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Patient Dosimetry Assessment During Lateral Cervical and Lumbar Spine Radiography in Selected Hospitals and Clinics in Al-Najaf, Iraq

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Abstract

Radiographic examinations of the cervical and lumbar spine are common diagnostic tests that can involve relatively high radiation exposure for the patient, particularly in lateral projections. The objective of this study was to evaluate the entrance surface dose (ESD) in adult patients during lateral radiographic imaging of the cervical and lumbar spine and to benchmark the findings against internationally published data. A prospective survey was conducted in six radiographic facilities, comprising three governmental hospitals and three private clinics. A total of 221 adult patients were included, comprising 107 cervical spine LAT examinations and 114 lumbar spine LAT examinations. The exposure parameters, tube potential (kVp), tube current (mAs), and source-to-image distance (SID), as well as patient data, were recorded. The ESD was estimated using the Edmonds dosimetric model and assuming a backscatter factor of 1.35. Mean ESD values ranged from 0.26 to 0.80 mGy for cervical spine LAT examinations and from 1.45 to 4.30 mGy for lumbar spine LAT examinations, with overall mean values of 0.52 mGy and 3.48 mGy, respectively. Lumbar spine examinations consistently yielded higher ESD values than the cervical spine examinations due to the greater anatomical thickness and X-ray attenuation. Furthermore, ESD values were significantly higher for lumbar spine LAT examinations performed in private clinics than in governmental hospitals ($p < 0.001$). The obtained ESD values were generally within internationally reported ranges. These results highlight the need for standardized protocols, quality control, and Local Diagnostic Reference Levels (LDRLs) for providing optimal patient protection.

Article Info.

Keywords:
Entrance Surface Dose (ESD), Cervical Spine Radiography, Lumbar Spine Radiography, Patient Dosimetry, Radiation Protection.

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1. Introduction

Traditional diagnostic radiography remains at the center stage of medical imaging since it is easily accessible, rapid, and rather cheap in comparison to other sophisticated modalities. However, the modality emits ionizing radiation with its known risks of carcinogenesis, gene mutation, and tissue reactions [1]. On this basis, patient dose management remains an essential component of good clinical practice [2]. When considering the dosimetric significance of routine skeletal radiography, cervical and lumbar spine lateral (LAT) radiographs are very important due to the denser anatomy of the region under investigation and projection geometries, which may have an exposure-increasing effect [3].

Global radiation protection frameworks, such as the International Atomic Energy Agency (IAEA) and other international bodies, have also pointed toward the necessity of continuous monitoring of radiation dose in diagnostic imaging for patients. Such organizations are strong advocates of using Diagnostic Reference Levels (DRLs) as a powerful tool for optimization to detect abnormally high levels of radiation and standardize radiographic practice [4,5]. Recent undertakings in spinal radiography have established considerable differences in patients' dose levels across healthcare facilities.

For example, Jeyasugiththan et al. (2022) found that lumbar spine examinations may display relatively large entrance surface dose (ESD) values over other radiographic examinations, in no small part because of their higher tube current (mAs) and lower tube potential (kVp) [6]. In the same way, Khurshid et al. (2024) reported that ESD values differ significantly in both cervical and lumbar projections of the spine [7]. These results demonstrate that the exposure parameters and optimization practices have a very high impact on patient dose. Moreover, recent technological and methodological investigations have also focused on the possibility of dose reduction in spinal imaging with the help of optimization strategies. As an example, Mekiš et al. (2024) have been able to show the possibilities of altering the imaging modalities, such as gridless techniques, which can lower the amount of radiation without compromising the quality of diagnostic images in cervical spine radiography [8, 9].

Despite the increasing number of international studies evaluating patient dose in spinal radiography, published data regarding ESD for cervical and lumbar spine radiography in Iraq remain limited. Moreover, no dosimetric survey was conducted to compare the doses received by patients in governmental hospitals and private radiology clinics in Al-Najaf Governorate. Thus, dose assessment in the area is necessary to provide baseline information for providing future Local Dose Reference Levels (LDRLs) and to enhance the practice of dose optimization. Thus, the objective of this study was to assess the ESD for cervical spine LAT and lumbar spine LAT radiography examinations in selected governmental hospitals and private clinics in Al-Najaf Governorate, Iraq, and compare the results with national and international published data.

2. Materials and Methods

The current research was carried out at three large public hospitals, namely Al-Najaf Al-Ashraf Teaching Hospital (ANATH), Al-Sader Medical City (ASMC), and Al-Sheikh Muthanna Al-Hatem General Hospital (ASMAGH) in Al-Najaf Governorate, Iraq, and at three private radiology clinics (Clinic 1, Clinic 2, and Clinic 3). The experiment was conducted after receiving official administrative and ethical concessions from the competent health authorities. The prospective (routine) clinical practice was used to collect data within the specified study period, from 24 November 2025 to March 2026 (approximately four months). Regular quality control measures are undertaken systematically in all the participating centers as per the institutional procedures to maintain the stability of the radiation output and also determine the stability of image quality. In addition, all details about radiograph equipment, including manufacturer, model, year of installation, system type (digital radiography, DR), and the country of manufacture, were recorded (Table 1).

2.1. Study Sample Demography

Patient dose measurement was carried out on adult patients who gave verbal consent. Demographic data about the patients, such as age (years), height (cm), weight (kg), and sex, were documented. A total of 221 adult patients were included in the study, comprising 107 cervical spine LAT examinations and 114 lumbar spine LAT examinations. Overall, the study population consisted of 107 males and 114 females. The age of the participants ranged from 18 to 82 years. Body Mass Index (BMI) in kg/m^2 for the patients was calculated using Eq. (1) [10]:

$$\mathrm{BMI} = \frac{\mathrm{weight\ (kg)}}{(\mathrm{height(m)})^2} \qquad (\mathbf{1})$$

To ensure homogeneity of the population under study, only adult patients (aged 18 years and older) were included, following the dosimetric survey recommendations set worldwide. As recommended by internationally set dosimetric survey standards, at least 10 patients should be included in the X-ray experiment to ensure a certain level of assurance in accurately estimating the dose, as suggested by IAEA standards and past research. Nevertheless, some guidelines suggest increasing the sample size (10-20 or more patients) to enhance statistical adequacy and representativeness [11-13].

2.2. Inclusion and Exclusion Criteria

This study included patients ≥18 years of age who had routine lateral (LAT) cervical spine or lumbar spine radiographs during the study period. Patients were included only when available demographic data, such as age, weight, height, and Body Mass Index (BMI), and complete exposure measurement records in the form of tube potential (kVp), tube current (mAs), and source-to-image distance (SID) were available.

Exclusion criteria included patients under the age of 18, bedridden patients, trauma or emergency cases in which body weight and height could not be obtained, repeated examinations, and incomplete information regarding the patient's demographic or exposure data.

2.3. Exposure (Physical) Parameters

Before estimating the ESD, the relevant exposure parameters were recorded for all adult patients undergoing routine cervical LAT and lumbar spine LAT radiographic examinations. Physical exposure factors derived directly from the X-ray unit console this time included tube potential (kVp), tube current (mAs), and SID (cm). Furthermore, the Source-to-Skin Distance (SSD) was fixed because it is an essential factor when estimating the dose of a source with regard to the inverse square law. The main technical parameters influencing the radiation dose to patients in traditional radiography are these exposure parameters [14]. The obtained empirical data were subsequently utilized to determine the dose that each patient got after adhering to a guided dosimetric regime.

2.4. Entrance Surface Dose (ESD) Calculations

To estimate the dose to the patient's skin, an empirical model first introduced by Edmonds (1984) was used [15], which has played a significant role in dose assessment research studies on diagnostic radiology [16,17]. The amount of ESD was estimated by taking the original surface (skin) dose (μGy) from the following equation:

$$\text{Skin Dose}(\mu\text{Gy}) = \frac{418\ (\text{kVp})^{1.74}\ \text{mAs}\ (\frac{1}{\text{T}} + 0.114)}{\text{SSD}^2} \qquad \textbf{(2)}$$

where kVp represents the tube potential, mAs represents the tube current, T represents the total beam filtration (mm Al), and SSD represents the distance between the source and the skin (cm). The total filtration was taken as T =3 mm Al [15,18,19]. The calculation of the SSD was done using the SID according to the following formula [20]:

SSD = SID - Patient Thickness **(3)**

The computed skin dose values in microgray (μGy) were converted to milligray (mGy) by dividing them by 1000. To account for radiation reflected by the patient's body, a backscatter factor (BSF) of 1.35 was used [21]. Based on this, the ESD was calculated using the following equation:

$$\text{ESD}(\text{mGy}) = \frac{\text{Skin Dose}(\mu\text{Gy})}{1000} \times 1.35 \qquad \textbf{(4)}$$

3. Results and Discussion

The current study has analyzed 221 adult patients who underwent cervical spine LAT and lumbar spine LAT radiographic examinations. Table 1 contains a summary of the technical specifications of the X-ray units, while Table 2 shows the descriptive statistical analysis of patient anthropometric parameters, namely weight (kg), height (cm), and body mass index (BMI) in each X-ray unit, with the results being given in the form of the mean with standard deviation (SD). Table 2 shows some differences in the anthropometric characteristics of the patients in the investigated clinics and hospitals. For cervical spine LAT examinations, the mean body weight ranged from 75.2 ± 14.8 kg to 80.6 ± 10.4 kg, while the mean BMI ranged from 28.72 ± 5.18 kg/m^2 to 31.49 ± 5.51 kg/m^2. For lumbar spine LAT examinations, the mean body weight ranged from 75.1 ± 17.2 kg to 88.1 ± 12.3 kg, whereas the mean BMI ranged from 27.50 ± 5.45 kg/m^2 to 32.42 ± 3.72 kg/m^2. Overall, the demographic characteristics of the study population were relatively comparable among the investigated centers. The BMI values were relatively comparable across the investigated centers, indicating a homogeneous study population. BMI was not directly assessed as a predictor of ESD but was digitally recorded as a patient's body habitus that may affect the mean X-ray attenuation and exposure parameter selection. Hence, the observed ESD differences may be due to differences in radiographic technique and exposure parameters, not the differences in patient body habitus. Table 3 shows the key exposure parameters that were used in the chosen clinics and hospitals. It clearly shows that there is variability in exposure parameters (kVp, mAs, and SID) in cervical spine LAT and lumbar spine LAT examinations across the clinics and hospitals under investigation, which suggests a lack of standard imaging protocols. For cervical spine LAT, kVp values ranged from 59.31 kVp (ANATH) to 72.59 kVp (Clinic 2), with mAs values between 7.38 mAs (ANATH) and 21.82 mAs (Clinic 2), and SID ranging from 84.76 cm (Clinic 3) to 124.59 cm (Clinic 2). In lumbar spine LAT, the kVp was 66.57 kVp (ANATH) to 87.06 kVp (Clinic 1), with mAs values significantly greater, 31.26 mAs (ANATH) to 61.88 mAs (Clinic 1), and with SID values ranging between 96.68 cm (Clinic 3) and 124.19 cm (ASMAGH).

The variability observed for kVp, mAs, and SID across the investigated centers in the study may be a result of the variation in the radiographic technique selection and optimization practices. The significant increase in tube current (mAs) values for lumbar spine (LAT) examinations is primarily due to the increased anatomical thickness and tissue attenuation of the lumbar region and the need for greater photon fluence to provide adequate detector exposure and diagnostic image quality [22]. Dose differences can also be caused by differences in SID due to the inverse square law and differences in tube potential (kVp) due to differences in beam penetration and patient radiation absorption [23]. These findings show that dose variability is related to the selection of the exposure parameters and underscore the need to standardize radiographic procedures and implement ongoing quality assurance programs.

Table 4 shows the descriptive statistics, which include the number of patients, mean values with standard deviation, the standard error of the mean, and the range (minimum-maximum) of the ESD data of the cervical spine LAT and lumbar spine LAT examinations across the chosen clinics and hospitals. The table summarizes dose distribution and variation between various units of X-rays. As Table 4 reveals, there is a significant inter-center difference in ESD of cervical spine and lumbar spine radiographic procedures. In cervical spine LAT projections, mean ESD values were found to be between 0.26 and 0.80 mGy, whereas in lumbar spine LAT examinations, the mean ESD values were much higher, averaging 2.42 to 4.30 mGy. This variance is mainly caused by anatomic factors; lumbar spine imaging has a greater patient thickness and X-ray attenuation, necessitating higher exposure parameters and resulting in a higher dose to the patient. These variations in patient dose depending upon the healthcare facility have been highly documented in the literature. A national survey by Hart et al. revealed extensive disparity in patient doses because of similar radiographic examinations in different institutions, and this was mainly attributed to differences in radiographic techniques and equipment performance [24]. Similarly, Ofori established broad inter-hospital variability in entrance surface dose values due to the lack of standardized imaging procedures, as well as disparities in operators' practices [25]. Differences in ESD values between lumbar spine and cervical spine imaging are consistent with the fundamentals of radiography dosimetry. Lumbar spine imaging requires more tube current (mAs) to overcome tissue attenuation and increase patient dose. Previous research has shown that in examinations of thicker anatomical regions, ESD values are much higher [25, 26].

Increased ESD values in some centers (e.g., Clinic 3 and Clinic 1) for the lumbar spine at the facility level may reflect the employment of unfavorable exposure parameters, especially high tube current (mAs) or poorly adjusted kVp-mAs ratios. It is already known that tube current-time product (mAs) is directly proportional to patient dose, whereas entrance surface dose can decrease as tube potential (kVp) increases when optimally adjusted, as a result of increased beam penetration and decreased absorption in the skin tier. High kVp-low mAs methods have been strongly suggested as a good approach to dose optimization in diagnostic radiography without jeopardizing image quality. There is an inverse correlation between kVp and mAs when changing dose, and it is a basic principle in selecting radiographic techniques [27, 28]. On the other hand, the lower ESD recorded for cervical spine examination at ANATH 0.26 mGy may indicate better optimization of the exposure parameters. Global recommendations point to the necessity of introducing DRLs and optimization measures that reduce the dose administered to a patient without harming the quality of diagnostic images [29, 30]. Moreover, the max/min ratios observed imply significant intra-center variability, indicating inconsistency in radiographic practice within the same facility. This heterogeneity is probably determined by variations in operator-specific variables, such as patient positioning and choice of exposure parameters (kVp and mAs). Such discrepancies have been reported as the main indicators of poor standardization of protocols and poor optimization practices. This inconsistency can contribute to patient overdose in digital radiography when wide exposure latitude is not controlled properly because unnecessary illumination of the patient is easily created. This is consistent with other studies that have made the case for standardized procedures, ongoing employee education, and regular quality control initiatives mandatory in ensuring consistency of dose and dose optimization [28]. Overall, these results highlight the significance of standardization of radiographic procedures, adoption of DRLs, and quality control in order to attain the ideal management of patients' dose in the scope of routine radiographic practice.

The differences in mean values of radiographic exposure parameters and doses between private clinics and governmental hospitals were examined using a comparative statistical analysis of the data. Both the cervical and lumbar spine LATs were compared, including SID, kVp, mAs, and ESD values. The results of the independent samples t-test are presented in Table 5. As shown in the table, significant differences were observed between private clinics and governmental hospitals for all investigated parameters during lumbar spine LAT examinations ($p < 0.001$), whereas cervical spine LAT examinations showed significant differences only in kVp values. The higher ESD values recorded in private clinics for lumbar spine LAT may be attributed to the combined effect of higher mAs values and shorter SID. These exposure conditions increase the radiation at the patient surface because the patient dose is proportional to mAs and inversely proportional to the square of the distance, according to the inverse-square law [23]. In addition, the lumbar spine has greater anatomical thickness and higher tissue attenuation, which require a higher photon fluence to produce acceptable image quality [22]. Thus, the differences in patient doses across different selections of exposure parameters are greater when imaging the lumbar spine than when imaging the cervical spine. Some clinical practices had somewhat newer digital radiographic systems, but newer systems do not necessarily mean lower patient doses. High ESD values in private clinics may also be due to the experience of the operator, different exposure protocols, and local imaging practices, with higher exposures being chosen to reduce retakes and provide acceptable diagnostic image quality. As shown in Fig. 1, the mean ESD values reported in the current study fall within the globally reported range, although variation among these countries is apparent. For cervical spine LAT, the mean ESD (0.52 mGy) was lower than in Morocco (1.8 mGy), Iran (0.85 mGy), and Ghana (0.63 mGy), but higher than Japan (0.40 mGy), India (0.25 mGy), and Nigeria (0.38 mGy). For lumbar spine LAT, the mean ESD (3.48 mGy) was lower than in Morocco (5.9 mGy), Iran (8.36 mGy), Ghana (4.95 mGy), India (7.75 mGy), and Nigeria (15.15 mGy), but higher than Japan (2.58 mGy) [31-36]. These results affirm that dose levels in the current study are reasonably optimized over various countries, though they could still be optimized further when compared to various highly optimized systems like Japan's.

A higher ESD of lumbar spine LAT (3.48 mGy) than cervical spine LAT (0.52 mGy) is anticipated to be the result of the increased anatomical attenuation and thickness of the lumbar area that requires a more rigorous exposure parameter (particularly mAs). The same patterns have been reported in lumbar spine examinations, notably that lateral projections are among the highest-dose procedures conducted in conventional radiography [37]. The difference in ESD values between countries, such as 0.25 mGy in India to 1.8 mGy in Morocco in the cervical spine, and 2.58 mGy in Japan to 15.15 mGy in Nigeria in the lumbar spine, can be discussed as differences in the practice of radiography, equipment working, and compliance with the principles of optimization. Poor choice in exposure parameters, improper collimation of the beam, shorter imaging distances, and the unavailability of standard protocols may greatly add to the patients' dose. On the other hand, dose reduction with the maintenance of diagnostic image quality is due to optimized imaging strategies, such as the right use of high kVp and low mAs and efficient quality control programs [38]. The reported low ESD values in Japan (0.40 mGy in cervical spine and 2.58 mGy in lumbar spine) point to the influence of properly optimized practices, such as the consistent adherence to the DRLs and quality monitoring. These values can be used as a set of working values in ending the dose optimization. It should be noted, however, that minimization of doses ought to be compromised with acceptable quality of diagnostic images, since DRLs are not a definite line but an investigation level [30].

In general, the results of this study suggest that the dose used in patients is not excessively high compared with most international studies, especially for the lumbar spine LAT. Still, the differences identified (particularly in comparison with lower values provided in Japan and India) denote that there is still room to optimize it even further. Thus, it is highly indicated that continuous dose monitoring, creation of local diagnostic reference levels (LDRLs), quality control, and harmonization in radiographic protocols should be employed to enhance patient safety and to promote ideal imaging practice.

Table 1: Technical specifications of the investigated X-ray units for DR system type.

X-ray Units	Manufacturer	Model	Installation date	Country of Manufacture
Clinic1	PHILIPS	RAD-74	2003	USA
Clinic2	SIEMENS	Mobilett XP	2006	Germany
Clinic3	SIEMENS	Mobilett II	2017	Sweden
ASMAGH	Canon Electron Tubes	DRX-724HD	2023	Japan
ASMC	Carestream	70-63009-6	2014	USA
ANATH	PHILIPS	SRO 33100 ROT 360	2013	Germany

Radiographic systems that were part of this study were entirely digital (DR) systems and were installed between 2003 and 2023, representing varying technological generations as well as operational ages.

Table 2: The mean and SD of weight (kg), height (cm), and BMI for patients undergoing cervical spine LAT and lumbar spine LAT radiography in selected clinics and hospitals.

X-ray Units	Radiographic Examination	No.	Weight (Kg) Mean±SD	Height (cm) Mean±SD	BMI (kg/m²) Mean±SD
Clinic 1	Cervical spine LAT	18	75.2±14.8	159.6±11.5	29.57±5.28
	Lumbar spine LAT	17	88.1±12.3	164.7±8.0	32.42±3.72
Clinic 2	Cervical spine LAT	17	80.3±11.2	163.2±9.3	30.17±3.68
	Lumbar spine LAT	16	85.8±16.5	163.1±8.8	31.99±4.03
Clinic 3	Cervical spine LAT	17	79.4±12.0	166.8±7.6	28.72±5.18
	Lumbar spine LAT	19	75.3±11.6	164.3±9.0	28.14±5.30
ASMAGH	Cervical spine LAT	19	80.6±10.4	161.1±6.0	31.10±3.97
	Lumbar spine LAT	21	75.1±17.2	165.0±9.6	27.50±5.45
ASMC	Cervical spine LAT	20	77.4±13.6	156.9±8.4	31.49±5.51
	Lumbar spine LAT	20	83.6±12.7	163.6±7.8	31.14±3.79
ANATH	Cervical spine LAT	16	77.4±15.1	163.2±9.9	29.06±5.09
	Lumbar spine LAT	21	81.1±19.6	161.3±12.6	31.46±7.70

Table 3: The mean, minimum and maximum values of the physical exposure parameters (kVp, mAs, SID) adopted for cervical spine LAT and lumbar spine LAT radiography in selected clinics and hospitals.

X-ray Units	Radiographic Examination	kVp Mean (Min–Max)	mAs Mean (Min–Max)	SID Mean (Min–Max)
Clinic 1	Cervical spine LAT	71.33 (70.0-73.0)	8.44 (6.0-10.0)	105.72(95-120)
	Lumbar spine LAT	87.06 (85.0-90.0)	61.88 (60.0-65.0)	123.65 (110-138)
Clinic 2	Cervical spine LAT	72.59 (70.0-75.0)	21.82 (20.0-25.0)	124.59 (112-142)
	Lumbar spine LAT	84.87 (80.0-88.0)	39.25 (38.0-40.0)	111.75 (100-123)
Clinic 3	Cervical spine LAT	60.44 (60.0-61.5)	8.49 (7.1-10.0)	84.76 (80-90)
	Lumbar spine LAT	83.05 (80.0-85.0)	34.89 (33.0-36.0)	96.68 (90-100)
ASMAGH	Cervical spine LAT	69.37 (67.0-71.0)	18.27 (14.4-20.2)	107.42 (95-118)
	Lumbar spine LAT	82.38 (80.0-86.0)	38.86 (28.8-44.8)	124.19 (110-144)
ASMC	Cervical spine LAT	62.75 (60.0-65.0)	9.81 (7.0-12.8)	103.90 (95-117)
	Lumbar spine LAT	87.05(85.0-88.0)	45.20 (42.0-48.0)	121.70 (110-135)
ANATH	Cervical spine LAT	59.31 (55.0-66.0)	7.38 (6.0-8.0)	106.50 (96-121)
	Lumbar spine LAT	66.57 (66.0-70.0)	31.26 (25.0-40.0)	121.81 (100-145)

Table 4: Descriptive statistics of entrance surface dose (ESD (mGy)) across clinics and hospitals.

X-ray Units	Radiographic Examination	No.	Mean±SD	SEM	Min	Max	Max/Min
Clinic 1	Cervical spine LAT	18	0.41±0.10	±0.024	0.27	0.63	2.333
	Lumbar spine LAT	17	4.24±0.59	±0.142	3.17	5.32	1.678
Clinic 2	Cervical spine LAT	17	0.75±0.12	±0.030	0.58	0.98	1.690
	Lumbar spine LAT	16	3.39±0.58	±0.144	2.37	4.39	1.852
Clinic 3	Cervical spine LAT	17	0.51±0.09	±0.022	0.38	0.67	1.763
	Lumbar spine LAT	19	4.30±0.29	±0.067	3.74	4.82	1.289
ASMAGH	Cervical spine LAT	19	0.80±0.11	±0.026	0.60	0.96	1.600
	Lumbar spine LAT	21	2.42±0.51	±0.111	1.82	3.40	1.868
ASMC	Cervical spine LAT	20	0.39±0.07	±0.017	0.28	0.55	1.964
	Lumbar spine LAT	20	3.23±0.49	±0.109	2.47	4.25	1.721
ANATH	Cervical spine LAT	16	0.26±0.07	±0.018	0.14	0.41	2.929
	Lumbar spine LAT	21	1.45±0.48	±0.105	0.80	2.60	3.250

Table 5: Comparison of radiographic exposure parameters and ESD between private clinics and governmental hospitals for cervical spine LAT and lumbar spine LAT examinations.

Radiographic Examination	Parameter	Private Mean±SD	Governmental Mean±SD	P value
Cervical spine LAT	SID (cm)	105.04±17.82	105.87±7.02	0.748
	kVp	68.18±5.71	64.04±5.07	0.0001#
	mAs	12.83±6.53	12.03±5.10	0.476
	ESD (mGy)	0.554±0.179	0.494±0.248	0.154
Lumbar spine LAT	SID (cm)	110.13±12.70	122.58±10.17	0.0001#
	kVp	84.92±2.96	78.53±8.96	0.0001#
	mAs	45.06±12.07	38.33±6.90	0.0001#
	ESD (mGy)	3.998±0.637	2.356±0.877	0.0001#

#Significant difference between two independent means using Students t-test at 0.05 level.

4. Comparison of Patient Mean Entrance Surface Dose (ESD, mGy) in the Present Study with Published International Data

The mean ESD of the present study was compared with published data (in various countries) to assess the level of radiation dose to patients. This comparative method is a critical reference point that evaluates changes in radiographic practice, potential differences in exposure parameters, and the extent of dose efficiency achieved across diverse clinical environments.

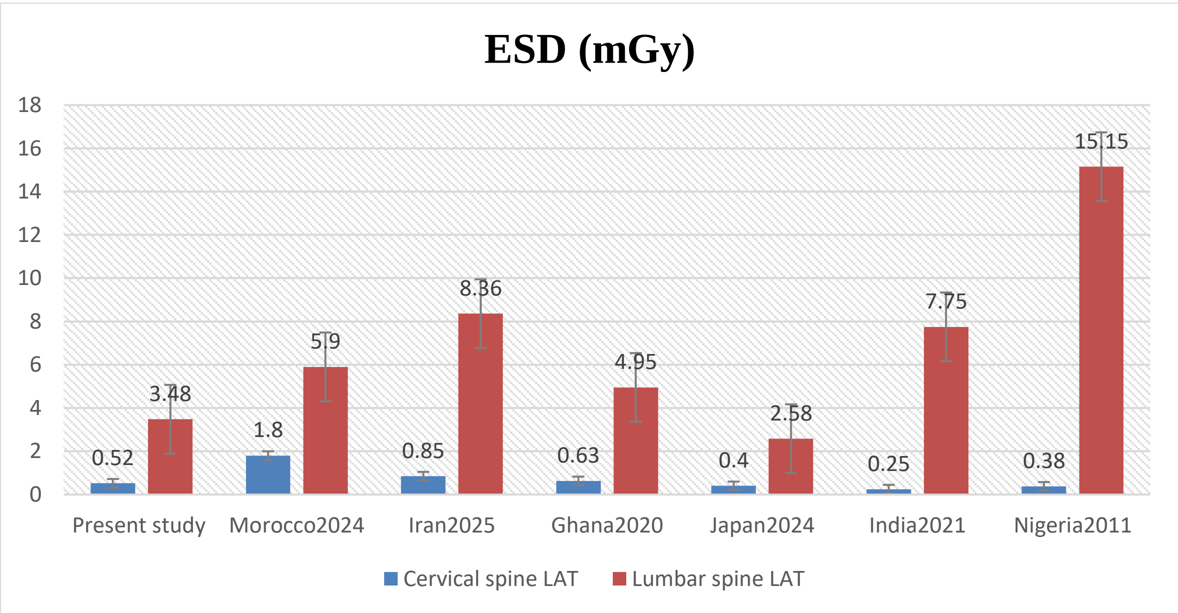

Figure 1: Comparison of the mean entrance surface dose (ESD- mGy) in the present study with the corresponding values reported for similar examinations in different countries.

5. Conclusions

ESD values of the cervical and lumbar spine LAT radiography in the current study across six radiographic centers in the Al-Najaf Governorate showed significant inter-center differences. In the cervical spine LAT, the ESD values in the study were lower than in Morocco, Iran, and Ghana, and higher than in Japan, India, and Nigeria. In the lumbar spine LAT, the values of ESD were less than those recorded in Morocco, Iran, Ghana, India, and Nigeria but were greater than those reported in Japan. In general, the ESD values obtained fell within the range of values reported internationally, and this demonstrated that the performance was acceptable with the future scope of dose optimization. These results underscore the importance of standardization of exposure parameters in radiographies, such as tube potential (kVp), tube loading (mAs), and SID, so as to have better dose optimization. Furthermore, regular Quality Assurance (QA) programs and the establishment of DRLs are recommended to minimize dose variability among radiographic centers and enhance radiation safety in clinical practice.

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Conflicts of Interest

The authors declare no conflicts of interest.

Ethical Approval

This study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Ethical approval was obtained from the Training and Human Development Center, Najaf Health Department, Ministry of Health, Republic of Iraq, under Approval No. 44726, 2025/11/24. Permission was also obtained from the participating hospital and radiology clinics before data collection. Informed consent was obtained from all participants before their inclusion in the study. Patient confidentiality and anonymity were maintained throughout the study.

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تقييم جرعة سطح الدخول (ESD) للمرضى أثناء التصوير الشعاعي الجانبي للعمود الفقري العنقي والقطني في مستشفيات وعيادات مختارة في محافظة النجف، العراق

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الخلاصة

تُعدّ فحوصات التصوير الشعاعي للعمود الفقري العنقي والقطني من الفحوصات التشخيصية الشائعة التي قد تُعرّض المريض لمستويات إشعاع عالية نسبيًا، لا سيما في الصور الجانبية. هدفت هذه الدراسة إلى تقييم جرعة الإشعاع السطحية عند مدخل جهاز الأشعة (ESD) لدى المرضى البالغين أثناء التصوير الشعاعي الجانبي للعمود الفقري العنقي والقطني، ومقارنة النتائج بالبيانات المنشورة دوليًا. أُجريت دراسة استباقية في ستة مراكز تصوير شعاعي، تضم ثلاثة مستشفيات حكومية وثلاث عيادات خاصة. شملت الدراسة 221 مريضًا بالغًا، منهم 107 خضعوا لفحص التصوير الشعاعي الجانبي للعمود الفقري العنقي و114 خضعوا لفحص التصوير الشعاعي الجانبي للعمود الفقري القطني. سُجّلت معايير التعرض، وهي جهد الأنبوب (kVp) وتيار الأنبوب (mAs) ومسافة المصدر إلى الصورة (SID)، بالإضافة إلى بيانات المرضى. قُدّرت جرعة الإشعاع السطحية عند مدخل جهاز الأشعة باستخدام نموذج إدموندز الجرعي، بافتراض معامل تشتت خلفي قدره 1.35. تراوحت قيم الجرعة السطحية المُقاسة (ESD) بين 0.26 و0.80 ملي غراي لفحوصات التصوير المقطعي المحوسب للعمود الفقري العنقي، وبين 1.45 و4.30 ملي غراي لفحوصات التصوير المقطعي المحوسب للعمود الفقري القطني، بمتوسط إجمالي قدره 0.52 ملي غراي و3.48 ملي غراي على التوالي. وقد أظهرت فحوصات العمود الفقري القطني باستمرار قيم ESD أعلى من فحوصات العمود الفقري العنقي نظرًا لزيادة سُمك الأنسجة وامتصاص الأشعة السينية. علاوة على ذلك، كانت قيم ESD أعلى بشكل ملحوظ في فحوصات التصوير المقطعي المحوسب للعمود الفقري القطني التي أُجريت في العيادات الخاصة مقارنةً بالمستشفيات الحكومية ($p < 0.001$). وكانت قيم ESD المُقاسة عمومًا ضمن النطاقات المُبلغ عنها دوليًا. تُبرز هذه النتائج الحاجة إلى بروتوكولات موحدة، ومراقبة الجودة، ومستويات مرجعية تشخيصية محلية (LDRLs) لتوفير الحماية المثلى للمرضى.

الكلمات المفتاحية: جرعة سطح الدخول، تصوير العمود الفقري العنقي، تصوير العمود الفقري القطني، قياس الجرعات الإشعاعية للمرضى، الحماية من الإشعاع.