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Evaluation of Radiation Dose Received by Trauma Patients in Majmaah Area, Saudi Arabia

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ABSTRACT

Background: Radiation exposure is the main hazard in medical X-ray investigations. The aim of this study was to evaluate the radiation dose received in chest x-rays for trauma patients in the Majmaah area. The results were compared with other national and international findings. Furthermore, the reference radiation dose level was measured for different examinations by conventional x-rays. Thus, conventional X-ray examination of trauma patients was investigated.

Materials and Methods: Seven hundred patients were evaluated at King Khalid Hospital, Majmaah. The average and range of exposure parameters were 73.5 ± 9.1 (65.9–124.9) and 2.7 ± 0.71 (0.2–9.6) for X-ray tube potential (kVp) and current multiplied by the exposure time (s) (mAs), respectively.

Results: The entrance surface air kerma dose measured for chest (PA), skull (AP and LAT), lumbosacral (AP and LAT), and knee joint (AP and LAT) were 0.20+0.07 with a range of 0.13–0.37, 0.86 ± 0.01 with a range of 0.09–2.92 and 0.09 ± 0.02 with a range of 0.04–0.17, 0.10 ± 0.02 with a range of (0.04–0.17 and 0.1 ± 0.02 with a range of 0.03–0.16, and 0.86 ± 0.01 with a range of 0.09–2.92, respectively. The measured doses for pediatric patients were 0.20 ± 0.07 (0.13–0.37) and 0.18 ± 0.03 (0.06–0.23) for female and male patients, respectively.

Conclusion: It was concluded that 90% of the procedures had normal findings. However, a precise justification is required, especially for young patients. For dose measurement techniques, the machine- and patient-related factors must be fixed in order to obtain accurate results.

Key words: Trauma patients, Radiology, Radiation protection

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INTRODUCTION

Trauma is an injury that can be life threatening and cause psychological and physical impacts. Recently, in Saudi Arabia, the number of traffic accidents and their effects has increased significantly. There is no clear protocol to describe radiation exposure of patients during radiation investigations. The usual radiation exposure varies between 10 and 100 mGy, which may increase the possibility of cancer incidence, especially among a population with high exposure [1-3]. Trauma X-ray imaging is one of the most common diagnostic tools used to analyze and identify pathological conditions [4-5]. However, it results in a significant radiation dose to patients. Because the applications of trauma radiology are growing quickly, it is crucial to appraise the radiation dosages during the examination and try to reduce them as much as possible [6-8]. Demographic data and exposure measurements are needed for all patients who are admitted to the radiology department. Radiation exposure is a main hazard in medical X-ray investigations [9]. Those exposures result from improper use of equipment and high exposure factors. The existence of diverse dose standards for exposure for the same medical investigation is a sufficient reason to draw attenuation to this matter. Radiation exposure can result in severe injuries and, possibly, cancer. Radiation medical imaging is used commonly for trauma assessment [10-12]. Imaging examinations help in the appropriate analysis of numerous disorders. They provide quick and precise analysis for the emergency physicians for the judgment of the serious afflictions in patients, particularly in some patients whose injuries are difficult to diagnose [13-14].

There are many hazards associated with radiation exposure, which include the acute (radiation injury) and chronic exposure (cancer) effects. The acute effects include organ injuries that can possibly lead to death at a high dosage [15-16]. Most radiographically investigations do not cause acute injuries to the patients because of their low energy (less than 10 mGy). The chronic effects of radiation include the danger of cancer and genetic disorders [17-19]. Measurements of the radiation doses from trauma radiological examinations have been conducted globally [20]. Most fast-changing innovations have been paired with digital radiography (DR) units. Many DR devices now use thin-film transistor (TFT) sets, which are commonly known as “flat panel arrays.” Charge-coupled device (CCD)-based systems make possible X-ray chest scans, with slot-shaped sensors, a single CCD, and CCD tiles with wide field-to-light transductors. Systems based on CCDs are usable [21-23]. TFT arrays are made of a single matrix with the same transistor for every. The transistors are used as doors so that when they are activated, electric current flows through them. When the X-ray is released, the gates are disabled, the picture forms as an electric current, and the load on each X-ray corresponds to the number of ray photons obtained in the region of the detectors (a linear connection again) [24-25]. The mechanism by which radiation is converted into retained energy varies greatly among organizations, but it is common to define whether radiation is indirectly transformed into observable light. A ray-to-light system, which in an indirect system, is in contact with the TFT, and it is close to that used in the SF scanning process [26-28]. Each TFT set includes a sensor (photodiode) that is used to convert florescent light into an electric charge. The TFT array comprises 23 layers of material directly within a single system. The X-ray photon is absorbed, and the electrical charge is generated and stored in the TFT table [29]. For direct and indirect panel detectors, the TFT array gate is switched on one row at a time after ray illumination. The load deposited in each x-rays of the row is transferred through drainage lines to a row of load amplifiers at the edge of the screen. Flipping all rows and storing data in the digital image matrix at the respective locations causes the entire detector to read sequentially [30-35].

DR's key constraints are high initial costs, lack of interaction between radiologists and technologists with electronic-image displays, and lack of consistent technology input on how to optimize acquisition software (instead of batch mode reading) [36-37]. The latter issue has helped to improve patient access with a wider range of digital systems. DR benefits include photo processing insulation features such as rate change (same for light) and window length (similar to contrast) for gray-scale object appearance in collection, display, and archiving, all of which provide considerable versatility. Nonetheless, as signal contrast increases, screen contrast is constrained by the underlying signal-to-noise ratio [38-42]. Some of the strengths include medical diagnosis and disease-based algorithms, better X-ray detection and enhanced quantum detective performance (QD), lower patient doses, and ability to assist the radiologist by using a second computer reader [43-45]. Film-based imaging provides technologists and radiologists with immediate feedback on providing sufficient access to patients [46-47]. If the optical densities of the image are too high, the patient receives too much radiation, whereas lower optical densities indicate that the radiation doses are less than the correct value. When digital image receivers bypass SF object receptors, regardless of the frequency used during processing, the illumination and the contrast are shown on the display [48-49]. Object noise often varies with exposure. Radiologists respond to excessive noise in digital images (low patient exposure), but they seldom complain of excessive patient exposure to photographs with reduced noise. Technologists immediately understand it by gradually increasing patient doses by downward switch in X-rays. This relates to the likelihood of dose creep in computed radiography (CR) and DR [50-54]. The medical physicist and imagery specialist must track dose creep on a daily, continuous basis as a chronic phenomenon. One efficient way of removing drug leakage is to build acceptable X-ray diagrams for all patient-size studies [55-56]. When such criteria are included in state-of-the-art X-ray device anatomical software, the equipment selects the options of radiological monitoring and patient volume, and it guarantees 27 standard X-ray procedure variables and normal radiation exposure, regardless of whether the study is conducted with an object detector on the switch [57-58]. Currently, most CR manufacturers offer photos shown on the workstation with exposure indicators. However, the data may not be passed to the picture archiving and communication system (PACS) or hidden on the patient's digital imaging and communications in medicine data page. Most PACSs display the exposure indicator on an image. Detailed numerical exposure measurements used by various CR manufacturers are no easy task. To make matters worse, most DR companies do not give an exposure indication to their processed images or forward this information to the PACS so it can be retrieved [59-63]. The American Association of Physicists in Medicine organized a "Task Group 116" to resolve the lack of a standard criterion for digital radiography images. Their study, "Recommended Electronic Radiography Exposure Indicator," recommends defining relative exposure indicators to standardize radiation conditions [64-66]. Because leading manufacturers participated in the electronic radiographic image receiver task group, this standardized exposure measure should move to future products [67,68].

MATERIALS AND METHODS

Sample and definition research

A survey of 700 patients at King Khalid Hospital, Majmaah, Saudi Arabia's radiological department, was carried out from October 2018 to June 2019. The institutional review board (IRB) of King Abdelaziz City for Science and Technology (KACST) and Ministry of Health, Saudi Arabia, have endorsed all data gathering techniques used for the study.

Specification of radiography system

The Siemens AXIOM imaging system (Germany 2014, model AlOIC) with pipe filtration 2.0–3.0 mm AL/70 kVp, was used.

Dose measurement technique

Entrance surface air kerma (ESAK) (mGy) was assessed for evaluating the X-ray scans of the head, skull, lumbosacral joint, and knee joint. This dose was used to measure ionizing radiation for trauma radiology patients nationally and internationally, consistent with previous studies. Data were analyzed using version 22 of the SPSS software, and results were obtained as graphs and tables. Thermo luminescent dosimeters (TLDs) were additionally used for dosage evaluation in this study. They were equipped with separate electrodes (LIF: MG and Cu) and ranged between 0.001 rad and 100 Gy.

Statistical analysis

All data from this study are shown as mean plus standard range variability. Analysis of variance and t-tests were used for statistical analysis using SPSS under Windows.

RESULTS

Table 1 shows mean, median, minimum, and maximum values of the patients' weight, height, and body mass index (BMI) for both genders in this study. Table 2 shows the mean age of the patients for both genders in this study and the exposure factors logged for each patient during the examination of each projection. The exposure factors logged were projection, kVp, mA, time, field size, part under examination, and tube-to-film distance. This study involved 700 patients (80% of the patients were males and 20% were females) undergoing chest, skull, lumbosacral, and knee joint X-ray examinations in the radiology departments at King Khalid Hospital in Majmaah. Table 3 shows the measured doses in patients at the King Khalid Hospital, Majmaah, and at other national and international hospitals. The doses were compared to national and international radiation dose limits. The measured ESAK for chest (PA), skull (anteroposterior (AP) and lateral (LAT)), lumbosacral joint (AP and LAT),

Table 1: Patient demographic features.

Parameters	Age (years)	Weight (Kg)	BMI	Height (cm)
Mean	37	79.5	25	171.5
Median	37.1	78.7	23.1	170.9
Standard deviation	13.3	8.91	9.2	11.5
Minimum	19	72	19.5	165
Maximum	15	115	32	192
Patients (Male: n=560, 80.0%; Female: n=140, 20.0%); Age: 37.1 ± 13.3 years with range of 18-63 years.				

Table 2: Patient X-ray image acquisition features.

Parameters	Chest	Skull		Lumbosacral		Knee joint	
	PA	AP	Lateral	AP	Lateral	AP	Lateral
Tube voltage (kVp)	124.8+0.14	124.5	124.9	75.8+7.8	83.8 ± 7.2	56.9 ± 5.1	55.7 ± 3.2
Tube current (mAs)	1.6+0.79	1	2.2	22.5 ± 3.9	22.4 ± 4.1	4.9 ± 1.1	4.9 ± 1.06
Tube-to-patient distance (cm)	178.7+11.6	-	-	113 ± 4.14	114.2 ± 5.2	106.2 ± 9.9	115 ± 11.5
Dose (mGy)	0.20+0.07	0.86+0.01	0.9+0.02	8.27 ± 3.01	10.04+3.43	0.10 ± 0.02	0.1 ± 0.02
Patients (Male: n = 560, 80.0%; Female: n = 140, 20.0%); Age: 37.1 ± 13.3 years in a range of 18–63 years.							

Table 3: Mean and standard deviation of radiation dose measured in King Khalid Hospital, Majmaah and national and international hospitals for chest, skull, lumbosacral joint, and knee joint.

	ESD (mGy)			
Projection	Mean ± S.D.	Minimum value (mGy)	Maximum value (mGy)	p-value
PA chest	0.20 + 0.07	0.13	0.37	0.103
AP skull	0.86 ± 0.01	0.09	2.92	
Lateral skull	0.9 ± 0.02	0.04	0.17	
AP lumbosacral	8.27 ± 3.01	0.2	22.3	
Lateral lumbosacral	10.04 ± 3.43	2.05	29.21	
AP knee	0.10 ± 0.02	0.02	0.17	
Lateral knee	0.1 ± 0.02	0.03	0.18	

Table 4: Mean values of entrance skin dose (ESD) (mGy) of chest examination for all age groups of the study sample.

Age Group (years)	ESD (mGy)											
	Present Study	KKUH	SFH	KACST	IAEA	USA	UK	Italy	China	Malaysia	Brazil	Nigeria
Chest (PA)	0.2	0.135	0.22	0.4	0.4	0.25	0.15	0.57	0.34	0.9	0.4	0.45
Skull (AP)	0.86	0.119	-	5	5	2.25	1.8	-	-	4.8	2.8	0.77
Skull (LAT)	0.9	-	-	-	3	-	1.1	-	-	2.4	2.04	0.69
L/S (AP)	8.27	0.655	5.23	40	10	6.54	5.7	8.9	5.18	7.5	5.4	0.99
L/S (LAT)	10.04	1.173	8.99	40	30	-	10	26.7	10.53	13.4	11.2	1.43
Knee (AP)	0.1	0.305	0.26	-	-	-	0.3	-	-	-	-	0.38
Knee (LAT)	0.1	0.334	0.24	-	-	-	0.3	-	-	-	-	0.69

Table 5: Correlation between the entrance skin dose (ESD) and the body characteristics (p<0.05).

	Height (cm)	Weight (Kg)	BMI	kVp	mAs
Sig. (2-tailed)	0.126	0.541	0.214	0.017	0.012
Correlation (Pearson)	0.118	0.091	-0.152	0.297	0.652

and knee joint (AP and LAT) were recorded (Tables 3–5). These amounts were dissimilar in patients at King Khalid, Majmaah and other Saudi hospitals (KKUH, KACST, and SFH) and at international locations such as the UK, China, Greece, Canada, and Italy and organizations such as the International Atomic Energy Agency (IAEA) and the Health Physics Society (HPS). The measured dose for chest x-rays in this study was 0.20 ± 0.07 mGy with a range of 0.13–0.37 mGy, while the lowest amount was 0.02 mGy at the HPS and the highest level was 0.69 mGy in Greece. The measured dose for PA projection of skull x-rays in this study was 0.86 ± 0.01 mGy with a range of 0.09–2.92 mGy, while the lowest dose level was 0.86 mGy in King Khalid, Majmaah and the highest level was 5.0 mGy in IAEA. Nevertheless, the measured dose for lateral projection of skull x-rays in this study was 0.09+0.02 mGy with range of (0.04–0.17 mGy), while the lowest dose level was 0.69 mGy in Nigeria, and the uppermost level was 3.00 mGy for the IAEA. The measured dosage for AP projection of lumbosacral joint X-ray scans in this study was 8.27 ± 3.01 mGy with a range of 0.20–22.3 mGy. The lowest dose level was 0.20 mGy in King Khalid, Majmaah, while the highest level was 40 mGy in KACST. Nevertheless, the measured dosage for lateral projection of lumbosacral joint x-rays in this study was 10.04 ± 3.43 mGy with a range of 2.05–29.21 mGy. The lowest dose level was 1.17 in King Khalid University Hospital (KKUH), while the highest level was 44 mGy in Greece (Tables 3–5).

The measured dose for AP projection of knee joint X-ray scans in this study was 0.10 ± 0.02 mGy with a range of (0.02–0.17 mGy), which was the lowest dose level, while the highest level was 0.30 mGy in KKUH. Nevertheless, the measured dose for lateral projection of knee joint X-ray scans in this study was 0.1 ± 0.02 mGy with a range of (0.03–0.18 mGy), which was the lowest dose level. The highest level was 0.33 mGy in KKUH (Tables 3–5).

DISCUSSION

This experimental study was performed to measure the dose received by organs in chest (PA), skull (AP and LAT), lumbosacral joint (AP and LAT), cervical (AP and LAT), and knee joint (AP and LAT) X-ray examination. A total of 700 patients were examined in two radiology departments in King Khalid, Majmaah hospital. The results of this study were compared with those obtained by other scientific studies nationally (Saudi Arabia) and internationally. The former studies showed different results in the dose received by patients [1,2,9,16,17]. There were many factors that might affect the results of the dose measurement, such as patient-related factors (BMI), technical factors (projection, techniques, and exposure factor selection) and machine factors (machine and TLD calibration and service). The dose increased with BMI, which agreed with the results obtained by [25,36]. This study highlights the importance of the quality control program in checking the machine performance and reduction of radiation dosage to both patients and healthcare staff. Recent studies showed that there were large amounts of radiation exposure in diagnostic radiology because of its wide utilization, especially in emergency departments [28,30-33]. This study recommends selecting the mean radiation dose of chest, skull, cervical spine, and knee joints as guidelines for radiation examination in the Majmaah area hospitals, because they were compared with other studies the least. Therefore, the calculated dose of the chest x-rays was 0.20 ± 0.07 mGy with a range 0.13–0.37 mGy. The calculated radiation dose for skull was 0.86 ± 0.01 and 0.09 ± 0.02 mGy for AP and LAT projections, respectively. The calculated radiation dose for the lumbosacral joint was 8.27 ± 3.01 and 10.04 ± 3.43 mGy with a range 0.20–29.21 mGy for AP and LAT projections, respectively. The calculated radiation dose for the knee joint was 0.10 ± 0.02 and 0.1 ± 0.02 mGy with a range 0.02–0.18 mGy for AP and LAT projections, respectively.

The lowest dose for chest X-ray level was 0.02 mGy for the HPS, while the uppermost level was 0.69 mGy in Greece. The lowest dose of AP skull X-ray level was for the HPS, while the highest level was in Greece. Nevertheless, the measured dose for lateral projection of lateral skull x-rays in this study was the lowest dose level, while the highest level was in Greece. The lowest dose level for AP projection of lumbosacral joint x-rays was in King Khalid, Majmaah, while the highest level was 40 mGy in KACST. Nevertheless, the measured dose for lateral projection of lumbosacral joint x-rays was the lowest in KKUH, while the highest level was 44 mGy in Greece.

CONCLUSION

Finally, in this study, it was found that radiation amounts for chest (PA), skull (AP, LAT), lumbosacral joint (AP, LAT), cervical (AP, LAT), and knee joint (AP, LAT) for the entire examination were higher. The ESDs for conventional radiology were lower in AP than those for lateral projection and LA/LS, respectively. Unlike in previous studies, the dose in L/S radiography was higher in conventional radiography compared with other techniques. Recently, DR and CR have become more popular because the important advantages of digital imaging are cost effectiveness and ease of access. Therefore, the importance of dose optimization during conventional radiology imaging must be considered. This study concluded that the doses for chest, skull, cervical, and knee joints were lower than in other comparable studies nationwide and globally. The dose in L/S radiography was higher in conventional radiography compared with other techniques. Recently, the utilization of an automatic exposure calculator has become more useful and reduced the dose to patients. CR is becoming more popular because of its value, access, and good dose changes. This study should help investigators discover the critical parts of radiation protection in trauma radiology departments that many investigators have not been able to explore.

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CONFLICT OF INTEREST

No potential conflict of interest relevant to this article is reported.

ETHICAL APPROVAL

The Institutional Ethics Committees of KACST and KSA with registration number H-01-R-012, OHRP/NIH, USA with registration number IRB00010471, and Federal Wide Assurance NIH, USA with registration number FWA00018774 approved the study. The ethical committee of the Deanship of Scientific Research at Majmaah University also approved this research with registration number MUREC-Nov.2l/COM-201 8/9.

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