DOI: 10.7860/JCDR/2020/42897.13555

Original Article

Radiology Section

Entrance Skin Dose Measurement for Diagnostic Spinal Radiographic Examinations in King Khalid Hospital, Saudi Arabia: A Prospective Study

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ABSTRACT

Introduction: Radiographic examinations has necessary role in the identification of spine injuries and pathologies. There are many hazards associated with the radiation exposure which included the acute (radiation injury) and chronic exposure effects (cancer).

Aim: To measure the entrance skin dose of spine vertebra (cervical, thoracic, lumbar and sacral) in AP and Lateral Views.

Materials and Methods: A prospective study was conducted with a sample of 250 adults and 100 paediatrics patients. The imaging apparatus, which was used in this study was Siemens with pipe Filtration 2.0-3.0 mm of AL/70 KVp. The parameters of patients collected were patients' characteristics and exposure factors. The dose was measured using Entrance Skin Dose (ESD) and International Atomic Energy Agency (IAEA) formula and compared nationally and internationally.

Results: The measured exposure parameters were 78.1±5.7 and 19.9±7.8 for the machine kVp and mAs, respectively. The measured ESD dose for cervical, thoracic, Lumbosacral (AP and LAT.) and sacral (AP) for adult population were 0.11±0.06 mGy and 0.15±0.07 mGy, (0.86±0.06 and 0.91±0.09 mGy, 0.88±0.07 and 0.92±0.09 mGy and 0.25±0.04 mGy, respectively. Similarly, measured ESD dose for cervical, thoracic, Lumbosacral (AP and LAT.) and sacral (AP) for paediatrics population were 0.09±0.01 mGy and 0.12±0.07 mGy, 0.32±0.03 mGy and 0.42±0.06 mGy, 0.38±0.06 and 0.74±0.08 mGy and 0.09±0.01, respectively.

Conclusion: The results of the study were within the range of permissible dose of the spine vertebrae dose (4.0-30.0 mGy). More studies are recommended to study radiation dose of the spine vertebrae with large patients' data and more than one modalities to compare.

Keywords: Radiation dose, Traumatic, Vertebra

INTRODUCTION

Radiation Exposure is main hazard in radiographic investigations. Now-a-days human organ imaging is performed by different systems and methods. As the new diagnostic methods including CT, MRI, and sonography are evolving but plain radiography is still a powerful tool with enough benefits to the patients undoubtedly. Therefore, patients' exposure to radiation has been increased all over the world due to this diagnostic radiography [1]. The basic concept to reduce the radiation exposure is to use the minimum dose needed for good image quality by radiological tests. Radiation hazard arises from abuse of equipments, high exposure factors and exposure to different dose levels for the same clinical investigations [2-4]. Radiation exposure can cause severe injuries and possibly leads to cancer [5-6]. Trauma is a grievance which leads to emotional and physical impact [7]. In recent times, in Saudi Arabia, the amount of road traffic accidents and their effects has augmented considerably [8,9]. There is no perfect procedure to define radiation experience of patients during radiation examinations [10]. The normal radiation exposure differs between 10-100 mGy, which may rise the chance of cancer occurrence usually among population who are highly unprotected [11-13]. The traumatic X-rays imaging considered as one of the most common analytical tool used to study and identify the pathological circumstances [14]. Since the entitlements of traumatic radiology are growing speedily, it is critical subject to evaluate the radiation dosages during the examination and try to reduce them as much as possible [15-17]. The sacral realm (sacrum) is at the bottom of the spine and prevarication between the fifth segments of the lumbar. Conventional X-rays examination is an accepted modality in detection and identification of the different spine disorders in both paediatric and geriatric patients [18,19]. However, X-rays exposure considers dangerous especially in fledgling patients. Some studies showed that the irradiation in the early ages could increase the probability of having radiation sickness and malignant disorders due to tissues hypersensitivity. Therefore, the justified request and optimised protection measures should be applied especially in the younger patients [20-22]. The measurement of the radiation exposure in spine vertebrae x-rays is very crucial as the cutaneous and subcutaneous tissues exposed to large amount of the dose [23]. The measured dose can be used to formulate diagnostic reference levels at national level.

One of the variables of radiation protection is the dosage of patients. The dose is usually determined by evaluating the Entrance Skin Dose (ESD) for patients who are exposed to X-rays diagnosis. The ESD is defined as the dose of air absorbed by the patient's entrance surface at the intersection of the beam axis, including the back dispersion. The surface dose entry is one of the critical quantities for estimating the patient dose and maximising the patient dose. This quantity is the fundamental requirement to be contrasted with other global dose levels of comparison, which are very important for safety against radiation. The ESD can generally be measured using two methods, either directly on patients' skin using Thermoluminescent (TLD) measurements, or indirectly using the template quality estimates of the X-ray machine [24-28]. The aim of the study is to measure the entrance skin dose of spine vertebra (cervical, thoracic, lumbar and sacral) in AP and Lateral Views.

MATERIALS AND METHODS

A prospective study was conducted with a sample of 350 patients who undergone radiological examinations at King Khaled Hospital, Majmaah, Saudi Arabia's radiological department, between October 2018 to June 2019. The research was approved by IRB00010471 (H-01-R-012, OHRP/NIH (FWA00018774) licensing committee of King Abdelaziz City of Science and Technology (KACST). A MUREC-Nov.2l/COM-2018/9 permit is given from the Ethics Committee of the University of Majmaah.

The patient's characteristics measured were age, Body Mass Index (BMI) and exposure factors, Focus-to-Skin Distance (FSD) and projections. The imaging system used in this study was Siemens, AXIOM imaging system made in Germany 2014, model: AlOIC with pipe Filtration 2.0-3.0 mm AL/70 KVp which was accompanied with dose controller (AEC). The machine output was measured and calibrated using reference dosimeter device with the high accuracy (±3%) and TLDs. The ESD was calculated as follows:

$$ESD = \text{machine O/P x} \left(\frac{Kv}{80}\right)^2 x \left(\frac{100}{FSD}\right)^2 x\, BSF$$

where:

(OP): the output of the machine

(mA) the product of the tube current

(FSD) the focus-to-skin distance (in cm).

(BSF) the backscatter factor,

Inclusion criteria: All traumatic patients who had conventional x-ray examination in area of the study were included.

Exclusion criteria: All traumatic patients who had other examinations rather than x-rays in area of the study.

STATISTICAL ANALYSIS

For statistical analysis SPSS version 23 was used. All data from this study are shown as mean plus standard range variability.

RESULTS

The mean age of adult patients was 32.9±7.1 years with range of 16-65 years and mean age of paediatrics' patients were 7.1±1.3 years with range of 1-15 years. Maximum number of adult patients were in the age group of 61-65 years [Table/Fig-1].

The registered exposure factors were 78.1±5.7 with range of (61.8-84.8) KVp, 19.9±7.8 with range of 1-48 mAs, 107.3±12.5 with range of 105-115 cm FSD and 0.11±0.06 with range of (0.05-2.01) mGy for tube potential, tube current, FSD and ESD Dose, respectively [Table/Fig-2].

Age group (years)	Male n (%)	Female n (%)
15-20	5 (2.3%)	1 (2.7%)
21-25	5 (2.3%)	1 (2.7%)
26-30	4 (1.9%)	3 (8.1%)
31-35	12 (5.7%)	2 (5.4%)
35-40	23 (10.9%)	3 (8.1%)
41-45	28 (13.2%)	3 (8.1%)
46-50	33 (15.4%)	7 (18.9%)
51-55	35 (16.4%)	6 (16.2%)
56-60	29 (13.6%)	4 (10.9%)
61-65	39 (18.3%)	7 (18.9%)

[Table/Fig-1]: The age distribution for both gender among adult patients in the study sample.

The exposure factors of the spine vertebrae cervical, thoracic, Lumbar and sacral Imaging is shown in [Table/Fig-3].

The measured ESD dose for cervical, thoracic, Lumbosacral (AP and LAT.) and sacral (AP) for adult population were 0.11±0.06 mGy and 0.15±0.07 mGy, (0.86±0.06 and 0.91±0.09 mGy, 0.88±0.07 and 0.92±0.09 mGy and 0.25±0.04 mGy, respectively Similarly measured ESD dose for cervical, thoracic, Lumbosacral (AP and LAT.) and sacral (AP) for paediatrics population were 0.09±0.01 mGy and 0.12±0.07 mGy, 0.32±0.03 mGy and 0.42±0.06 mGy, 0.38±0.06 and 0.74±0.08 mGy and 0.09±0.01, respectively [Table/Fig-4,5].

Variables	Tube potential (KVp)	Tube current×time (mAs)	Focus-to-skin distance (cm)	Entrance skin dose (mGy)
Mean	78.1	19.9	107.3	0.11
Median	74.8	17.15	106.1	0.10
Standard deviation	5.7	7.8	12.5	0.06
Minimum	61.8	1	105	0.05
Maximum	84.8	48	115	2.01

[Table/Fig-2]: Imaging parameters of the study.
KVp: Kilovoltage peak; mAs: Milliampere-seconds; cm: centimeters; mGy: megagray (10^6 gray)

Variables	Cervical spine		Thoracic spine		Lumbar spine		Sacral	
	KVp	mAs	KVp	mAs	KVp	mAs	KVp	mAs
Mean	77.9	22.8	70.8	6.67	80.2	21.3	73.14	5.12
Median	73.7	21.1	68.1	6.15	78.3	20.9	72.9	4.7
Standard deviation	8.1	7.2	5.6	2.4	8.91	6.2	7.7	1.93
Minimum	60.1	29	61.8	2.1	72.9	3.2	72.9	0.4
Maximum	83.8	1	76.8	18.7	84.8	48	76.8	20.4

[Table/Fig-3]: Exposure factors of the cervical, thoracic, Lumbar and sacral vertebrae imaging.
KVp: Kilovoltage peak; mAs: Milliampere-seconds

Examination	Number	Mean	Minimum	Maximum
Cervical vertebrae				
AP	60	0.11±0.06	0.08	0.31
Lateral		0.15±0.07	0.09	0.39
Thoracic vertebrae				
AP	40	0.86±0.06	0.01	0.99
Lateral		0.91±0.09	0.02	0.81
Lumbar vertebrae				
AP	120	0.88±0.07	0.05	1.95
Lateral		0.92±0.09	0.06	2.01
Sacral vertebrae				
AP	30	0.25±0.04	0.01	0.99

[Table/Fig-4]: Entrance skin dose measured for adult population.

Examination	Number	Mean	Minimum	Maximum
Cervical vertebrae				
AP	35	0.09±0.01	0.06	0.23
Lateral		0.12±0.07	0.04	0.45
Thoracic vertebrae				
AP	20	0.32±0.03	0.01	0.92
Lateral		0.42±0.06	0.03	0.77
Lumbar vertebrae				
AP	40	0.38±0.06	0.02	1.18
Lateral		0.74±0.08	0.05	1.01
Sacral vertebrae				
AP	5	0.09±0.01	0.01	0.39

[Table/Fig-5]: Entrance skin dose measured for paediatrics population.

DISCUSSION

This present study was performed to measure the ESD received in spine vertebrae (C/S, D/S, L/S, S/S) AP and lateral projections. A total 250 adults and 100 paediatric patients were examined in two radiology departments in king Khalid Hospital, Majmaah in which 85% of the patients were males and 15% were females. In a study conducted by Aliasgharzadeh A et al., the mean ESD values were 2.18 and 5.36 for lumbar AP and Lateral, respectively

Examination	Present study	Abdelhalim A [11]	KACST [11]	Malaysia [11]	IAEA [11]	UK [11]	Abdelhalim M et al., [11] (SFH)
	0.11	2.280±1.56	10	1.02	-	-	0.67
Cervical spine (AP)	0.15	5.790±4.85	30	1.60	-	-	0.99
Cervical spine (Lateral)	0.86	-	-			-	-
Thoracic spine (AP)	0.91	-	-			-	-
Thoracic spine (lateral)	0.88	9.19±2.69	40	10.56	10.0	6.10	5.23
L/S (AP)	0.92	21.22±3.85	40	18.60	30	16.0	8.90
L/S (LAT)	0.25	-	-		-	-	-
Sacral (AP)							

[Table/Fig-6]: The mean values of ESD (mGy) of Vertebrae spine examination of the study sample compared with other scientists results nationally and internationally.
SFH: Security force hospital; KACST: King Abdelaziz City of Science and Technology; IAEA: International atomic energy agency

[1] which was much higher in comparison to the results of present study. The ESD obtained for this study was compared with other studies nationally and internationally in [Table/Fig-6]. In present study, the mean radiation dose for spine lumbar sacral in AP-OBL position was 0.88±0.07 mGy, the lowest radiation dose was 0.65 mGy in KKUH, the highest radiation dose was 40 mGy in KACST [11]. However, the mean radiation dose for spine lumbar sacral in LAT-OBL projection was 0.92±0.09 mGy in present study which is lower than KKUH (1.17 mGy) [11]. The dose amounts were different in this study comparing with other Saudi hospitals (KKUH, KACST and SFH) and international places (IAEA, UK, and Malaysia). As it was observed that ESD results obtained in different studies varies a lot. The reason for this might be due to different patient size, investigation method, medical situation as well as the expertise of the radiologist. Another reason could be different values of tube current, tube potential, beam field of view, distance to patient The results of present study paediatrics population cannot be compared as no such studies are conducted nationally and Internationally which have measured the ESD dose in spinal radiography. The forthcoming study should contain more patients and many imaging modalities and departments. This study will help the medical physicists and radiation protection investigators to discover the critical areas of medical exposures that many investigators were not able to explore.

Limitation(s)

This study did not study the other radiological modalities' exposures, which should be studied to check the radiation dose and to highlight the radiation hazard. The study did not link the ESDs with diagnostic image quality of spine vertebrae examination.

CONCLUSION(S)

The results of the study were within the range of permissible does of the spine vertebrae X-rays examination and lower than the most of other studies (4.0-30.0 mGy). The Computed radiology and exposure control could decrease the radiation dose sufficiently. The effective quality assurance should be applied in radiology department.

Acknowledgement

The author is thankful to the Deanship of Scientific Research, at Majmaah University for funding this research [Project No. 38/147].

Authors' Contribution: All authors conceived of the presented idea. YM developed the theory and performed the computations. YM and NA verified the analytical methods. YM supervised the findings of this work. All authors discussed the results and contributed to the final manuscript.

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PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Sep 24, 2019
- Manual Googling: Feb 01, 2020
- iThenticate Software: Feb 20, 2020 (7%)

ETYMOLOGY: Author Origin

AUTHOR DECLARATION:
- Financial or Other Competing Interests: As declared above
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. NA

Date of Submission: **Sep 23, 2019**
Date of Peer Review: **Oct 18, 2019**
Date of Acceptance: **Feb 03, 2020**
Date of Publishing: **Mar 01, 2020**