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Optimization of Radiation Dose and Effective Dose for CT Pelvis Examinations in Main Hospitals in ALTaif Region

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Abstract

Introduction: CT scan is one of the medical imaging methods that irradiate patients with significant amounts of radiation. These amount of radiation doses must be well estimated if the imaging area is in part containing radiation-sensitive organs such as the pelvic area. Objectives: the objectives of the current study were to assess radiation dose during pelvis and Abdomen CT imaging and estimate the effective dose as well as to propose diagnostic reference level (DRL).Methodology: 200 adult patients irradiated in two major governmental hospital in Taif city, Saudi Arabia, patients' demographic data from was collected such as weight, height, and age. Scanner specifications and scan parameters for each pelvis examination were recorded in special data collection sheet. Volume CT dose index (CTDIvol and dose length product (DLP) were utilized to estimate the radiation dose and effective dose. Microsoft Excel was used to analyse the data.Main Results: there was variation in scanning parameters among two hospitals under study and this result in variation in effective dose between two hospitals. The average DLP, CTDIvol and effective dose were 368.5, 390.7 mGy-cm,10.2,10.8 mGy and 7, 7.4 mSv for hospital one and two respectively. Conclusion: Based on the third quartile of DLP and CTDIw, the recommended DRL for both hospitals was 405 mGy-cm and 21.75 mGy, respectively. The findings revealed a reduced effective dose value when compared with previous studies.

Keywords: *CT, radiation dose, pelvis,Abdomen, Taif.*

Introduction

1.1 Radiation classification and photons interaction

Radiation is divided into two categories based on its ability to ionize matter: non-ionizing and ionizing. Ionizing radiation can directly or indirectly ionize matter:

Charged particles such as electrons, protons, particles, and heavy particles are directly ionizing radiation-rays, photons, and neutrons are examples of indirect ionizing radiation (neutral particles).

Concerns regarding patient safety are developing as the number of computed tomography (CT) treatments performed in Saudi Arabia and around the world continues to rise. There is currently no mechanism in place to track a patient's lifetime cumulative exposure from medical sources, and concerns have been raised about the public health risks associated with the extensive use of CT, particularly in pelvic examinations.

Photons can interact with the atoms of an attenuator in several different ways; the probability or cross-section for each interaction is determined by the photon's energy hv and the attenuator's atomic number

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Z. Photon interactions can occur with a firmly bound electron (photoelectric effect, coherent scattering), the nucleus' field (pair generation), or an essentially free orbital electron (essentially free orbital electron) (Compton Effect, triplet production).

The photon may disappear totally (photoelectric effect, pair formation, triplet production) or be dispersed coherently (coherent scattering) or incoherently during the encounter (Compton Effect). All these methods of interactions have their specific requirements to occur (specific condition).

1.2 Clinical X-ray beam

The source of radiation in clinic is X-ray tube target which yield characteristic beam and braking radiation (bremsstrahlung) radiation.

'The line spectra that are distinctive of the target material are overlaid on the continuous Bremsstrahlung spectrum in a typical spectrum of a clinical X-ray beam. Bremsstrahlung spectra come from the X-ray target, while characteristic line spectra come from the target and any attenuators in the beam. Most photons are produced at 90 degrees from the direction of electron acceleration in the diagnostic energy range (10-150 kV), while most photons are produced in the direction of electron acceleration in the megavoltage energy range (1-50 M V).

1.3 Effects of radiation in biological tissue

Radiation dose quantities function as indications of the risk of biologic damage to the patient, hence radiation dosimetry is of primary interest.

Radiation's biological effects can be categorized as deterministic (non-stochastic) or stochastic.

1.3-1 Non stochastic effects

Cell death is thought to generate deterministic or non-stochastic effects; if a significant number of cells in an organ or tissue are killed, its function can be affected. Teratogenic effects on the embryo or fetus, skin damage, and cataracts are examples of deterministic or non-stochastic effects. It is possible to set a threshold below which the impact will not occur.

The severity of the effect increases with increasing dosages above the threshold level. The dose to an organ is evaluated to determine the possibility of a predictable consequence from an imaging process.

1.3-2 Non-deterministic effects

Damage to a cell that creates genetically changed but reproductively viable children, cancer, and hereditary effects of radiation are examples of stochastic effects. Instead of increasing in severity, the probability of a stochastic consequence grows with dose.

1.4 Main information about CT dose

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Figure 1.4. CT scanner

Computed Tomography (CT) (Computed relates to computer, Tomo means cutting or designated layer in Greek, and graph means to write in Greek) (Alkadhi H, Euler A.,2020).

CT is well-established as a major source of population exposure from diagnostic X-ray examinations and an important technique in diagnostic radiology that delivers high-quality cross-sectional X-ray images of the body, but at rather high patient doses (Figure 1).

LITERATURE REVIEW

2.1 Historical background

One of the most significant developments in modern medicine has been the advent of computed tomography (CT) scanners. In 1972, they were first used in clinical practice (Johns and Cunningham, 1983). CT (computed tomography) is a method of imaging that generates body-slice data in a three-dimensional format. CT scans have a better contrast resolution than planar radiography, allowing for a greater capacity to detect tiny variations in tissue attenuation (contrast) (Shrimpton and Wall., 1995; Mohammad et al., 2024a; Mohammad et al., 2023a; Mohammad et al, 2024b). CT now enables for sub-millimeter resolution imaging of the entire body in 5-20 seconds (Hausleiter et al., 2009). CT delivers high-quality cross-sectional pictures, and its widespread use has had a significant impact on patient care as well as population exposure to medical X-rays (Alkadhi and Euler., 2020; Mohammad et al., 2023b; Al-Hawary et al., 2020; Al-Husban et al., 2023). CT examinations have different exposure conditions than conventional X-ray techniques. National surveys on CT practice have revealed that CT' is becoming a more major source of medical X-ray exposure (Alkadhi and Euler., 2020). Due to rapidly with the advent of CT technology and its widespread use, CT scanners currently account for around 40% of medical X-ray exposure in the public, (Brix et al., 2003). The best use of ionizing radiation necessitates the collaboration of three crucial elements of the imaging process. Image quality, radiation dose to the patient, and examination technique selection are all factors to consider (Tsapaki et al., (2001). One of the fundamental concepts of radiation protection is to limit the dosage to the patient as low as reasonably achievable (ALARA) while still meeting the clinical purpose (Treier, et al., (2010; Al-Nawafah et al., 2022; Alolayyan et al., 2018).

The International Commission on Radiological Protection has suggested that efforts be made to reduce CT radiation (ICRP). The International Commission on Radiological Protection, the International Atomic Energy Agency, and the European Commission have all recommended the establishment and implementation of CT dose guidance levels for the most common CT examinations to promote radiation dose optimization strategies.

The importance of X-ray CT radiation dose has lately been highlighted by the attention paid to dose concerns and the accompanying projected risk in scientific publications and literatures. CT provides doses that are higher than those provided by conventional radiography and fluoroscopy, and its use is growing at a rate of 10-15% every year. Therefore, CT will continue to account for a significant amount of the overall

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collective dose supplied to the general public as a result of ionizing radiation medical tests. The fast advancement of CT technology and the resulting explosion of new clinical applications, such as cardiac CT and perfusion CT, has necessitated the teaching, understanding, and implementation of CT dosage information in more practical aspects.

Patient dose optimization is a legal responsibility to guarantee that the radiation dose for each medical exposure at (ALARA principle) while still achieving the desired diagnostic or therapeutic result . Direct measurement of patient dose and the formation of diagnostic reference levels (DRLs) are essential to achieve optimization, both of which are regulatory requirements (Vano, et al., 2015; Alzyoud et al., 2024; Mohammad et al., 2022; Rahamneh et al., 2023).

There is an implied necessity for each radiological examination to ensure that the patient benefit outweighs any associated radiation risk (Vano, et al., 2015). As a result, practitioners must be aware of the amount of radiation hazards involved with radiological investigations, as well as how these risks fluctuate with patient demographic characteristics such as gender and age.

Addressing patient risks is extremely crucial in computed tomography (CT) imaging, where radiation doses are typically substantially higher than in other imaging modalities. CT was responsible for approximately half of the total population exposure from medical imaging in 2006, accounting for 17% of all diagnostic exams ((Tsapaki et al., (2071).

There are many ways and technique available to estimate CT dose for patients, one of these ways to consider the index of CT dose (CTDI either weighed CT dose or volume CT dose and the parameter of dose length product.

The volume CT dose index (CTDJvol) and the dose length product (DLP) are presented to operators during CT exams. CTDI is a measure of the amount of radiation required to do a CT examination that is independent of the scan length. Multiplying CTDI by the relevant scan length provides DLP, which may be used to calculate the total amount of radiation used to perform a CT examination. The amount of radiation absorbed by the patient, on the other hand, is determined by the patient's physical attributes and the type of CT examination.

2.2 Introduction to previous studies

To make more precise diagnoses, physicians have come to rely on complex imaging techniques, and CT has become the modality of choice for many specialists. Scan times have been shortened, resulting in improved image quality and increased patient throughput. Aldrich and Williams., 2005 conducted a significant study that tracked variations in the number of radiological tests performed at Vancouver General Hospital from 1991 to 2002 and looked at the relationship between the patient's radiation exposure and the number of exams performed. They observed that the average annual effective dosage per patient nearly quadrupled throughout the research period, from 3.3 mSv in 1991 to 6.0 mSv in 2002, in addition to a four-fold increase in CT exams. According to other studies, the average axial scanning effective dosage for diverse body areas is 6.2 mSv. According to Aldrich and Williams, CT is the most significant contributor to patient dosage in radiology.

2.3 Previous studies

Yates et al., (2004) calculated effective dose (ED; per unit dose-length product (DLPj conversion factors for computed tomographic (CT) dosimetry using a CT dosimetry spreadsheet. The ED/DLP ratio was calculated using 16-section CT scanners from four suppliers as well as five models from one manufacturer spanning more than 25 years. For 2-cm scan lengths along the patient axis, as well as 1'Or common scan lengths encountered at head and body CT exams, ED to DLP ratios were established. The effect of X-ray tube voltage (kilovolts) on the ratio of ED to DLP was explored, and the results from the spreadsheet were compared to those from two other commercially available Cl' dosimetry software tools. Changes in the scan region resulted in variances to ED of a factor of 30 for 2-cm scan lengths, although there was

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significantly less variation for common scan durations for clinical head and body imaging. For ED/DLP, inter- and intra-manufacturer variances were generally minor. At 120 kV, representative ED/DLP values were 2.2 |Sv/mGy-cm (head scans). Cervical spine scans are 5.4 Sv/mGy-cm, while body scans are 18 Sv/mGy-cm.

Huda et al., (2007) investigated patient dose, the environment, and subsequent assessment of diagnostic reference levels in a novel study titled effect of multi-slice scanners on patient radiation from routine CT exams in East Anglia. Audits of effective dose in CT were conducted in East Anglia in 1996, 1999, and 2002. Nine of the 14 scanners reviewed in the 2002 audit had been replaced since the previous assessment. Eight of the new scanners were multi-slice scanners, which could acquire up to 16 slices in one revolution. The purpose of the 2002 audit was to see how the introduction of these multi-slice scanners affected patient doses from normal CT scans. For ten different types of routine CT examinations, exposure parameters were collected. The National Radiological Protection Board published the findings of Monte Carlo simulations, which were used to establish effective dosages. Averaged across all 10 examinations, regional mean effective doses| are higher than m previous single slice. The multi-slice scanners in the region give, on average, 35% more effective dose than previous single slice scanners. The effect of collimation in multi-slice scanners makes these elective dose differences most notable for examinations that use narrow slice widths, further optimization of exposures on multi-slice scanners has the potential to reduce the differences observed between single-slice and multi-slice doses.

Christner et al., (2012) intended out if there was a correlation between patient size, scanner radiation output, and size-specific dose estimates (SSDEs) for adults who had chest computed tomography (CT). CTDIvol was substantially connected with size for patient sizes ranging from 42 to 84 cm (slope = 0.34 mGy/cm; 95 percent confidence interval [CI]: 0.31, 0.37 mGy/cm; R2 = 0.48; P 0.001), whereas SSDE was unrelated to size (slope = 0.02 mGy/cm; 95 percent CI: 20.02, 0.07 mGy/cm; R2 = 0.00 Patient size explained 48 percent of the observed variability in CTDIvol but less than 1% of the reported variability in SSDE, according to these R2 values. CTDIvol varied from 12 to 26 mGy in the 42–84 cm range, according to a regression of CTDIvol versus patient size. The SSDE values were independent of patient size when the assessed automatic exposure control system was used to adjust scanner output for patient size. According to the findings, CTDIvol (scanner output) increased linearly with patient size for the evaluated automatic exposure control system; however, patient dose (as measured by SSDE) was unaffected by patient size, implying that increasing scanner output for larger patients will not necessarily increase the mean absorbed dose to these patients.

C Anam., et al., (2016) did a study with the goal of calculating and investigating the size-specific dose estimate (SSDE) in thoracic and head CT exams using routine imaging techniques. Their findings revealed that the DW value in the thoracic region was 4.5 percent lower than the Deff value, while the DW value in the head region was 8.6 percent greater. The diameter (Deff and D) and CTDIvol correlations were distinct. Because the tube current modulation (TCM) was turned off in the head, decreasing the patient diameter resulted in a constant CTDIvol, whereas in the thoracic region decreasing the patient diameter resulted in a decrease in the value of CTDIvol due to TCM being turned on; in the head region, decreasing the patient diameter resulted in an increase in the value of SSDE, whereas in the thoracic region decreasing the patient diameter resulted in a decrease in the SSDE. The paper suggested a technique for calculating Deff, DW, and SSDE automatically. They conclude that when TCM is engaged, the radiation dosage (SSDE) for thoracic examinations lowers as the patient diameter decreases. If TCM is not engaged, the radiation dose (SSDE) increases with a decrease in patient diameter for head scans.

Rumi Imai, et al., 2015, and his colleagues at a Japanese national children's hospital evaluated paediatric abdominal/pelvic computed tomography by calculating SSDE and comparing it to CTDIvol, as well as generating DRLs from both CTDIvol and SSDE. According to their findings, size-specific dose estimations, which take body size into account, are a very good index for calculating exposure dose in children. The SSDE-based diagnostic reference levels for children aged 1, 5, and 10 years could be compared to the previously published CTDIvol-based diagnostic reference level, and the SSDE for the

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abdominal/pelvic CT examination performed at the hospital was low compared to the rest of the world, indicating that it could be used as a reference level for a low-dose protocol for children.

METHODOLOGY

Data collection

Data were collected for 200 patients from two hospitals: The hospitals that participated in the study are: King Abdul Aziz specialist hospital (KAASH), and King Faisal Medical Complex (KFMC) at Taif city Saudi Arabia.

Firstly, each hospital's radiographers were required to disclose information on their CT scanners. The following information was gathered (table 1 shows CT machines specifications): Name of the hospital, manufacturer of the CT machine, type of machines according to number of slices produced, model, year of installation, type, last date of quality control (QC) check for spiral CT scanners used in both hospitals.

Both of machines display DLP and CTDI during the scan and record this facility during imaging achieving.

Table 3.1: Specifications of Machines Used in Data Collection

Hospital	Manufacturer	Type	installation	Previous QC check
KAASH	**Siemens**	**Spiral/ 128**	**2011**	**September 2021**
KFMC	**Philips**	**Spiral/128**	**2016**	**October 2021**

3.Design of the study

The study examined on 200 adult patients who had pelvic CT scans at two multi-slice computed tomography (MSCT) facilities. The hospitals were in Taif, in the western region of Saudi Arabia. The two hospitals chosen were government hospitals that serve the highest population density and provide diagnostic services to a huge area around them. These hospitals were chosen because they are among the busiest in terms of patient volume. Patients were chosen in order, and dosage information was taken from the archive of exams conducted between June 1 and October 31, 2021. 116 patients' data were acquired from KAASH, while 84 patients' data were collected from KFMC. All of the participants in the study were adults, with a mix of male and female patients undergoing CT scans for various clinical purposes.

3.2.1 Inclusion and exclusion criteria

Inclusion criteria include any adult patient's female or male during the data collection phase requested CT pelvis and Abdomen exam in hospitals under study.

Exclusion criteria include paediatric patient requested CT pelvis and Abdomen during the data collection phase requested CT pelvis and Abdomen exam in hospitals under study.

3.2.2 Patients data collection

Patients' characteristic such as age weight and gender were collected in special data collection sheet. Body mass index then calculated by dividing the square of height in centimetre by weight in Kg.

$$BMI = L2/Kg \qquad (3.2)$$

Patients dose calculation

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Patient information (age, gender and weight), tube voltage, tube current, rotation time(s), pitch value, and CTDIvol, and Were obtained from patients underwent CT pelvis and Abdomen examinations and some of patients underwent pelvis examination their data achieved from the DICOM.

We used digital callipers on the scanner console to measure the diameter of the patient's images for size specific dose estimate (SSDE) estimations. Anterior-Posterior diameter (DAP) and lateral diameter (DLAT) were measured on transverse CT images from the mid-slice position, and DLAT on scout images. As patient size markers, measured dimensions (DAP and DLAT) were used:

The effective diameter was achieved using equation 3-3 which obtained from report of AAPM No 204.

$$Effective\ diameter = \sqrt{DAPXDLAT} \qquad (3\text{-}3)\ (AAPM\ ,204)$$

The SSDE was then determined by multiplying the CTDIvol presented on the console by the size-specific conversion factors (f) listed in AAPM report 204.

$$SSDE = CTDIvol\ X\ F \qquad (3.4)\ (AAPM,204)$$

Then comparison is made between SSDE, CTDIvol achieved in present study with previous studies in literature Also correlation of SSDE and CTDIvol is found.

The CT examination DLP was multiplied by a k-coefficient derived from a table provided by ICRP 102, to estimate effective dose, as illustrated in equation 3-5.

$$Effective\ dose = DLPXK \qquad (3\text{-}5)\ (ICRP,102)$$

More information can be found at https://www.ajronline.org/doi/full/10.2214/AJR.14.13317

Also, the weighted CT dose index is calculated using the below equation (equation 3-6) that achieved from AAPM report 204.

$$CTDIw = CTDIv\ X\ Pitch \qquad (3\text{-}6)\ (AAPM,\ 204)$$

Recognize that in CT, spiral pitch is inversely proportional to CT radiation dose. The spiral pitch is calculated by dividing the table movement (input into the gantry) by the collimator width for each gantry rotation.

Data management and analysis were performed using Microsoft MS Excel version 2010.

3.4 Ethical considerations

Ethical approval was taken from the Ministry of health Taif and then from each hospitals KAASH and King Faisal complex building, then the administrator focused the researcher to department un each above hospitals to start the data collection phase.

3.4.1 Informed Consent

Participants were fully informed about the study being conducted – including the purpose of the project, funding, how the findings will be used, if there would be any potential adverse impacts of their participation, and who would have access to the findings

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3.4.2 Voluntary Participation

Participants were informed about the possibility of withdrawing from the study at any time, and that their withdrawal from the study would not be negatively impact the healthcare they receive or their relationships with any of the physicians or researchers involved. In addition, explanations from the participants would not be required should they decide to discontinue for any reason.

3.4.3 Confidentiality

Identifying information would not be made available to or accessed by anyone but the research team. All data sheets were protected by password and strictly shared with the research team only.

RESULTS AND DISCUSSION

A- Results

The objectives of current study were to assess the pelvic radiation dose in computed tomography for two main hospitals in Taif city and compare the results with literature available, as well as to establish local diagnostic reference level for the local practice.

The results were divided into the following portions: -

- Patients sample and their demographic data
- Reason for performing CT pelvis and Abdomen examinations
- Patient dosimetry and estimation of patient effective dose
- Compare the patient's dose with previous studies
- Suggest local diagnostic reference level (DRL)

4-1 Sample size

There were 200 patients distributed between male (94), which represented 47% and female (106), which represented 53%., Figure 4-1-1 shows the frequency distribution of sample size. There is no wide variation between gender participated in this study, so the sample can be considered as homogeneous sample.

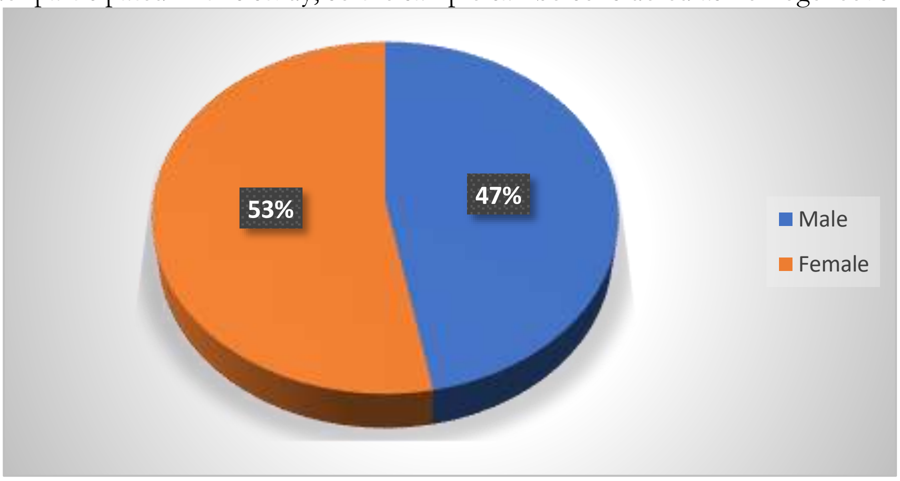

Figure 4-1 shows the frequency of gender among sample size participated in the study

The average age and body mass index among participants in this study was 37.3 years. and 25.5 (Kg/m^2) respectively Table 4-1shows the statistical variation of age,weight and BMI.

Table 4-1 Statistic variation of age, weight and BMI among study sample

Parameter	mean	Max	Min	±STD
Age (year)	37.3	82	20	12.9

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Weight (Kg)	69.2	79	46	10.3
BMI (Kg/m²)	25.5	30.6	18.5	4.7

There was wide range of age among adult participant (20-82Y) and less range of BMI among those participants (18.5-30.6 Kg/m²). This will Give us better distribution about radiation dose among participants. The average weight shows less than standard man described by ICRP 1977 (ICRP 1977) which showed the reference weight of 70 Kg. data for the above table (Table 4-1) was statistically calculated for two hospitals.

Indication of CT pelvis examinations

For specific conditions, a CT scan of the pelvis or abdomen/pelvis is performed. These scans were performed for diagnosis and evaluating the following conditions:

Aneurysms of the abdominal aorta, Cancers of the liver, kidney, pancreas, ovary, or bladder in the pelvic region Crohn's disease, pancreatitis, liver cirrhosis, ulcerative colitis, and other inflammatory disorders are examples of inflammatory diseases. Injuries to the liver, kidneys, spleen, or other abdominal organs are among the most common. Stones in the renal or bladder Pancreatitis, and Appendicitis, pyelonephritis, and pelvic inflammations are examples of pelvic infections.

Figure 4-2 summarized the indications of CT pelvis and Abdomen examination throughout this study

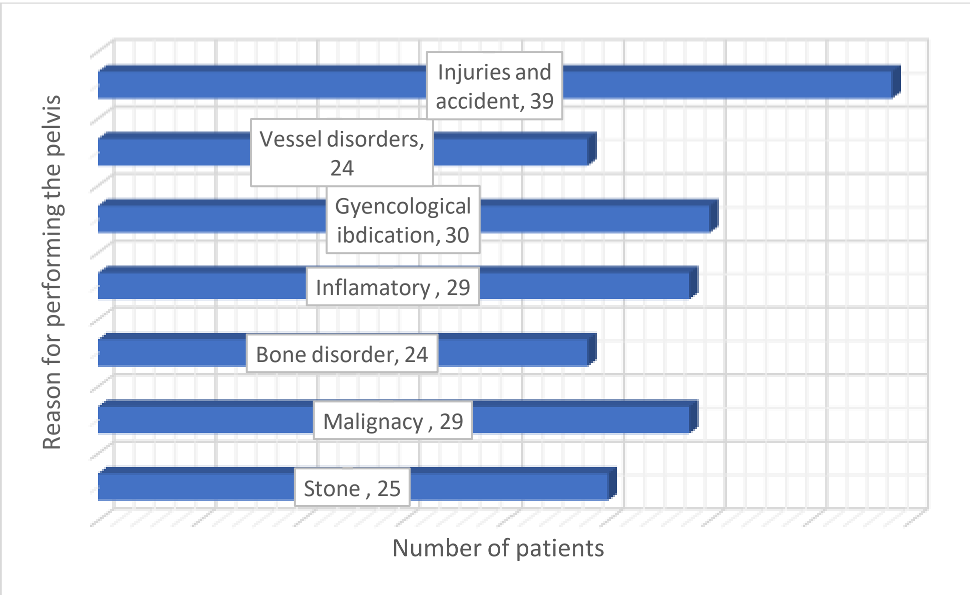

Figure 4-2 Reasons for performing CT pelvis and Abdomen examination against the number of patients

From the figure 4-2 showed that the highest indication for pelvis examination was the injuries and accidents and this may due to type or nature of hospitals under study as they were the main governmental hospitals in Taif city and received mostly emergency cases that required irradiation to diagnose their injuries.

4-3-1 Dosimetry and exposure factors

The exposure factors and patients characteristic (age and weight) for pelvis examination were recorded, the following table (Table 4-3-1) shows the slice thickness (ST), number of slices (NS), pitch, product of tube current and time and tube kilovoltage, for hospital one and two. The sample size in hospital one was 91, while for hospital two was 109 patients.

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Table 4-3-1 Descriptive statistics of patient's characteristics in each hospital and the scan parameters for pelvis and Abdomen examination

Hospital 1							
	Patients' characteristics		**Scan parameters**				
	Age (year)	Weight (Kg)	Kv	mAs	ST (mm)	NS	Pitch
Mean	42.8	68.7	120	190.6	5.4	18	1.8
Median	47	74	120	340	6	16	1.9
Max	71	78	120	642	8	24	1.9
Min	24	57	120	49	.1	12	1.25
Sample size	91						
Hospital 2							
	Patients' characteristics		**Scan parameters**				
Parameter	Age	Weight	kV	mAs	ST (mm)	NS	Pitch
Mean	55.4	69.3	120	224.5	6.2	16	1.4
Median	61	72	120	420	8	20	1.5
Max	82	79	120	680	10	32	1.8
Min	20	46	120	80	1.5	10	0.8
Sample size	109						

kV tube potential, mAs tube current, ST slice thickness, and NS describes number of slices

4-3-2 Patients dosimetry

The DLP, CTDIv were recorded, also calculated values of CTDIw and SSDE gathered using equation 3-5 and 3-6, The statistic of DLP and CTDI in each hospital were summarized in table 4-3-2.

Table 4-3-2 Descriptive statistics of DL P, CTDIvol, CTDIw and SSDR

Hospital 1					
Parameter	Mean	3rd quartile	Max	Min	±STD
DLP (mGy-cm	368.5	390	420	159	12.4
CTDIvol (mGy)	10.2	11.2	12.1	9.2	1.7
CTDIw (mGy)	18.3	20.5	23	11.6	3.8
SSDE (mGy)	24.4	32.6	40.4	18.2	4.8
Hospital 2					
parameter	Mean	3rd quartile	Max	Min	±STD
DLP (mGy-cm	390.7	420	442	192	13.1
CTDIvol (mGy)	10.8	11.9	13	9.5	1.5
CTDIw (mGy)	20.5	23	26	14.3	4.5
SSDE (mGy)	25.4	34.7	42.8	19.6	2.8

The above table (Table 4-3-2) showed variation of practice among two hospitals

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and consequently variation in radiation dose during the pelvis procedure.

The below figure (Figure 4-3-1) summarized the comparison of average value of DLP, calculated CTDI and SSDE achieved in two hospitals participated in this research.

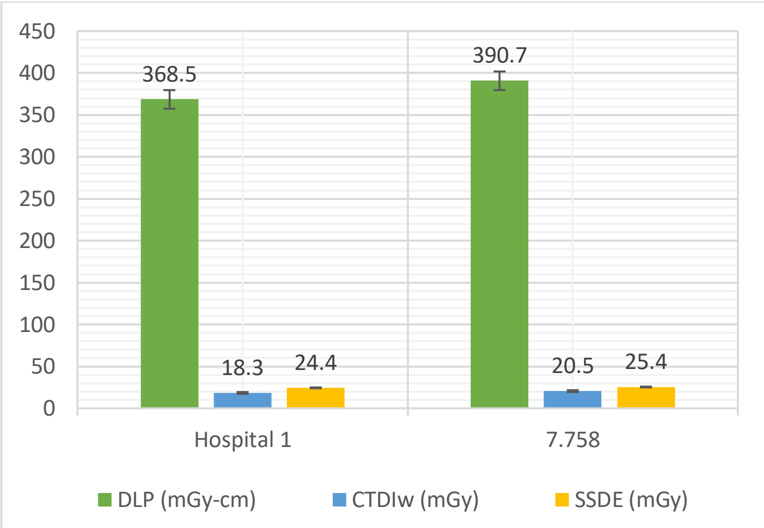

Figure 4-3-1 Comparison of DLP, CTDIw and SSDE in two hospitals

The correlation of CTDIw and SSDE plotted in Figure 4-3-2, showed there was linear correlation between SSDE and CTDIw, and the correlation coefficient was 0.6 (R^2=0.6).so the two quantities are strong dependent.

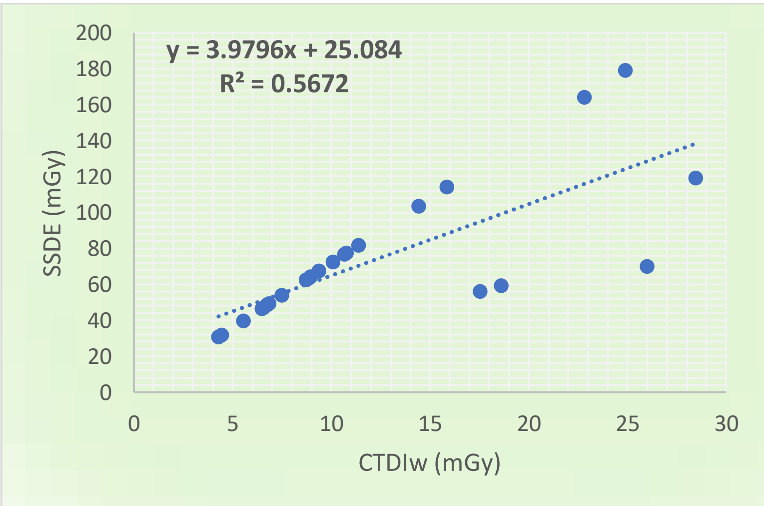

Figure 4-3-2 CTDIw versus SSDE in both hospitals

4-4 Effective radiation dose for CT pelvis and Abdomen examination

To estimate effective doses from patient examinations, the DLP of each examination was multiplied by previously established conversion factors for a 70-kg male (ICRP, 102; Osman et al., 2020; Al-Azzam et al., 2023; Al-Shormana et al., 2022; Al-E'wesat et al., 2024) with this conversion factor being 0.019 mSv/mGy cm for the pelvis and 0.017 mSv/mGy cm for the abdomen-pelvis.

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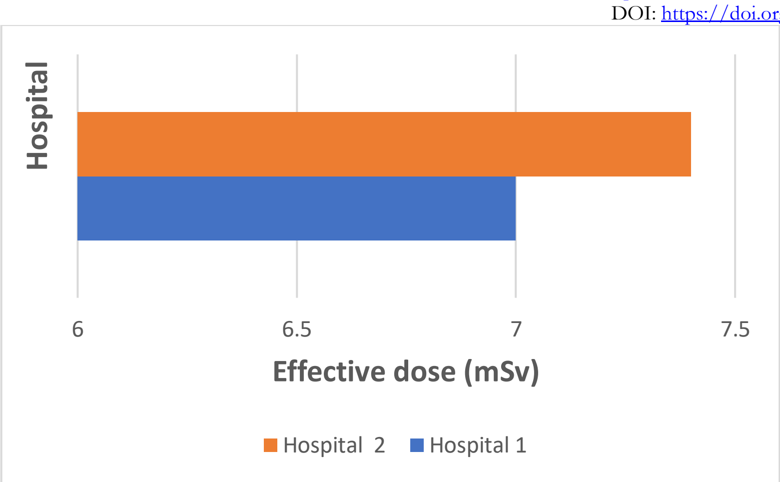

Figure 4-4 comparison of effective dose in both hospital

There was no wide variation in both hospital in term of effective dose and the average of effective dose was 7.21 mSv.

B- Discussion

The current research was to evaluate the radiation dose during CT pelvis and Abdomen examination in two main hospitals in Taif, Saudi Arabia, as well as to estimate effective dose, in addition to propose diagnostic reference level in a forementioned procedure. The sample size from these hospitals was 200 adult patients underwent CT pelvis and Abdomen examination, 53% was female and 47% was male. The average age, weight and body mass index among the participants in this research was 37.2 years,69.2 Kg and 25.5 Kg/m2 respectively, so according to ICRP 60 (ICRP 60.,1991) the weight and BMI in this study can be considered as normal weight man, and therefore for estimating the effective dose in this study, the researcher used the conversion coefficient from their publication of normal weight patients. on publication of ICRP 1990 (ICRP 1990) the normal weight man was 70 Kg and in current study it was 69.2.

There were different reasons to request CT pelvis and Abdomen in hospitals in our study which ranged range from plain CT to complicated CT procedure using contrast agent. For our study the most highest reason to request CT was for diagnosing injuries and accident (39 patients) that represented 19.5% from all participants, and the second reason was for gynecological purpose (30 patients that represented 15% (Figure 4-2), This may be attributed to the fact that the two hospitals chosen to conduct this study are considered two major hospitals that receive a huge number of accidents and emergencies and cover a large number of residents in the city of Taif, in addition to the fact that most of the accidents require CT scans in addition to routine X-rays as part of the emergency work protocol.

In our study when comparing the pitch in each hospital we concluded that the H**ospital two** irradiates patient with higher value of pitch than hospital one, and this will definitely affect the amount of radiation dose received by patients in the **Hospital number two** compared to **Hospital One**. These findings are similar to Mahadevappa (Mahadevappa et al., 2001) in their original report described the relationship between pitch and patient radiation dose, it mentioned that when increasing the pitch the radiation dose received by patient will decrease, and consequently the pitch and radiation dose inversely proportion, so, this might be the reason that we estimated the radiation dose in the Hospital one less than in the Hospital two.

Our study demonstrated the average value of DLP in the Hospital two was higher compared to the Hospital one, this may be attributed to average pitch used in hospital one which was lower than hospital two as well as number of slices and mAs encountered. When we compared the average DLP in our study with previous studies (Shrimpton et al., 2003, Tsapaki et al., 2001) the current recorded finding showed lower value than previous studies, and this might be due to that the chosen hospital used modulated mA during CT gantry rotation, and this technology may be absent in previous studies.

Our study also showed SSDE and CTDIw was higher for the Hospital two compared to the Hospital one. There was significant correlation of SSDE and CTDIw with the correlation coefficient achieved was 0.6 ($R2=0.6$) in our study. This suggests that CTDIw effect directly the amount of radiation dose received by

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patients during CT pelvis and Abdomen. The CTDIw our study was lower than previous studies value for pelvis and Abdomen CT examination (Tsai et al., (2007); Trier et al., (2010)). According to Livingston (Livingston et al., 2009) they reported that, if proper work standards are followed by workers operating the CT machine, dose reduction is achievable with their CT scanners. When compared to the weight-based strategy, the dose modulation methodology is a more effective method of controlling dose for patients undergoing CT scans. In our study CT machines used in the two hospitals equipped with mA modulation strategy thus resulted in reduction of CT radiation dose as demonstrated by lower CTDIw values.

In our study we estimated the effective dose was estimated using **equation 3-5**, the conversion factor between effective dose and DLP was extracted from ICRP 102 (ICRP 102). The conversion factor varied in different previous studies (Deak et al., 2010; Sahbaee, et al., 2014) and this factor depends mainly on patient characteristic such as weight and body mass index. The average effective dose in our study was 7 and 7.4 mSv for the Hospital one and the Hospital two respectively. In comparison to study by Nwokorie et al (Nwokorie et al., 2017) they reported the range of effective dose to pelvis and abdomen from 8-14 mSv, so, the current study showed less value for pelvic effective radiation dose. This difference may be attributed to their patient's size and protocol applied during their scan or even scanner characteristics. The average of effective dose achieved in two hospitals under study compared to previous studies is given as **Figure 4-5**

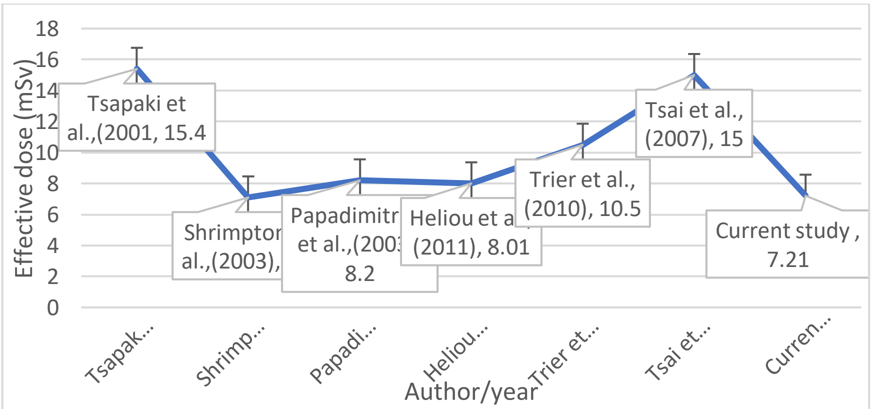

Figure 4-5 comparison of effective dose in current studies with previous studies

DRLs are a useful tool for promoting optimization. It's important to realize that DRLs are mostly just one portion of the overall optimization process. DRLs are a basic guidance for clinical procedures that do not apply to specific patients or investigations. DRLs should be established for representative examinations or procedures carried out in the local area, country, or region in which they are used. The third quartile values (the values that separate the top 25% of data from the other 75% of data) of these national distributions are typically used as NDRLs. As a result, NDRLs aren't optimal doses, but they can assist identify potentially anomalous practices (healthcare facilities where median doses are among the highest 25 percent of the national dose distribution). DRLs can also be established for a specific region within a country or, in rare situations, for multiple countries. For current study the third quartile of DLP and CTDIw is selected to establish local diagnostic reference level for the practice of CT pelvis and Abdomen in selected hospitals.

Conclusions

5-1 Conclusion

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The current research revealed that accident and emergency causes were the most common reasons for CT pelvis and Abdomen imaging at two large hospitals in Taif, Saudi Arabia. The radiation dose during the procedure was also investigated, and the average DLP, CTDIw, SSDE, and effective dose for both hospitals were 379.6 mGy-cm, 19,4 mGy, 24.9 mGy, and 7,2 respectively. The proposed DRL for both hospitals were 405 mGy-cm and 21.75 mGy, respectively, based on the third quartile of DLP and CTDIw. In compared to previous studies, the research found a lower effective radiation dose value.

5-2 Study limitation

Short of period allowed for data collection and consequently the data collected for the current study is limited. For future study we suggest to include contrast media images to be considered for estimating the DRL for them. Also, an ethical approval took long time to be signed and administrator agree to perform the thesis in selected hospitals.

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