X-ray examination to measurement radiation doses of patients in three Erbil hospitals

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Abstract:

Thermo luminescent dosimeters **(TLDs)** have been used to measure the entrance surface doses **(ESDs)** of patients undergoing pelvis, abdomen and lumbar spine diagnostic X-ray examinations in **Erbil**. A total of three public hospitals and **171** patients were included in this investigation. The ages of the patients involved were from **40** years to **85** years, while their weights ranged from **64** kg to **73** kg. Mean, of ESDs are reported. The results showed that in most cases, for each of the examinations, the individual ESD values are found to be comparable with, and higher than, those from **Ghana** and **Tanzania**, respectively. The ranges found in this work are high and this indicates more attention needs to be given to X-ray facilities in the country. This also suggests that radiographic departments need to review their radiographic practices in order to bring their doses to optimum levels. Effective doses were also calculated from the ESD values. The radiographic parameters used for all the patients were also compared with the European criteria. It is recommended that the tube filtration at one hospital be increased. The importance of good regulatory activities and trained personnel is stressed in this work. Apart from the fact that the data provided in this work will be useful for the formulation of national guidance levels, they also provide patient dosimeter information on healthcare level countries.

INTRODUCTION

In applications of ionizing radiation to problems related to medicine, it is important to measure the amount of radiation delivered. In diagnostic procedures such as x-ray examinations, the number and range of X-ray facilities and X-ray equipment is increasing rapidly **[1].** Although alternative modalities for diagnosis of diseases and injury, such as **ultrasound** and **MRI** are becoming increasingly available, steady improvement in the quality of X-ray images and patient protection have ensured that diagnostic X-rays remain the most used tool in diagnosis **[2]** and hence make a major contribution to man's exposure to ionizing radiation from artificial sources. In recent years, health physicists have devoted much effort to the minimization of patients' doses in diagnostic radiology. Through these efforts, substantial reductions in radiation doses to patients resulting from radiographic procedures have been achieved in many countries **[3].** A useful background for such efforts is the knowledge of radiation doses to patients. This has led to surveys of patients' doses in diagnostic radiology in many countries **[1–7].**

In Nigeria, to the best of our knowledge, there are two published works on the survey of patients' doses in diagnostic radiology, one by Ajayi and Akinwumiju **[4]** and the other by Ogunseyinde et al **[5],** financed by the International Atomic Energy Agency **(IAEA).** In their work, patients' doses in the **X-ray** examinations of chest poster anterior **(PA),** skull **PA**, skull **AP** and skull lateral **(LAT)** were reported. However, some examinations such as pelvis, abdomen and lumbar spine that were not considered in these two past studies are also known to contribute to the population collective dose **[6].**

During pelvis and abdomen examinations, critical organs that contribute to effective dose are exposed to radiation, while lumbar spine examinations are known to be associated with higher entrance surface dose **(ESD)** values compared with all other X-ray examinations **[6].** Though Ajayi and Akinwumiju **[4]**.According to the classification by the United Nations Scientific Committee on the Effects of Atomic Radiation **(UNSCEAR) [1],** Nigeria is in the healthcare level IV category.

Radiographic techniques and dose for each radiograph were assessed during the study and have been compared with other published works from Africa **[2, 4, 7],** the quality criteria for diagnostic radiographic images proposed by the European Commission **[8, 9]** and the recently published UK reference doses **[10].**

The aim of the study:

- Measure patients' doses arising from **X-ray** examinations of the pelvis, abdomen and lumbar spine in some selected hospitals in **ERBIL.**
- Data from these measurements will serve as a useful baseline against which measurements at individual **X-ray** departments may be compared and also as an investigation of the possibility of further reduction in patients' doses.
- The review according to this document will involve systematic compilation of new national survey data.
- Hence the patients' doses reported in this work will also be useful for this kind of review by both local and international organizations.
- Radiographic techniques and dose for each radiograph were assessed during the study and have been compared with other published works.

Materials and methods:

This survey was carried out on **171** patients in three hospitals in the **Erbil**, Teaching hospital al-jemhori , Rezgare hospital, and the emergency hospital.

Teaching hospital Al jemhori is included in this study because it has many and more qualified radiologists and radiographers also because regulatory activities had been fairly prominent there. As a result, their operations are expected to be better optimized. For each **X-ray** room, available machine specific data such as type, model and year of manufacture were recorded. Information on film–screen speed was not available. These data are presented in **Table 1**. The only information that is available on the films used in these hospitals is the manufacturer's name and this has been included in the table.

Table 1.

X-ray personnel and specific data of the X-ray machines used in each of the hospital:

Hospital name	Model/type	Manufacturer	Year of manufacturer	Year of installation	Filtration (mmAL)	Number of radiologists (radiographers)	Film type
Al-Jemhori	Semins AG	GERMAN	1998	2002	1.0	12	Agfa
Rezgari	Semins AG	GERMAN	1996	2001	1.5	8	Agfa
Emergency	Sedecal	SPAN	2000	2003	1.5	4	Agfa

The following four types of radiographic views were included in the study: **pelvis AP**, **lumbar spine LAT**, **lumbar spine AP** and **abdomen AP**. Cases considered were those for which the images were diagnostically acceptable. Acceptability of diagnostic images is purely subjective and is assessed by the radiographers. For each patient and X-ray unit the following parameters were recorded: **sex, weight,** tube potential **(kVp), mAs** and focus–film distance **(FFD).** The **ESD** of each of the patients was also measured. For patient dosimeter in diagnostic radiology, guidelines established by the **NRPB [11]** advocate the estimation of **ESD** using **TLD** measurement techniques. In this work, the use of TLD was therefore adopted for the measurement of ESD.

Measurements of **ESD** were made with **TLD** attached to the patient's body at the centre of the X-ray field. The TLD- **LiF (lithium fluoride)** chips used were annealed by heating them at **400°C** for **1 h** and then at **80°C** for **18 h**. The chips were calibrated at Radiation Protection center of Ministry of science and Technology in **Bagdad,** using the facilities of the Secondary Standard Dosimetry Laboratory **(SSDL).** For each of the filtrations (1.5 mmAl, 2.5 mmAl and 2.7 mmAl), calibration factors were first obtained for exposures at five different values of tube potential **(45, 60, 75, 85 and 95 kVp).** These five calibration factors from each hospital were interpolated in order to obtain the calibration factor to be used for a patient given the tube voltage used to produce the film. The standard deviation in light output of the TLD batch used was below **5%.** Three chips were sealed in thin black polythene, coded for proper identification, before being placed on the patient's skin surface. For any three chips used the associated standard deviation in their outputs was not more than **4%**. The average of the ESDs of the three chips is recorded as the patient's ESD. In all cases the estimated uncertainties in the measured TLD values are less than **7%.**

Effective dose was estimated by using the dose conversion Coefficient in the **NRPB** document **[12]** for the radiographic procedures and projections studied. The effective doses in **Rezgare hospital** where the total filtration is 1.5 mmAl could not be calculated because there were no conversion factors listed in the document for X-ray machines with total filtration less than 2 mmAl.

Results and discussion:

A total of **171** patients, from three different hospitals, Were included in this survey. Patient age, weight and their sex distribution by hospital and examination are shown in **Table 2** the ratio of male to female can be seen to vary with the type of examination. The mean ages of the study sample are within the ages of patients **(47–66 years)** used in the **UK** survey **[13].**

Table 2:

Sex distribution, mean of age and weight by examination of the patient for entrance surface dose measurements:

Hospital	Abdomen AP	Pelvis AP	Lumber spin AP	Lumber spin LAT
Al-Jemhori				
• No. of male patients	8	5	3	5
• No, of female patients	11	13	7	7
• Age(year)	52.5(45-64)	59.2(42-73)	58.3(45-69)	57.8(53-65)
• Weight (Kg)	66(65-71)	68(66-72)	70(68-73)	67(65-73)
Rezgari				
• No. of male patients	10	7	7	5
• No, of female patients	7	8	3	5
• Age(year)	56.4(40-83)	54.8(40-73)	55.4(41-74)	56.1(40-72)
• Weight (Kg)	65(64-68)	66(64-69)	71(70-73)	69(67-72)
Emergency				
• No. of male patients	10	12	6	5
• No, of female patients	10	8	4	5
• Age(year)	54.1(40-85)	55.5(42-70)	53.8(45-65)	60.2(42-80)
• Weight (Kg)	68(66-70)	67(66-70)	70(68-71)	66(64-73)
All				
• No. of male patients	28	24	16	15
• No, of female patients	28	29	14	17
• Age(year)	54.6(40-85)	56.3(40-73)	55.8(41-74)	58.0(40-80)
• Weight (Kg)	67(64-71)	67(64-72)	70(68-73)	67(64-73)

The summary of the technical data **(tube potential**, **exposure time)** in each of the hospitals included in this survey is given in **Table 3**. Also included in the table are these parameters calculated using the patients in all the three hospitals .Antiscatter grids were employed only for some of the patients that underwent lumbar LAT examinations in **Al- Jemhori hospital**. In **Rezgari hospital** the total filtration used was below the range of values specified for total filtration recommended as good practice in the **UK** survey **[8, 9].** It is surprising that this low filtration is used in a facility that was just installed in **2002.**

Table 3: Mean (Range) of radiological data used in the hospitals:

Examination	Hospital	Tube voltage(kVp)	Exposure time

			(ms)
Abdomen AP	• ALjemhori • Rrzgari • Emergency • All	66.5(54-86) 82(76-85) 84.8(80-90) 78(54-90)	152.4(60-400) 376.5(300-400) 500(500-500) 351.8(60-500)
Pelvis AP	• ALjemhori • Rezgari • Emergency • All	73.2(50-90) 81.6(76-85) 81.8(77-85) 78.8(50-90)	208.3(100-800) 373.3(300-400) 500(500-500) 365.1(100-800)
Lumber spine AP	• ALjemhori • Rezgari • Emergency • All	78.2(60-85) 80.3(76-85) 82.2(80-85) 80.3(60-85)	316(175-500) 370(300-400) 500(500-500) 395(275-500)
Lumber spine LAT	• Aljemhori • Rezgari • Emergency • All	85.4(80-92) 86.5(85-90) 83.8(82-85) 82.3(80-92)	583.3(300-800) 420(400-500) 500(500-500) 506.3(300-800)

Other parameters are generally in agreement with the criteria except in a few cases where FFD were outside the stipulated ranges. Guidance values for pelvis AP were used for abdomen AP because no guidance value was found for abdomen AP. The values of tube potential and mAs used are also within the ranges of values of these parameters reported by **NRPB [10].** The variations in these parameters, as reflected in the range values, are partially due to variations in patient size and technique. Most of the low tube potentials reported are used in Al- Jemhori hospital and the radiographers could not give any reason for this, other than the fact that it gives acceptable images. It therefore shows that in the hospital less attention is paid to patient dose, as the lower the tube potential the higher will be the dose to the patient.

Figure (1) table (4) gives a summary of ESD measurements **(mean)** for each hospital and examination surveyed. Also included in the figure are these parameters calculated using the patients in the entire three hospitals .The range factor **(RF) is defined as the**

ratio of maximum individual ESD to minimum individual ESD for the same type of examination. The individual ESD values are within the range of individual ESD values that have been reported in the literature for each examination.

The mean ESD from the present work are found to be comparable with those from a measurement carried out in **Ghana&Tanzania,** the closeness in the values of radiological parameters used in this work and those used in the Ghana&Tanzania measurements, especially the tube potential, may explain the similar mean ESD values obtained from these two measurements. Comparison of the mean ESD values in this work with those from **Ghana&Tanzania** [2-7], showed that the present values are higher. A possible explanation for this may be the fact that in most of the Ghana&Tanzanian measurements, higher filtrations were employed. (Table 5).

Therefore with the tube potential values similar to the ones used in the present work, lower ESD values are expected with the higher filtrations used in Tanzania. The mean ESD values are also found to be within the range of their corresponding values that have been reported from countries outside **Africa [1, 6, 14, 15]** and the radiological parameters (that influence ESD) in the present work are also within those reported from these other countries.

When compared with the **UK (ESD)** reference values **[10],** the mean ESD values in Al–Jemhori hospital and Emergency hospital are generally below their corresponding ESD reference values for all the four types of examinations. Anti scatter grids were not used for most of the examinations and this may be responsible for the low doses reported in this work when compared with the UK reference where the use of grids is a standard. It is however expected that the lack of anti scatter grids (or any other alternative method) would have resulted in a lower quality image.

In Rezgari hospital the mean ESD values are above the Corresponding UK reference value for all the examinations. Though the filtration values in this work were not measured, but given by the radiographers, a possible explanation for this may be because in Rezgari hospital very low filtration (1.5 mmAl) was employed when compared with UK standard that states that filtration should be greater than 2.5 mmAl.

The doses obtained for **lumbar spine** examinations at Al-Jemhori hospital in the present work are higher than previously reported **[4]**. This probably is due to the effect of age on the facilities and lack of a good quality assurance program.

The observed interhospital and intrahospital dose variations, as revealed by the range factors, for the same type of X-ray examination, are an indication that operational conditions were not fully optimized. These variations are partly due to the differences in patient sizes **(Table 3).** Other sources of variations include possible differences in radiographic technique used by different radiographers, radiographic equipment, film type, processing chemicals and processing conditions. For example, if the filtration in **Rezgari** is increased the intrahospital variations will be reduced. Comparison of the range factors obtained in this work in ALL with those found in the literature **[13]** showed that the range factors we obtained are generally higher. This shows that operational conditions are less optimized in the hospitals used in this work and there is therefore much room for dose reduction.

Table 4: Entrance surface dose (mGy) obtained in this work with UK

Hospitals	(ESD) Abdomen	(ESD) Pelvis (AP)	(ESD) Lumber spine (AP)	(ESD) Lumber spine (LAT)
Aljemhori	2.3	2.8	3.1	12.2

Rezgari	14.6	13.8	14.33	24.3
Emergrncy	4.2	1.9	3.1	4.6
All	6.8	6	5.4	12.6
UK	**5.6**	**5.8**	**4.2**	**13.9**

Table 5: The ratio of maximum to minimum effective dose for some X-ray examination at three hospitals in (Tanzania &Ghana)

Hospitals	x-ray examination	Mean effective dose (mSv)	Max. / min. ratio
KCMC	• Lumbar spine • Abdomen • pelvis	8.1 10.3 6.2	3.7 4.6 1.3
BMC	• Lumbar spine • Abdomen • Pelvis	9.0 12.7 15.7	1.3 3.3 6.8
RMC	• Lumbar spine • Abdomen • Pelvis	4.9 13.2 4.9	2.3 2.0 1.35

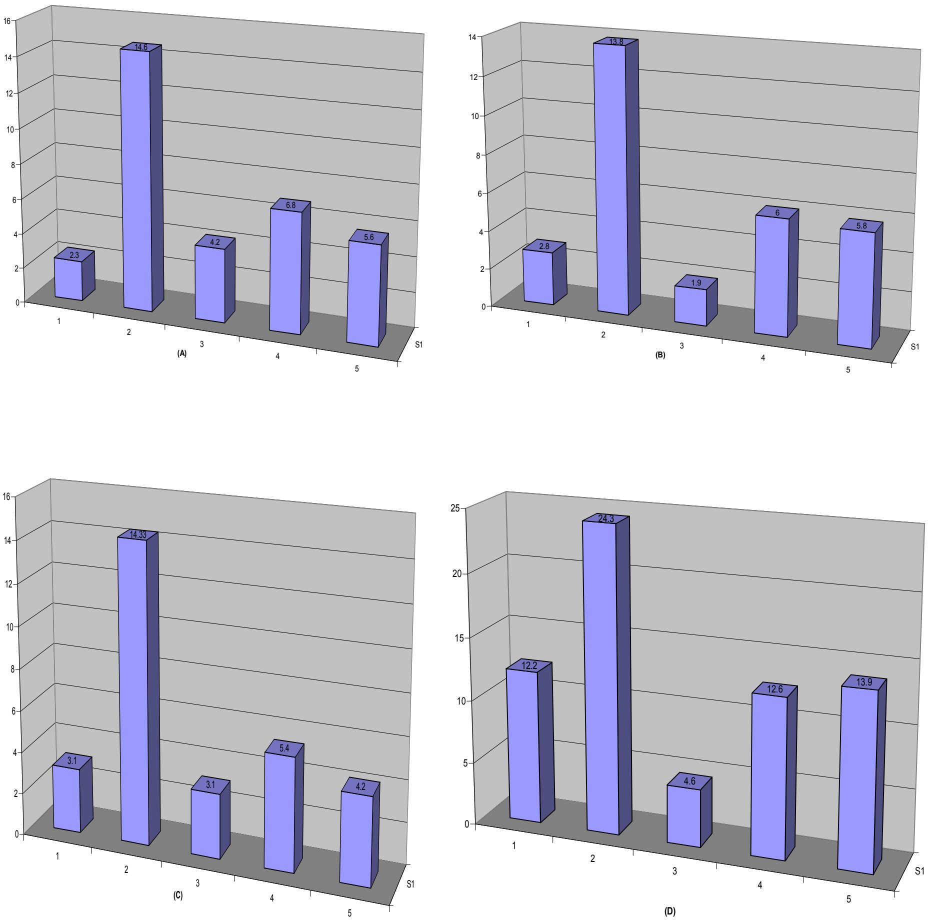

Figure1: Mean entrance surface dose (ESD)(mGy) for A: Abdomen anteroposteror(AP), B: Pelvis (AP), C: Lumbar spine (AP), D: Lumbar spine lateral (LAT) Examination and UK reference dose.

1: Al jemhori hospital 2: Rezgari hospital
3: Emergency hospital 4: All 5: UK

Conclusion:

Radiological parameters of patients undergoing abdomen, pelvis and lumbar examinations in three **Erbil** hospitals together with their radiation doses have been monitored. The individual ESD values were observed to be within the range of values that have been reported in past studies. Comparison between the present measurements and those from Ghana and Tanzania, revealed that mean ESD values in the present work are mostly comparable with and higher than, those from Ghana and Tanzania, respectively. From the present work, it is clear that if the filtration in **Rezgari hospital** is increased and if higher tube voltage settings were used in **Aljemhori hospital** the range factors will be reduced and may become comparable with those in the literature. These findings point to the fact that there is a serious need to institute programs and monitoring aimed towards reducing patient dose in **Erbil.** These could include organization of conferences, workshops and courses in order to retrain the personnel, so they can be aware of latest developments in the field. Provided data obtained with very low filtration are excluded, the mean effective doses from this work are generally below those reported from other countries. Consequently, the radiation risk to an average patient in the hospitals included in this work is less than that of an average patient in the hospitals surveyed in these other studies.

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