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Entrance surface dose measurements for routine X-ray examinations in Chaharmahal and Bakhtiari hospitals

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Background: There is not any report on the radiation doses received by patients in diagnostic radiology sections in hospitals under control of Chaharmahal and Bakhtiari Medical Sciences University, in the south west of Iran. The aim of this study is measurement of entrance surface doses (ESD) for the most routine types of X-ray procedures in radiology centers as part of ongoing dose reduction program. ***Materials and Methods:*** Geiger-Muller and thermoluminescence dosimeters (TLD), were used to measure entrance surface doses for four common radiographic views in six hospitals (7 X-ray machines). The entrance surface dose was measured on 20 randomly selected patients (male and female) for each X-ray examination. Patients were not exposed to any additional radiation and the radiographs were used for diagnostic purposes. ***Results:*** The entrance surface doses for the PA and lateral chest X-ray examinations were found to be in the range of 0.22-1.45 and 0.34-4.90 mGy, respectively. The ESD values for the AP or PA skull and LAT skull were in the range of 2.55-8.45 and 2.85-9.12 mGy, respectively. Most of the ESD measured doses were slightly greater than the ICRP and NRPB reference doses. ***Conclusion:*** The results of the present study indicate a need for quality assurance (QA) programs to be undertaken to avert considerable cost and high patient doses. The recommendations to avoid unnecessary radiation exposure are also given without lose of image quality.
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Keywords: *Entrance surface dose, X-ray examination, dosimetry, diagnostic radiology.*

INTRODUCTION

Over the past hundred years or so, X-rays have been used for diagnostic purposes. The use of X-rays for imaging purposes, however, exposes patients to ionizing radiation. The increasing use of X-ray in hospitals has made medical exposure an important source of radiation in the population collective dose [1, 2]. Ionizing radiation has the ability to break apart biologically important molecules such as DNA in exposed cells and can cause harm. As a result, the amount of radiation received by patients undergoing X-ray examinations needs to be quantified to estimate the possibility of harm. Patient doses in radiography primarily depend on the entrance surface dose and the sensitivity of the organs and tissues that are irradiated during the radiographic examination [3].

The patient effective dose is proportional to the entrance surface exposure, and also depends on the X-ray penetrating power. The body region being examined is another important factor for determining the patient dose. The effective dose is a radiation dose parameter, which takes into account the absorbed dose received by each irradiated organ and the organ's relative sensitivity. Since the effective dose may be taken as an approximate measure of the stochastic radiation risk, it may be used to quantify the amount of radiation received by patients undergoing diagnostic examinations [4].

Radiation protection is concerned with the control of the manner in which sources of ionizing radiation are used so that the user of the sources and also members of the public are not irradiated above acceptable levels recommended by the International Commission on Radiological Protection [2].

Many studies have been proposed to measure entrance surface dose in different countries and their results were compared with dose levels recommended by relevant organizations. Also, organizations such as the National Radiological Protection Board and International Atomic Energy Agency [1, 5] recommended the use of dose constraints or

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investigation levels to provide guidance for medical exposures. In the United States [6], Greece [7, 8], Brazil [9] and Bangladesh [10] investigations showed that patients dose from common X-ray examination were below the ICRP reference doses. In contrast, in China [11] and Tanzania [12] researchers reported that the average entrance surface doses were comparatively high for X-ray examination.

Most countries have legislation controlling the use of ionizing radiation and although legal systems differ, the dose levels recommended by the ICRP, together with its general philosophy and recommendations, are common factors. As part of the development of legislation, it was considered important to measure entrance surface dose and to provide additional advice to national or local authorities and the clinical community on the application of diagnostic reference levels as a practical tool to manage radiation dose to patients in diagnostic radiology. Diagnostic reference levels are then used to manage the radiation dose to the patient so that it is commensurate with the clinical purpose.

For these reasons, this work is the first to investigate entrance surface dose of the patients undergoing routine X-ray procedures in hospitals under control of Chaharmahal and Bakhtiari Medical Sciences University in Iran. Knowledge of the corresponding patient doses will help to determine whether these X-ray radiation doses to patients are as low as reasonably achievable, as required by the ICRP or other relevant organizations.

MATERIALS AND METHODS

Entrance surface dose is the absorbed dose to the entrance skin of the patient at the central point of the irradiated area [3, 13]. The values of entrance surface dose was measured for routine radiographic examinations such as chest radiograph (posterior-anterior, PA and lateral projections, LAT) and skull (anterior-posterior, AP or PA and LAT) examinations. To collect the data six hospitals (7 X-ray machines) were investigated. The X-ray sections of investigated hospitals were equipped with stationary X-ray units (Siemens, Shimadzu, Philips, Genius and Varian). The measurements were done on 20 randomly selected adult patients (140 patients in total with mean age of 42.7 years old included 87 male and 53 female) for each X-ray machine using thermoluminescence dosimeters. The lithium fluoride chips (LiF:Mg) is the most commonly used thermoluminescent material for patient dosimetry.

Thermoluminescent dosimeters were read out in accordance with manufacturer's recommendation and the data was appended manually to the spreadsheet to provide an alternate assessment of the quantity absorbed dose (including backscatter) at the patient surface. Thermoluminescence dosimeter were mounted on a tape and placed on center of X-ray beam on the patient's skin. Therefore, the backscatter radiation was included in the record surface dose. Three TLD chips were placed on the skin of each patient and the doses were averaged for each radiography and mean of ESD of all patients calculated. The measurements of dose using Geiger-Muller (SUM-AD8, Ricken Fine, Japan) detector was also performed by placing the detector at least 30 to 40 centimeters above of the X-ray table (instead of patient thickness) and therefore, no was any patient for measurement of ESD using Geiger-Muller dosimeter.

All measurements were made at the center of the X-ray beam with a fixed field size. The exposure data such as kVp, mAs, the type of cassette and the focal source distance for each examination was also recorded. The results of Geiger-Muller counter was also converted to absorbed dose as described previously [14] in accordance with the following equation:

$$D_{air} = 8.69\times10^{-3}\ X\ (Gy)$$

where 8.69×10^{-3} is a conversion factor obtained using the 34 eV ionization energy required to produce an ion pair, multiplied by 1.6×10^{12} ions produced for one Roentgen exposure.

For all mentioned X-ray machines, the average value of ESD using TLD for routine

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examination was calculated. Finally, the result of this study was compared with the other reported data of relevant organizations.

RESULTS

There was no significant difference among the values of entrance surface doses by the detectors used. The results of the entrance surface dose are indicated in table 1 for adult patients those were randomly selected for X-ray examinations at different hospitals. As can be seen from this table, the maximum and the minimum values of ESD was obtained for X-ray units located in Kashani and Ardal hospitals, respectively. Of course, another reason is the high number of patients which examined per day in Kashani hospital compared to other hospitals.

The exposure parameters and the entrance surface dose values for all routine X-ray examinations are shown in table 2. For certain X-ray examinations, particularly chest and skull, mean generating voltages (kVp) and mean entrance surface doses are presented and compared with guidance levels. As results shows the values of the ESD of skull were higher than that of chest examinations.

DISCUSSION

Records of medical examinations and personnel monitoring must be kept and made available to medical advisers, employing authorities and government health inspectors.

There have been a number of different quantities used for reference levels. The quantity selected is dependent on the type of clinical procedure, for example, whether it is an individual radiographic projection, a procedure or examination consisting of multiple projections or field locations.

The results of this study showed that the entrance surface dose of patients was comparable to the result reported in

Table 1. The ESD (Entrance surface dose) values for studied 7 X-ray machines at different hospitals using TLD.

X-ray unit	Name of Hospital	Chest PA ESD (mGy)	Chest LAT ESD (mGy)	Skull AP/PA ESD (mGy)	Skull LAT ESD (mGy)
Siemens	Kashani	1.45	4.90	8.45	9.12
Shimadzu	Kashani	1.07	3.37	8.33	9.01
Philips	Hajar	0.70	2.75	8.42	7.87
Genius	Ardal	0.22	0.34	2.55	2.58
Varian	Farsan	0.46	1.67	5.84	7.62
Shimadzu	Boroujen	0.74	2.89	7.92	8.37
Varian	Lordegan	0.31	1.62	6.93	8.54

Table 2. The exposure parameters and the values of the ESD for four routine X-ray examinations using TLD (20 experiments for each type of examination).

Type of examination	Ranges of kVp	Ranges of mAs	Ranges of ESD (mGy)	Mean of ESD (mGy)
Chest PA	75-85	5-25	0.22-1.45	0.70
Chest LAT	76-87	10-40	0.34-4.90	2.51
Skull PA/AP	85-95	20-90	2.55-8.45	6.92
Skull LAT	82-96	20-80	2.85 -9.12	7.59

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Tanzania. In Tanzania the value of ESD for chest AP was reported to be in the range of 0.08-0.56 mGy [12]. In contrast, the value of ESD measured here was significantly greater than those recorded in some other countries such as the United States [6], Greece [7, 8], Brazil [9] and Bangladesh [10]. In Greece, the mean values of ESD were found to be 0.044 mGy for chest PA and 0.043 mGy for chest LAT. In Brazil mean values of ESD for PA and LAT projections were 0.22 mGy and 0.98 mGy, respectively.

It was also found that the entrance surface dose increased with the number of patients examined per day. For instance, the number of patients examined per day for X-ray units located in Kashani hospital of Shahrekord city was two to three times more than those X-ray units located in the other hospitals, in particular in Ardal hospital. As can be seen from table 2, the large variations in the entrance surface dose indicate that much can be done in order to reduce the patient doses by adequate changes of physical parameters, without lose of image quality. Of course, the other reasons for these variations may be due to variations in the number of imaging per day and also the thickness of the patient influences the values of ESD.

Table 3 shows comparison of reference level dose as recommended by ICRP [15] and results of the present work. All the ESD values found are higher than reference level dose for studied X-ray examinations (table 3).

As table 2 showed, the high tube potential technique (such as skull LAT) delivers significantly higher values of ESD by factors of 2-4. In addition, the findings here also evident that the older X-ray equipment (such as X-ray machine located in Kashani hospital with more than 20 years old may) result the higher ESD values.

The optimization process should consist of the quality assurance including quality control programs to reach as low as reasonably achievable dose conditions. Therefore, the result indicates a need for quality assurance programs to be undertaken to avert considerable cost and high patient doses.

Several exposures to patients undergoing X-ray examinations increased the overall annual collective doses. As a result, protective measures designed for patients with special radiographic procedures should be improved. The optimization of the technique in the X-ray procedures was responsible for a significant reduction in the overall average doses received by some critical organs. The potential for reduction of radiation doses to patients undergoing some X-ray examinations was achieved.

Overall, the results of the patient entrance surface dose measured for the different types of X-ray procedures in hospitals under control of Chaharmahal and Bakhtiari Medical Sciences University in south west of Iran was found to be greater than the ICRP and ESD measurements in other countries. It was also indicated that efforts should be made to further lower patient doses while securing image quality. In addition, the need to provide relevant education and training to staff in the radiology sections is of utmost importance.

Table 3. Entrance surface dose (mGy) values recommended by the relevant organizations [15].

Type of X-ray Examination /Organization	NRPB, 1999	IAEA, 1994	(General UK) IPSM, 1992	Present work
Chest PA	0.3	0.4	0.3	0.7
Chest LAT	1.5	1.5	1.5	2.51
Skull PA/AP	5	5	5	6.9
Skull LAT	3	3	3	7.6

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REFERENCES

1. International Atomic Energy Agency (1996). International basic safety standards for protection against ionizing radiation and for the safety of radiation sources. *IAEA safety series, No. **115**, Vienna: Austria.*
2. International Commission on Radiological Protection (1996). Radiological protection and safety in medicine. Publication No. **73**. Annals of the ICRP 26, Oxford: England, Pergamon press.
3. Faulkner K, Jones AP, Walker A (1995) Safety in diagnostic radiology. National radiological protection board report No. **72**, The institute of physical sciences in medicine, York: UK.
4. Wall B, Harrison R, Spiers F (1988) Patient dosimetry techniques in diagnostic radiology. *York, UK: The Institute of Physical Science in Medicine, Report No. **53**.*
5. National Radiological Protection Board (1990) Patient dose reduction in diagnostic radiology. Documents for the NRPB, Vol.1, No. **3**, Chilton, Didcot, UK.
6. Michel R and Perle SC (2002) Effective dose equivalent estimates in diagnostic radiology with single dosimetry. *Health Phys, **79**: 17-19.*
7. Yakoumakis E, Tsalafoutas IA, Nikolaou D, Nazos I, Koulentianos E, Proukakis C (2001) Differences in effective dose estimation from dose area product and entrance surface dose measurements in intravenous urography. *Br J Radiol, **74**: 727-734.*
8. Makri T, Yakoumakis E, Papadopoulou D, Gialousis G, Theodoropoulos V, Sandilos P, Georgiou E (2006) Radiation risk assessment in neonatal radiographic examinations of the chest and abdomen: a clinical and Monte Carlo dosimetry study. *Phys Med Biol, **51**: 5023-33.*
9. Freitas MB and Yoshimura EM (2003) An overview of doses to patients and irradiation conditions of diagnostic chest x ray examinations carried out in hospitals of the City of Sao Paulo, Brazil. *Radiat Prot Dosimetry, **103**: 141-148.*
10. Begume Z (2001) Entrance surface, organ and effective doses for some of the patients undergoing different types of X-ray procedures in Bangladesh. *Radiat Prot Dosim, **95**: 257-262.*
11. Li LB, Wang JP, Yu XR, He SS, Yu FH, Ding CH (2001) Medical radiation usage and exposures from medical X-ray diagnosis in Shandong province of China. *Radiat Prot Dosim, **93**: 261-266.*
12. Muhogora WE and Nyanda AM (2001) The potential for reduction of radiation doses to patients undergoing some common X-ray examinations in Tanzania. *Radiat Prot Dosim, **94**: 381-384.*
13. Omrane LB, Verhaegen F, Chahel N, Mtimet S (2003) An investigation of entrance surface dose calculations for diagnostic radiology using Monte Carlo simulations and radiotherapy dosimetry formalisms. *Phys Med Biol, **48**: 1809-1824.*
14. Shahbazi-Gahrouei D (2003) Natural background radiation dosimetry in the highest altitude region of Iran. *J Radiat Res, **44**: 285-287.*
15. International Commission on Radiological Protection (2001) Diagnostic reference levels in medical imaging. Draft No. **5**, Feb 2001, Committee 3, Oxford: England, Pergamon press.

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