*	*STD*	*Min*	*Max*	*3dQuartile*	*Mean*	*STD*	*Min*	*Max*	*3dQuartile*
Age	50.78	20.62	18	85	69.50	47.20	20.69	18	85	65
BMI	25.01	2.76	19.53	31.14	27.07	28.89	4.34	20.44	39.52	31.64
mA	180.98	4.01	60	225	225	183	56.58	60	300	225
DLP mGy.cm	1006.24	718.26	186.5	3313	1524.25	924.14	529.49	158	1940	15544
CTDIv mGy	44.16	45.43	4.05	239	77	37.13	31.14	4.02	81	77
ED mSv	14.08	10.06	2.61	46.38	21.34	12.93	7.41	2.22	27.17	21.62

kV= 120

Table-6: Compare the present study with diagnostic reference level and other countries

Study	*CTDIvol mGy*	*DLP mGy.cm*
Present study	58.96	1552.77
Japan 2015	85	1350
United kingdom 2013	39	544
European DRL 2013	60	1050
Australian 2013	60	1000
ICRP 2001	60	1050

DISCUSSIONS

The important of this study comes from the increased number of patient in CT investigations. However, reducing the radiation dose significantly important by using technique that minimizing radiation exposure (ALARA concept) and limit patient dose. Patient data for both male and female collected from four different hospital and centers in Khartoum which using different CT scanner modalities at four hospitals to scan chest and brain for adult patient (18-78) years old. Table 2. present the demographic and radiographic information for patients underwent CT brain examinations as mean ± standard deviation, for age and body mass index was 48.78 ± 20.47 and 2.83 ± 4.03, for Ma, DLP, CTDIvol and effective dose was 209.11 ± 64.71, 2142.3 ± 3309.17, 77.44 ± 30.1 and 4.49 ± 6.94 respectively.

Comparing the demographic and radiographic information from CT brain among male and female for age and BMI the age data shows the males was older than female 52.63 ± 19.122 years and 43.22 ±21.22 years and the body mass index data its almost similar for both gender. The radiographic data the ma was higher for female 238.71 ± 42.32 for male was 205.73 ± 69.17 while the DLP CTDIvol and effective dose was higher for male 2232.69 ± 3791.54, 78.79 ± 31.38 and 4.69 ± 7.96, the data for female 2206.39 ± 323.17, 76.24 ±34.36 and 4.63 ± 6.79. Table 2. present the demographic and radiographic information for patients underwent CT Chest examinations as mean ± standard deviation, were the mean ± STD for age was 48.88 ± 20.64, Body Mass Index 27.13 ± 4.16, for kV, Ma, DLP, CTDIvol and ED was 120 ± 0.0, 182.0 ± 5.12, 963.23 ± 624.77 ± 40.47± 38.58 and 13.48± 8.74.

Comparing the demographic and radiographic information from CT chest among male and female we found that the Ma for female was higher than male 183± 56.58 and 180.98 ± 4.01, while the dose length product and computed tomography dose index per volume was higher for male which was 1006.24 ± 718.26, 44.16 ± 4.43 and for female 924.14 ± 29.49, 37.31 ± 31.14, for the effective dose the male was higher 14.08 ± 10.06and for female was 12.93 ±7.41. Comparing the dose parameters among the two exams for all hospitals for brain the CTDIvol, DLP and ED was 77.44 ± 30.51, 2142.3 ± 3309.17 and 4.49 ± 6.94 respectively, while for chest was 40.47 ± 38.58, 963.23 ± 624.77 and 13.48 ± 8.74.

The results of present study comparing with diagnostic reference level and other countries found that the CTDIvol was lowest at present study between all studies except the study from UK 2013.

CONCLUSIONS

This study helps to improve Occupational awareness to ionizing radiation hazard from CT procedures and the impotent of radiation protection protocols to a chive ALARA.

Comparing the demographic and radiographic information from CT brain among male and female for age and BMI the age data shows the males was older than female and the body mass index data its almost similar for both gender. The radiographic data the mA was higher for female than male while the DLP CTDIvol and effective dose was higher for male. the demographic and radiographic information from CT chest among male and female we found that the Ma for female was higher than male, while the dose length product and computed tomography dose index per volume was higher for male, the effective dose the male was higher than that from female.

Comparing the dose parameters among the two exams for all hospitals for brain the CTDIvol, DLP and ED was 77.44 ± 30.51, 2142.3 ± 3309.17 and 4.49 ± 6.94 respectively, while for chest was 40.47 ± 38.58, 963.23 ± 624.77 and 13.48 ± 8.74. And when compared with diagnostic reference level and other countries found that the CTDIvol was lowest at present study between all studies except the study from UK 2013. Using different scanner contributed to limitation of this study due to the variation of DLP from scanner to another witch reflect on the values of the effective dose.

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