

# Diagnostic Reference Dose Levels in Computed Tomography

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## Abstract

Radiation doses associated with Computed Tomography is higher than the corresponding doses associated with x-ray examinations by more than one hundred. The research study aims to evaluate the radiation doses associated with CT examinations in examinations in Hospital A in one of the radiology departments. This hospital participated in a dose survey for the three most commonly used CT protocols. CT dose indices are calculated and shown by CT machine via Picture archiving communication system. The volume CT dose index, dose-length product, and effective dose for the head were 48.7 mGy, 600 mGy.cm, and 1.38 mSv; for the chest, 15.5 mGy, 349 mGy.cm and 4.89 mSv; for the abdomen- pelvic, 14 mGy, 551 mGy.cm, and 5.3 mSv. The diagnostic reference dose levels were lower than those of international organizations. The study concluded that the effective doses for head, chest and abdomen pelvic are calculated and can be used as additional tools to verify the quality control of CT scanners.

**Keywords:** head CT; chest CT; abdomen-pelvic CT; PACs

## Introduction

Medical x-rays are the largest man-made source of public exposure to ionizing radiation. The contribution of CT to the collective dose in 1991-1996 was 34% [1,2]. Medical radiation protection principles should include justification and optimization by applying the ALARA principle, as low as reasonably achievable. There are few studies about the evaluation a radiation doses associated with computed tomography examinations in Cairo that means Egypt needs to evaluate the effective doses for all CT examinations for all the hospitals of ministry

of health. The effective dose for CT examinations plays an important role in generating a diagnostic dose baseline for the CT scanners. The paper is aimed to calculate the radiation doses associated with CT examinations in Hospital A in Cairo.

## Materials and Methods

### CT scanner specifications

The study was performed using CT scanner. It includes a Siemens CT machine with 64 multislice as described in Table 1. The demographic data are presented Table 2.

**Table 1:** Specification of CT scanner.

Number	CT Manufacture	Scanner Type	Detector type
2	Siemens	MDCT 64	Scintillation detectors

**Table 2:** Biometric parameters and main CT acquisition parameters for Hospital A.

Biometric Parameters				Main CT Acquisition Parameters			
CT Protocol	No. of Patients	Age (year)	Weight (kg)	Kilo Voltage, kV	Effective mAs	Section Thickness (mm)	Number of Slices
Head	50	33 ± 14	76 ± 17	120 ± 0	172 ± 0	0.5 ± 0	188
Chest	50	52 ± 15	85 ± 25	120 ± 0	250 ± 0	2.0 ± 0	142
Abdomen-Pelvic	50	45 ± 15	86 ± 19	120 ± 0	134 ± 0	3.0 ± 0	124

## CT Dosimetric Unit

CTDI<sub>w</sub>: Weighted Computed Tomography Dose Index [6].

$$CTDI_w = \frac{1}{3}CTDI_{100,center} + \frac{2}{3}CTDI_{100,peripheral}$$

CTDI<sub>vol</sub>: Volume Computed Tomography Dose Index [6].

$$CTDI_{vol} = \frac{N \times T}{I} \times CTDI_w$$

and  $l$  = the table increment per axial scan (mm). Since pitch is defined as the ratio of the table travel per rotation ( $I$ ) to the total nominal beam width ( $N \times T$ ) [3].

The Dose-Length product (DLP) is calculated as presented in equation 6.

$$\text{DLP (mGy.cm)} = \text{CTDI}_{\text{vol}} \times \text{scan length (cm)}$$

Effective dose was estimated multiplying CT dose length product CT, mGy.cm by a corresponding normalized conversion coefficient that is defined as

specific only to the anatomic region ( $k$ ), mSv/mGy.cm for multislice CT scans [4-7].

## Results

The mean values of CTDI<sub>vol</sub> and DLP for fifty CT examinations for each case for different weight intervals presented as shown in Table 3. The Hospital A in Cairo country participated in a dose survey for the three most commonly used CT protocols. CTDI<sub>vol</sub>, DLP for head/sinus, chest was recorded by (PACS) from Hospital A as shown in Table 4.

**Table 3:** CTDI<sub>vol</sub> (mGy) and DLP (mGy.cm) at CT scanner for Hospital A.

CT protocol	Dosimetric data	41-60 kg	61-80 kg	81-100 kg	101-120 kg
Head	CTDI <sub>vol</sub> (mGy)	48.85±5.0	48.80±1.6	48.95±12	48.36±8
	DLP (mGy.cm)	602.38±148	601.37±208	602.75±141	593.85±234
Chest	CTDI <sub>vol</sub> (mGy)	14.40±2.5	14.10±6	15.20±3.5	17.00±2.5
	(DLP) (mGy.cm)	107.60±46	312.80	342.40±149	342.50±135
Abdomen-Pelvic	CTDI <sub>vol</sub> (mGy)	6.47±2.5	10.06	14.91±2.9	21.83±2.9
	(DLP) (mGy.cm)	279.80±102	379.31	420.20±88	921.23±220

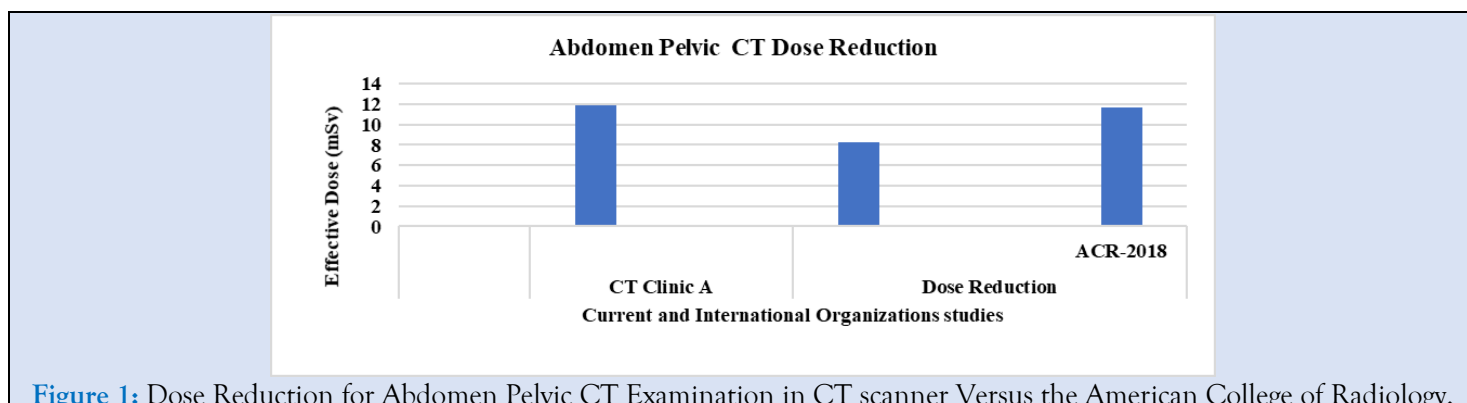
**Table 4:** Mean values of CTDI<sub>vol</sub>, DLP and effective dose for CT protocols.

CT Protocol	Dosimetric Data/CT Examination	CT Scanner A	ACR-2018
Head	CTDI <sub>vol</sub> (mGy)	61.80± 1.8	56.00
	DLP (mGy.cm)	598±29	962.00
	E (mSv)	2.55 ± 0.13	2.21
Chest	CTDI <sub>vol</sub> (mGy)	15.50 ± 0.62	10.00
	DLP (mGy.cm)	349±67	400.00
	E (mSv)	9.21 ± 0.06	6.80
Abdomen-Pelvic	CTDI <sub>vol</sub> (mGy)	10±0.1	16.00
	DLP (mGy.cm)	379±25	781.00
	E (mSv)	8 ± 0.8	11.72

## Dose Optimization of Abdomen-Pelvic CT Protocol

Twenty cases for abdomen- pelvic CT examinations were classified into two groups. The physical parameters for group one was examined for of 120 kV, 224 mAs and group two was examined for 120

kV, 182 mAs respectively. Effective for doses the abdomen-pelvic CT protocol is reduced to 55% due to decrease the tube current-product time, 224 mAs to 182 mAs that effect on the dose out [6] as presented in Figure 1.



**Figure 1:** Dose Reduction for Abdomen Pelvic CT Examination in CT scanner Versus the American College of Radiology.

## Discussion

The CT DIvol and dose length product, DLP corresponding CT protocols in CT clinic were recorded for about 150 patient sizes of selected CT scanner. The demographic data was collected for many patient weight intervals as shown in Table 3. The variation in Cvol and dose length product, DLP for head CT scan for different weights is not significance because of little difference in the number of slices.

The CT DIvol and DLP for chest CT scan for patient's weights greater than 100 kg increase by a about 10% than patient's weights lower than 100 kg may be due to difference patient's chest size.

CT DIvol and DLP for lower limb CT examinations for different patient's weight ranges increased gradually due to decreasing pitch factors. Table 4 present the volume CT dose index (CT DIvol), dose-length product (DLP), and effective dose) for adult's head, chest and abdomen- pelvic CT Examinations for Hospital A in Cairo and comparison with international organizations. In the CT clinic A, CT DIvol, DLP, and effective dose for the head were 48.7 mGy, 600 mGy.cm and 1.38 mSv; for the chest, 15.5 mGy, 349 mGy.cm and 4.89 mSv; for the abdomen, 14 mGy, 551 m4Gy.cm and 5.3 mSv. The effective dose for head CT, chest CT and abdomen CT was presented as shown in Table 4.

## Conclusions

The results show that the effective doses for head, chest and abdomen pelvic are calculated. Effective doses for the -abdomen-pelvic CT protocol is reduced to 55% due to optimize the tube current product time.

## Abbreviations

CT DIvol: Computed Tomography volume dose index, DLP: dose length product, ACR: American College of Radiology, CT: Computed Tomography, kVp: kilovoltage, peak kilovoltage (Kvp), milli-

Ampere-second: mAs, Pitch factor: P, slice-width: T, length of scan: L, Picture archiving communication system: PACs, CT DIvol: Volume Computed Tomography Dose Index.

## Declarations

### Disclosure Statement

No potential conflict of interest was reported by the authors.

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