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(Research Article)

Radiation Dose estimation for adult patient undertaking certain radiologic X-rays examinations

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Abstract

This study is aimed at calculating the amount of dose delivered to those patients whose ages are over 18 years old that undergoing certain radiological examinations. It was conducted at certain local hospitals namely, Al-Sadr Teaching Hospital, Al-Hakim General Hospital, and Al-Furat Al-Awsat Hospital. Thirteen patients as minimum number were selected for each type of radiographic examination. For the dose to be calculated, physical factors (i.e. Tube voltage (kV), tube current (mAs), and tube patient distance (FSD-cm) were reported. The dose was calculated for all cases enrolled in this study. The considered X-ray examinations include shoulder (AP), arm (AP), elbow (AP), knee (AP) and wrist (AP). Patient dose was evaluated using mathematical formula. The results revealed that in Al-Hakim General Hospital that the lowest dose for the elbow was (0.29) mGy, while the highest value was (2.02) mGy for the shoulder (AP). The lowest skin dose was (0.12) mGy and the highest values were (2.22) mGy, arm (AP), the lowest value was (0.18) mGy, and the highest values were (1.25) mGy. For wrist AP, the lowest value was (0.23) mGy and the highest value was (3.01). For the knee (AP), the lowest value was (0.26) and the highest value was (2.53). The results demonstrated that in Al-Sadr Medical City, the lowest value for the elbow was (0.56) mGy, while the highest values were (2.23) mGy for the shoulder (AP). The lowest skin dose was (0.15) mGy and the highest value was (2.50) mGy, arm (AP), the lowest value was (0.32) mGy, and the highest value was (2.93) mGy. For wrist AP, the lowest value was (0.56) mGy and the highest value was (3.64) AP. For the knee (AP), the lowest value was (0.42) and the highest value was (2.84). In Al-Furat Al-Awsat Hospital, the results showed that for the elbow the lowest value was (0.34) mGy, while the highest value was (2.04) mGy. For the shoulder (AP), the lowest dose was (0.13) mGy and the highest value was (2.35) mGy. Concerning the arm (AP), the lowest value was (0.24) mGy, and the highest value was (1.31) mGy. For wrist AP, the lowest value was (0.27) mGy and the highest value was (3.26) AP. For the knee (AP), the lowest value was (0.32) and the highest value was (1.83).

Keyword: X-Ray; Radiation Exposure; Radiation Dose; Al-Najaf Hospital

1. Introduction

Due to the uncertainty surrounding safe levels of radiation exposure, legislation has been enacted to limit permissible radiation doses for the general public. Ionizing radiation is now a cornerstone of a wide range of medical, industrial, and veterinary applications, underscoring the need for stringent safety measures to ensure the well-being of both operators and patients [1, 2]. Figure 1 illustrates the relative contribution of radiation doses from different sources.

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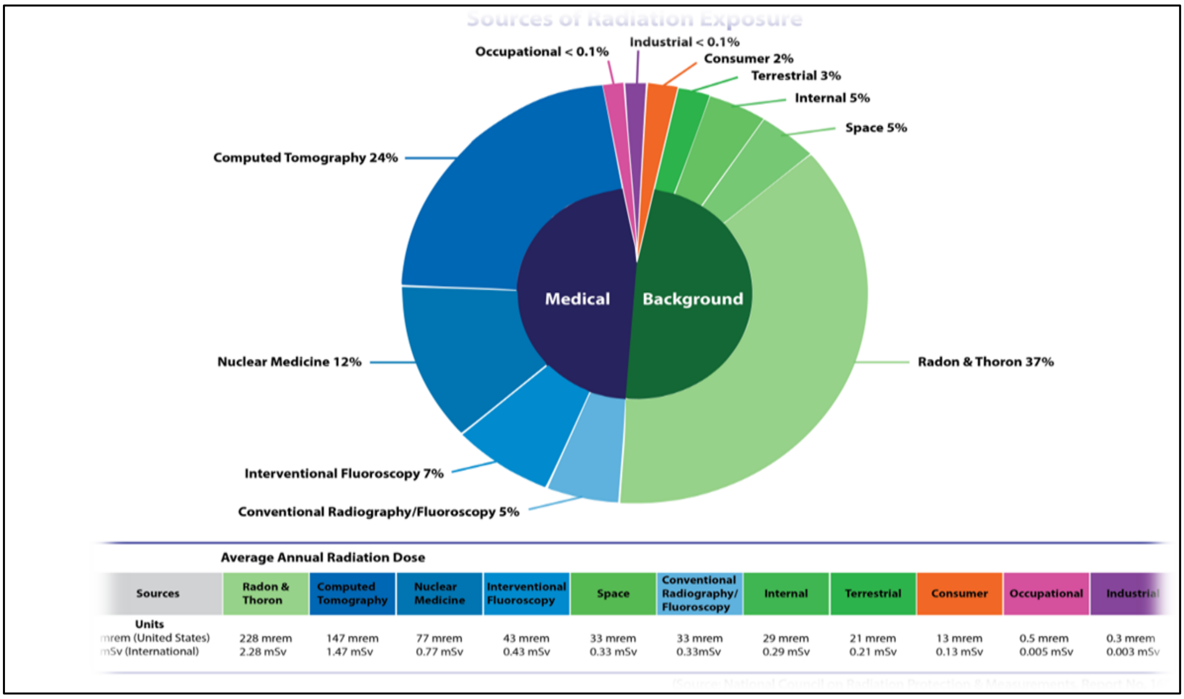

Figure 1 Dose contribution from different radiation sources

Despite the significant benefits that radiation technologies offer patients in the medical field, their increasing use has led to a substantial rise in population exposure rates. This highlights the necessity of conducting radiological examinations only when medically warranted, with radiation doses and image quality optimized to suit the diagnostic purpose without excess. Furthermore, rapid and continuous technological advancements necessitate appropriate infrastructure, enhanced staff training, and equipment upgrades, along with a greater role for manufacturers in ensuring the safe clinical use of their products [3, 4].

It is important to note that the medical uses of ionizing radiation fall into three main areas: the first is diagnostic radiology, which relies on X-ray machines to capture images of the internal parts of the patient's body. The second is nuclear medicine, which uses radioactive materials introduced into the patient's body for diagnosis or treatment. The third is radiation therapy, which uses various types and sources of ionizing radiation to treat cancerous tumors or alleviate their symptoms, among other diseases. [5,6]. Many research works have been conducted to estimate the patients radiation dose throughout the world [7,8,9] .

This work is aimed at assessing patient dosimetry during selected radiologic examinations.

2. Methods of Calculations

In this study, the Entrance Surface Dose (ESD) was estimated for five X-ray imaging techniques, which included: shoulder, knee, elbow, wrist, and arm. These specific techniques were chosen because they are among the most common radiographic examinations performed in radiology departments.

Prior to the dose calculation process, the technical exposure factors used for each patient and imaging technique were recorded. These factors included: tube voltage (kVp), the product of current and exposure time (mAs), and the source-to-image detector distance (SID) in centimeters. These parameters are essential for calculating the surface dose (measured in (milliGray), which represents the dose absorbed in air at the point where the X-ray beam enters the patient's skin, taking into account the contribution of backscatter.

The surface dose was calculated using Equation (1) [10, 11]:

$$\boldsymbol{ESD = PO\left(\frac{KV}{80}\right)^{2} \times mAs \times \left(\frac{100}{FSD}\right)^{2} \; BSF \ldots\ldots\ldots\ldots\ldots (1)}$$

Where:

Output is the X-ray tube output factor (in mGy/mAs), measured at a standard distance of 100 cm from the focal spot and at 80 kVp.

kVp is the peak tube voltage.

mAs is the product of the tube current (mA) and the exposure time (seconds).

FSD is the focus-to-skin distance (in centimeters), which was derived by subtracting the body part thickness from the SID.

BSF is the backscatter factor, for which a standard value of 1.3 was adopted, as is common in diagnostic energy ranges [12,13,14].

To increase the speed and accuracy of the dose calculations, Equation (1) was converted into a simple program using the Visual Basic language. This facilitated the processing of a large number of calculations while reducing the margin of error.

3. Results and Discussion

This research was conducted across three principal hospitals within the Najaf governorate. The study encompassed the following medical centers: Al-Sadr Teaching Hospital, Al-Hakim General Hospital, and Al-Furat Al-Awsat Hospital. Of these hospitals, three x-ray units are included. Tables 1 to 3 show the results obtained from calculating the skin dose for the studied X-ray examinations (eg shoulder, knee AP, arm AP, ankle AP and elbow AP) in terms of (mean ± σ) and exposure factors (kVp, mAs, SID). Analyzes were performed on measurements in all three radiology sections. It is clear from Table (1) that the doses offered in Sadr City Medical Hospital were higher compared to the doses of other hospitals included in the study. This can be attributed to the use of relatively higher X-ray tube parameters. From Table 1, it can be seen that the highest skin dose values were around 0.6 mGy ± (0.31) which were reported for shoulder in Sadr Medical City.

This is due to the relatively high tube parameters (kVp and mAs) with a small SID (cm), used in this hospital for this type of X-ray examination. Variations in these parameters, as reflected in the range values, are due in part to differences in patient size and the technique used. Compare the mean patient dose values for adult individuals with other reference dose values can be seen in Tables 4. For each, the majority of doses were above the corresponding UK , India, Saudi Arabia, and also in UNCER reference levels[15,16,17,18]; This includes all functions, and for all three hospitals, it was noted that the hospital with the highest dose given to the patient was the Al-Sadr City Teaching Hospital.

Table 1 Patient exposure parameters and skin dose for selected x-ray examination in Al-Sadar general Hospital-Najaf.

Type Examination	**kVp**		**mAs**		**SSD (cm)**		**Dose (mGy)**	
	Average	±SD	Average	±SD	Average	±SD	Average	±SD
shoulder	72.5	9.501	11.3	7.25	87	8.23	0.63	0.31
knee	58.6	9.47	5.62	1.73	45.6	7.53	0.54	0.26
Arm	60	6.39	4.08	2.37	42	7.52	0.45	0.21
ankle	64.9	13.68	6.34	3.49	45.2	13.98	0.52	0.33
elbow	56	3.94	5.12	2.56	38	3.49	0.38	0.18

Tabel 2 Patient exposure parameters and skin dose for selected x-ray examination in Al- Hakim general Hospital-Najaf

Type Examination	**kVp**		**mAs**		**SSD (cm)**		**Dose (mGy)**	
	Average	±SD	Average	±SD	Average	±SD	Average	±SD
shoulder	55.5	8.65	3.83	2.21	98	11.35	0.24	0.18
knee	54.8	6.98	5.45	2.06	103	10.59	0.31	0.21
Arm	51.5	6.32	4.77	4.173	100	9.42	0.20	0.16
ankle	54.4	4.45	5.46	2.26	102	7.88	0.32	0.15
Elbow	54.7	5.27	4.99	2.05	94	5.16	0.33	0.21

Table 3 Patient exposure parameters and skin dose for selected x-ray examination in Al- Furat al-Awsat general Hospital-Najaf.

Type Examination	**kVp**		**mAs**		**SSD (cm)**		**Dose (mGy)**	
	Average	±SD	Average	±SD	Average	±SD	Average	±SD
Type Examination	kVp	mAs	SSD (cm)	Dose (mGy)				
	Average	±SD	Average	±SD	Average	±SD	Average	±SD
Shoulder	51	5.03	3.48	1.17	78	7.82	0.27	0.15
Knee	54.8	6.98	5.45	5.63	83.02	11.3	0.36	0.25
Arm	52	5.86	4.77	5.02	65.5	8.57	0.24	0.19
Ankle	55	4.54	5.46	5.52	87	10.2	0.37	0.176
Elbow	54.7	5.27	4.99	4.99	45.3	7.25	0.36	0.17

Table 4 The average dose (mGy) for all hospitals included in this study compared to the level of guidelines recommended by the UK, India, Saudi Arabia and UNICER [15,16,17,18].

Examination	**Reference dose**	**Al Sader Hospita**	**Al-Hakim Hospital**	**AI-Furatalawst Hospital**	**Average of Hospitals**
shoulder	0.31 [15]]	0.63	0.24	0.27	0.52
knee	0.22 [16]	0.54	0.31	0.36	0.65
elbow	0.05 [17]	0.38	0.33	0.36	0.35
ankle	0.42 [16]	0.52	0.32	0.37	0.84
Arm	0.15 [18]	0.45	0.20	0.24	0.53

4. Discussion

The results presented in Table 4.4 show the skin dose for all tests that were included in this study for the three devices at three hospitals and the guideline levels recommended by the IAEA and the UK. The skin dose in (Al-Sadr Teaching Hospital) was higher for the majority of X-ray examinations. This may actually be due to the higher applied tube voltage with the lowest distance used in the majority of x-ray examinations. For the shoulder (AP) as well as the rest of the examinations, all values are above the level recommended by the IAEA. This could be attributed to the relatively high exposure standards used in these hospitals? It's also possible that the experience of the photographers could have some influence. A similar statement can be made for other hospitals where high skin dose values have been observed. In contrast, it can be seen that the radiation dose evaluated in both Al-Hakim and Middle Euphrates hospitals was low compared to Al-Sadr General Hospital, but still higher than that of the United Kingdom, India, Saudi Arabia, and UNCER when compared to other hospitals in this study and those published internationally [15,16,17,18]. Based on the results obtained, recommendations will be made on how to reduce doses below the international recommended dose levels. In general, all skin dose values in this study are within UK and IAEA recommendations and exceed with a fraction in some cases[19,20].

5. Conclusions

Cutaneous dosing of patients undergoing examination of shoulder (PA), arm (AP), knee (AP), elbow (AP) and ankle (AP) in three hospitals - in Najaf. All individual doses were noted to be elevated compared to the values reported in the UK published reports as well as the IAEA [10,11,12]. This is especially for those doses noticed in (Al-Sadr Teaching Hospital) and a slight decrease in a certain value in some other radiological situations (Al-Furat Hospital). The mean values of this study are compared with reference levels in the literature and the values in this current study are slightly comparable.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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