

## Estimation the Effective Dose for Pediatric during Common Computed Tomography Examinations

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## Abstract

## Original Research Article

The aim of this study to estimate the effective dose for pediatric during common Computed Tomography examinations, at five different hospitals in Khartoum state – Sudan, is presented, the gender distributed according to selected CT scan were the total number of patients was 855 patients, approximately 45% of the patient for brain (386; 233 males and 153 female), about 22% for chest (191; 121 males and 70 female), about 10% for CT abdomen (90; 44 males and 46 female) and 21% for pelvis CT (188; 102 males and 86 female) with total number of male and female 500 and 355 respectively. The effective dose found 1.93 mSv for brain (1.98 mSv for male and 1.87 mSv for female), in CT Chest the effective dose was 3.58 mSv (3.57 mSv for male and 3.59 mSv for female), for abdomen was 5.69 mSv (5.25 mSv for male and 6.13 mSv for female) and for pelvis the E found 7.14 mSv (8.04 mSv for male and 6.23 mSv for female). This study recommends that the CT technologist should be aware to achieving the optimization of patient's dose using the best strategies available for reducing radiation dose, and the patient's Dose must be monitored regularly.

**Keywords:** MDCT, Effective Dose, Pediatric dose.

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## 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]. Exposure to x-ray from CT resulting in high dose to surface of the tissues due to the scattering effect, therefore, the beam divergence and limited collimator efficiency [3], and cancer can be induced CT Exposure according to UNSCEAR. As proved that the patients dose from CT procedures is higher than doses from other x-ray imaging modalities; Such as examined by CT of chest give a higher dose that delivers from conventional chest x-ray reach up to 400 times [4,5]. Recently, studies in CT dosimetry increased, so worries concerning the knowledge have been increased in various usage of CT [6].

Marked improvements in diagnostic imaging performance of CT have been accompanied by

increased concern regarding higher radiation doses and corresponding patient risks [7-9].

Radiation doses in CT are markedly higher than in conventional radiography. A chest CT, for example, has an effective dose (E) of approximately 5 mSv, which is equivalent to approximately 100 chest radiographic examinations because the latter have effective doses of approximately 0.05 mSv [10]. Radiation dose quantities in CT are currently expressed in CT dose index (CTDI). [11] Converting CTDI dose indices into meaningful dose metrics (ie, organ and effective dose) requires explicit consideration of both technical and patient factors. [12] Converting organ doses into radiation risk data also requires considerable care and must take into account patient demographics [13,14]. Quantifying patient detriment needs to take into account the life expectancies of the exposed population and the lengthy latent period associated with radiation-induced cancers [15]. The dose characteristics of new MDCT scanners merit investigation to give practitioners a better Understanding of how radiation doses from these newer systems compare with the single-detector systems prevalent in the 1990s. A major effort has recently been undertaken to optimize CT [16,17] using imaging protocols that explicitly take into

account the characteristics of the patient being examined [18-20]. It is therefore of interest to investigate how the introduction of MDCT scanners and patient-size-dependent imaging protocols have affected patient doses.

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 [21]. 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 [22,23]. The main concern 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 [24-26].

The effective dose is a radiation descriptor that may be used to characterize radiation exposures to patients undergoing computed tomographic (CT) examinations, where radiation levels are well below threshold doses required to induce deterministic effects. (The effective dose  $E$ , defined in publication 60 of the International Commission on Radiological Protection [27], and the effective dose equivalent  $H_E$ , defined in publication 26 of the International Commission of Radiological Protection [28], are conceptually identical but use different organ-weighting factors;  $E$  and  $H_E$  are interchangeable in this article.) The magnitude of the effective dose is related to the stochastic radiation risks of cancer induction and the production of genetic effects.

National and international organizations are using the effective dose to quantify exposures of patients to radiation in diagnostic radiology [29,30]. The aim of the study is to estimate the pediatric radiation dose during Computed Tomography Procedures.

## METHODOLOGY

For a given patient and a constant x-ray tube potential, the value of the effective dose from brain, chest, abdominal and pelvis CT examination depends on the tube current (in milliamperes), the scanning time (in seconds), the section thickness (T), and the total number of sections (N). These four factors were obtained for 855 randomly selected patient's underwnt CT examinations on CT scanners (3 machine Toshiba Aquilion 64 slices, Siemens Sensation 16 slices and GE 16slices).

## CT machines

CT scanners that participated in this study are helical CT scanners in five hospitals. All scanners displayed volume Computed Tomography Dose Index (CTDI) and Dose Length Product (DLP). The data were collected from each CT scanner. All quality control tests were performed to the machines prior to any data collection. All the data were within an accept.

## CT dose measurements

Radiation dose indicators CTDIvol and DLP can be obtained from a dose summary page, which includes information about the CT exam. CTDIvol 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 [31]. DLP, an indicator of the dose imparted to the patient, is calculated by multiplying CTDIvol times the scan length. In addition to being affected by the issues associated with CTDIvol, DLP can be problematic in a limited scan range [32].

## Calculation of Effective Dose

CT scanners record the radiation exposure as a DLP in mGy.cm. The determination of external exposure to the patient is basically from the CT scan that generates the x-ray. As referred to ICRP publication 102 [33], external exposure will determine using the CT Dose Index (CTDI) and Dose Length Product (DLP) value which can have obtained direct from screen computer scan. The effective dose, E for external exposure was then calculated according to equation [33].

$$E = k \times DLP$$

Where k is coefficient based on empirical weighting factor, which functional of the anatomical region scanned (mSv.mGy-1.cm-1) in ICRP 102 [33] and k=0.015 for trunk.

## RESULTS AND DISCUSSION

An overview of patient information and scan parameters used for Computed Tomography CT At five different hospitals in Khartoum state – Sudan, is presented, the gender distributed according to selected CT scan were the total number of patients was 855 patients, approximately 45% of the patient for brain (386; 233 males and 153 female), about 22% for chest (191; 121 males and 70 female), about 10% for CT abdomen (90; 44 males and 46 female) and 21% for pelvis CT (188; 102 males and 86 female) with total number of male and female 500 and 355 respectively.

**Table-1: Show the gender distributed according to selected scan**

<i>Gender</i>	<i>Brain</i>	<i>Chest</i>	<i>Abdomen</i>	<i>Pelvis</i>	<i>Total</i>
<i>Male</i>	233	121	44	102	500
<i>Female</i>	153	70	46	86	355
<i>Total</i>	386	191	90	188	855

**Table-2: Show demographic information for all patients**

<i>Exam</i>	<i>Gender</i>	<i>Age years</i>	<i>High cm</i>	<i>Weight kg</i>
<i>Brain</i>	<i>Male</i>	8.7±5.5 1-18	119.9±38.7 15-188	30.35±19.2 3-80
	<i>Female</i>	9.2±5.6 1-18	121.7±37.2 20-170	31.2±17.8 5-73
<i>Chest</i>	<i>Male</i>	10.8±6.8 1-18	135.15±40.9 53-180	42.5±28.98 5-152
	<i>Female</i>	10.33±6.5 1-18	129.5±35.8 55-185	34.8±20.2 6-73
<i>Abdomen</i>	<i>Male</i>	9.6±6 1-18	129.1±54.9 36-618	35.29±24.82 3-160
	<i>Female</i>	11.24±5.9 1-18	133.8±34.1 34-180	37.2±19.3 6-75
<i>Pelvis</i>	<i>Male</i>	10.37±6.4 1-18	130.18±38.7 60-185	38.15±24.6 8-76
	<i>Female</i>	11.4±6.2 1-18	135.3±35.5 15-178	38±20.18 7-74

**Table-3: Show radiation dose parameters per exam for male and female**

<i>Exam</i>	<i>Gender</i>	<i>Tube Voltage</i>	<i>Tube Current</i>	<i>CTDIvol mGy</i>	<i>DLP mGy.cm</i>	<i>ED mSv</i>
<i>Brain</i>	<i>Male</i>	120.60±6.7 100-130	220±150 11-721	48.62±25.7 1.6-99.5	944.7±654 52-3049	1.98±1.37 0.11-6.40
	<i>Female</i>	119.5±6.6 110-130	218.55±136.4 29-490	52.99±42.6 1.9-467.9	890.8±601.2 7.4-2449	1.87±1.26 0.02-5.14
<i>Chest</i>	<i>Male</i>	119.2±5.8 100-130	120.6±85.2 18-544	7.4±5.85 1-38	255.2±203 26.5-821	3.57±2.84 0.37-11.5
	<i>Female</i>	120.3±6.4 100-130	127.17±96.12 17-350	8.2±6.6 0.6-31.3	256.8±260 10.9-1205.9	3.6±3.64 0.15-16.88
<i>Abdomen</i>	<i>Male</i>	119.1±54.9 80-130	126.8±112.5 19-339	8.62±8.4 0.9-27.6	350.09±385.8 17-1508	5.25±5.79 0.03-22.63
	<i>Female</i>	119.76±8.2 80-130	160.1±121.2 22-360	10±9.6 1-49	408.76±417.9 39.2-1447.3	6.12±6.26 0.59-21.71
<i>Pelvis</i>	<i>Male</i>	120.29±6.7 110-130	146.5±144 15-490	13.79±20.7 1-75	536±940 1.3-4548.7	8±14.1 0.02-68.23
	<i>Female</i>	119.4±6 90-130	141.8±125.4 16-490	11.2±16.1 1-75.2	415.7±648.6 1.3-3481.8	6.2±9.7 0.02-52.2

**Table-4: Show statistical parameters of effective dose for all patients**

<i>Exam</i>	<i>Gender</i>	<i>Mean</i>	<i>STD</i>	<i>Median</i>	<i>Min</i>	<i>Max</i>	<i>3d Quartile</i>
<i>Brain</i>	<i>Male</i>	1.98	1.37	1.42	0.11	6.40	3.28
	<i>Female</i>	1.87	1.26	1.36	0.02	5.14	2.99
<i>Chest</i>	<i>Male</i>	3.57	2.84	2.89	0.37	11.49	4.76
	<i>Female</i>	3.59	3.64	2.60	0.15	16.88	4.39
<i>Abdomen</i>	<i>Male</i>	5.25	5.79	2.70	0.03	22.63	6.52
	<i>Female</i>	6.13	6.26	3.34	0.59	21.71	6.48
<i>Pelvis</i>	<i>Male</i>	8.04	14.11	2.40	0.02	68.23	7.04
	<i>Female</i>	6.23	9.73	2.93	0.02	52.23	6.53

CTA examinations in adult patients have contributed greatly to the diagnosis of different diseases; however, the radiation exposure to the patient

is significantly higher compared with other radiologic examinations. An overview of patient information and scan parameters used for Computed Tomography CT At

five different hospitals in Khartoum state – Sudan, is presented Table 1. show the gender distributed according to selected CT scan were the total number of patients was 855 patients, approximately 45% of the patient for brain (386; 233 males and 153 female), about 22% for chest (191; 121 males and 70 female), about 10% for CT abdomen (90; 44 males and 46 female) and 21% for pelvis CT (188; 102 males and 86 female) with total number of male and female 500 and 355 respectively.

Mean, and standard deviation, Maximum and minimum, of demographic information for all patients age years, weight kg and high cm, and for male and female patients separately. Shown in table 2. Table 3. Show radiation dose parameters tube voltage (kV), tube current –time (mAs), CTDIvol (mGy), DLP (mGy.cm) and effective dose per mSv for all patients and for male and female patients separately.

The effective dose consider the important unit of patients dose, here we present the statical parameters for effective dose shown as mean, median, standard deviation, minimum, maximum and third quartile for all patients and for male and female patients separately in table 4. The effective dose found 1.93 mSv for brain (1.98 mSv for male and 1.87 mSv for female), in CT Chest the effective dose was 3.58 mSv (3.57 mSv for male and 3.59 mSv for female), for abdomen was 5.69 mSv (5.25 mSv for male and 6.13 mSv for female) and for pelvis the E found 7.14 mSv (8.04 mSv for male and 6.23 mSv for female).

## CONCLUSION

Estimation of radiation effective dose for pediatric from CT procedures, in five main hospitals in Khartoum state-Sudan, total number of patients included in this study were 855 patients, the effective dose was slightly variety for patients according to gender and patient's age, Different technician's habits and lack of training among hospital staff responsible from these variations. Dose estimation for patients according to gender has been found.

The effective dose found 1.93 mSv for brain (1.98 mSv for male and 1.87 mSv for female), in CT Chest the effective dose was 3.58 mSv (3.57 mSv for male and 3.59 mSv for female), for abdomen was 5.69 mSv (5.25 mSv for male and 6.13 mSv for female) and for pelvis the E found 7.14 mSv (8.04 mSv for male and 6.23 mSv for female).

The main contributor for this difference between the hospitals because the use of a larger scan length due to lack of proper training to CT operators in Sudan.

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