Exposure of Patients with X-Ray in Chest Radiography

Avni Morina[a], Burim Polloshka[b]
[a] Department of Engineering Physics, Polytechnic University of Tirana, Tirana, Albania
[b] Regional Hospital of Gjakova, Gjakova, kosova

Abstract

Exposure of patients with X-ray during radiographic examinations depends mainly on the most important parameter of medical radiation exposure, which is the entrance surface dose in the patient's body and the sensitivity of body tissues and organs to medical X-ray exposure. This study aims to evaluate the entrance surface dose on the patient's body who were examined in chest radiography. Evaluation is done indirectly through the use of two mathematical models, but also through direct measurements of dose by thermoluminescent dosimeters. Measurements of doses that patients receive, which are subject to these examinations, are done in Gjakova Regional Hospital of the Republic of Kosovo, while readings of dosimeters are made through the thermoluminescent detectors Thermo Scientific Harshaw 4500 system. From measurements and assessments, we came on conclusion that these models gave results that justify direct measurements, which were performed by thermoluminescent detectors. According to Faulkner model, the calculated entrance surface dose (ESD) for this kind of examination is 0.34 mGy, while for the same examination, its values measured directly with TLD is 0.33 mGy. According to Tong and Tsai model, the calculated value of entrance surface dose for this kind of examination is 0.35 mGy. Also, for this type of medical X-ray exposure, we compared the measured values and estimated by mathematical models, with the values of guiding levels of entrance surface dose.

KEYWORDS: medical exposure, entrance surface dose, X-rays.

Introduction

X-ray examinations in health care become the largest source of exposure for the population. Measurements of patient entrance surface dose provide valuable data for radiation protection of patients on radiographic X-ray equipment. The aim of this study is to measure and evaluate entrance dose in patients body surface, who were exposed during Chest- Pa radiodiagnostic examinations in Regional Hospital in Gjakova. Dose that patients receive during radiographic examinations depends mainly from the entrance surface dose in patient's body and the sensitivity of body tissues and body organs of the patient to medical radiation exposure [1]. Entrance surface dose is a dose absorbed in the patient's body surface, in the centre of the beam X, including the backscattered radiation during the process of exposure [2]. Entrance surface dose is an important parameter in evaluating the dose that the patient receives, even by a single radiographic exposure. In radiographic exposures is required to make regular and periodic measurements and assessments, in order to ensure optimization of protection of patients and use the minimum dose values. The need for standardization of medical exposure has been supported through different recommendations on the guidance levels for various radiographic examinations, by international organizations[3]. In Kosovo and also in Gjakova Regional Hospital, until today there weren't realized any research of measurements and evaluation of doses that patients receive, but in these centres only professional exposure measurements are achieved. For this purpose, in different countries of the world many authors and researchers, in addition to systematic and direct measurements of doses, they have also used various mathematical models to make appropriate assessments of levels of uses in radiographic imaging. In this study, entrance surface dose for X-ray examination of the chest radiography is measured and evaluated by indirect methods through the use of parameters that characterize the process of X-ray exposure.

Materials and methods

Radiological device for X-ray exposure that is used in this study is located in the radiology department of the Regional Hospital "Isa Grezda" in Gjakova. This device is a product of 2002 by the company APELEM and has these technical features: internal filtering is 2mmAl, X-ray tube is RALCO series SR.I IEC 522/1976 and operates up to 150 kVolt. Thermoluminescent dosimeters used to make direct measurements of doses are HARSHAW type TLD100, which are crystals of lithium fluorine (LiF), in which the magnesium and titanium is added. Exposed patients were different genders and ages and for every patient we have kept notes of body weight, age and gender. Also, for each exposure we have taken notes of tube voltage, tube current, exposure time, distance from the focus of X-ray tube up to film and the distance from the focus of tube to the patient's body surface. With these parameters we calculated the average entrance surface dose of the patient's body, directly placing the three thermoluminescent dosimeters at the same time exposure. A dosimeter is placed within the beam on the surface of patient's body, another one at exit of the patient's body, near the film and within the X-ray beam, and another one sideward, out of the X-ray beam at a distance of 1 meter from its centre. In the situation that the dosimeters are exposure with the presence of the patient, for efficiently reading, dosimeters were held in those positions to 10 exposures on different patients for the same examination. To implement the methodical of measurement, dosimeters were exposed even without the presence of the patient, at a certain distance in the center of the X-ray beam. The exposure of dosimeters were done in the same parameters (mAs, kV, etc.) as they were used in corresponding examination with the presence of the patient. In the case of exposure without the presence of the patient, we executed two exposures. During the realization of measurements, two thermoluminescent dosimeters have been not used, so that the exposure value of natural radiation collected by them during the implementation of measures, to read and that value to subtract from the value accumulated by dosimeters, which were settled in the area of X-ray radiation during the dosimetric measurement. For the evaluation of entrance radiation dose on the patient's body surface, we used two models; Faulkner Model and Tong&Tsai Model.

Faulkner Model

According to this model the entrance surface dose (ESD) can be estimated by knowing the exposure that gives the X-ray tube in 1 meter distance from its focus (Tube Output) expressed in unit (mGy / mAs), in the centre of the X ray beam. This exposure should be made by applying the amount of 10 mAs and 80 kV voltage [3]. During the measurements we have demonstrated that the value of given dose by the X-ray tube, increases with increasing voltage. Thus, for the value of increased voltage from 60 kV to 90 kV, for constant values of exposure of 10 mAs (Table 1), we got increasing dose values, at a certain distance from the focus of the tube in the centre of beam (fig. 1).

Table 1. Dose dependence from voltage

TLD	Position of TLD	Exsposure (mAs)	Voltage (kV)	Dose (μGy)
TLD 1	In the centre of beam	10	60	451.4
TLD 2	In the centre of beam	10	70	677.6
TLD 3	In the centre of beam	10	80	1331.6
TLD 4	In the centre of beam	10	90	1397.3

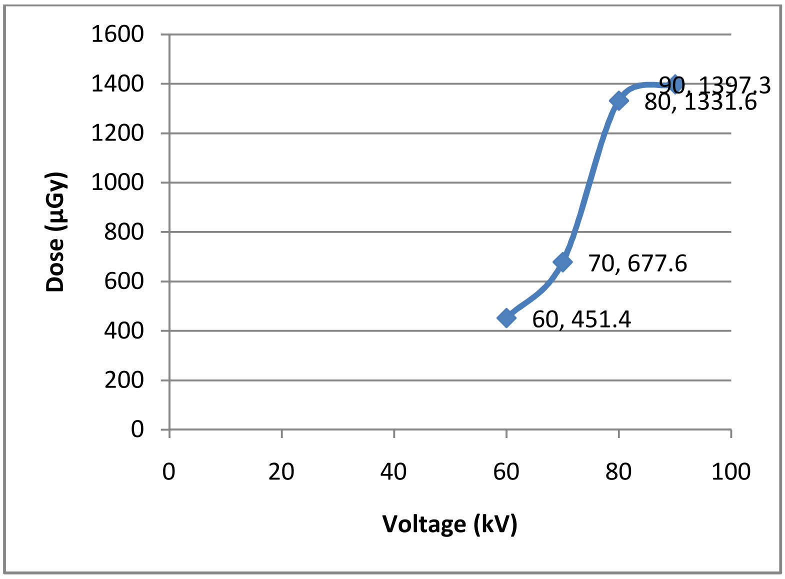

Fig. 1. Dose dependence from voltage applied in the X-ray tube

To calculate the entrance surface dose, Faulkner model offers this formula:

$$ESD = TubeOutput\left(\frac{mGy}{10\,mAs}\right)_{1m} \times \left(\frac{kV}{80}\right)^2 \times \left(\frac{100}{FSD}\right)^2 \times \frac{mAs}{BSF}$$

Physical quantities of this formula are: the value of the exposure that applies to relevant patient (mAs), which represents production of electric current (mA) and exposure time (s), the distance from the focus of source to the surface of the patient's body (FSD) and backscatter factor (BSF).

Tong & Tsai Model

According to this model, entrance surface dose (ESD) is in direct proportion to the production of air exposure by X-ray tube (FAE - Free Air Exposure) in certain distance, with the ratio between the absorption coefficients of biological tissue and air $\left(\frac{\frac{\mu}{\rho}tissue}{\frac{\mu}{\rho}air}\right)$ and backscatter factor (BSF).

The formula proposed by Tong and Tsai model is [4]:

$$ESD = FAE(mGy) \times 0.00877\left(\frac{mGy}{mR}\right) x \left(\frac{\frac{\mu}{\rho}tissue}{\frac{\mu}{\rho}air}\right) x\ BSF$$

In this formula, the ratio between the absorption coefficients of biological tissue and air, is 1.06 for all energies that are used in radiography [5], while 0.00877 $\left(\frac{mGy}{mR}\right)$ is the coefficient used to convert the dose from the unit mR into mGy, because 1mR = 0.00877 mGy. [6]. Exposure of air by the X-ray tube (FAE) was set by measuring with TLD, setting a TLD in the centre of the beam, at distance of 1.5m from X ray tube, without the presence of the patient.

Results and discussion

Based on measurement methodology and through the use of two models, we got the relevant results of entrance surface dose in radiographic Chest –PA examinations. In the following tables (table 2 & table 3), we present the results measured directly by thermoluminescent dosimeters and indirect results evaluated by two models.

Table 2. Characteristic quantities of dosimetric measurement

Gender (M/F)	Age (years)	Mass (kg)	Voltage (kV)	Exposure (mAs)	Filtration	Focus-film distance
M	60	90	97	18	2 mm Al	1.5 m
F	37	85	97	12	2 mm Al	1.5 m
M	66	74	96	18	2 mm Al	1.5 m
F	38	68	93	16	2 mm Al	1.5 m
M	65	65	90	14	2 mm Al	1.5 m

In the second table we presented all characteristic quantities, which accompanied the process of dosimetric measurements during radiographic exposures.

Table 3. Values of ESD in radiographic examination of the Chest - PA

Position of TLD	Electric charges of chrystals from 5 exposures	Average values of ESD measured with TLD / 1 exposure	ESD evaluated by Faulkner model / 1 exposure	ESD evaluated by Tong&Tsai model / 1 exposure	ESD according to IAEA guidance levels/ 1 exposure
TLD before	71.9 nC	0.33 mGy	0.34 mGy	0.35 mGy	0.4 mGy
TLD behind	12.9 nC	0.07 mGy			
TLD lateral	7.4 nC	0.04 mGy			

By the third table data, we see that entrance surface dose estimated by the Faulkner model is 0.34 mGy, while estimated by the Tong&Tsai model is 0.35 mGy. These dose values are very close to the dose measured directly by thermoluminescent dosimeters. This fact shows that these two models are valid and justifiable enough to use in evaluation of indirect dose that patients receive. In particular, it is important to note that the results of measurements and evaluations showed that entrance surface dose of exposure of patients who undergo radiographic examinations of Chest - PA, compared with guidance levels given by the International Atomic Energy Agency (IAEA) [7] does not exceed these levels, that is less than 0.4 mGy.

Conclusions

In research conducted at the Regional Hospital "Isa Grezda" in Gjakova and from evaluations made after the measurement process and effective use of mathematical models, we draw the following conclusions:

- From measurements and assessments, we came on conclusion that these models gave results that justify direct measurements, which were performed by thermoluminescent detectors.
- According to Faulkner model, the calculated entrance surface dose (ESD) for this kind of examination is 0.34 mGy, while for the same examination, its values measured directly with TLD is 0.33 mGy.
- According to Tong and Tsai model, the calculated value of entrance surface dose for this kind of examination is 0.35 mGy.
- X-ray examinations of the Chest – PA in the Department of Radiology of this Hospital, uses equipment that provide permitted exposure and in full compliance with international guidance levels for the effective use of doses.

References:

[1] K. Faulkner, AP Jones, A Walker (1995) Safety in diagnostic radiology. National radiological protection board report No. 72, The institute of physical sciences in medicine, York: UK.

[2] Dosimetry in diagnostic radiology : An international code of practice,Vienna : International Atomic Energy Agency, 2007.

[3] K. Faulkner, D. A. Broadhead, R. M. Harrison: Patient Dosimetry Measurement Methods, Applied Radiation and Isotopes; Pergamon Press (**1999**) 59,113-123

[4] Tung CJ, Tsai HY: Evaluations of Gonad and Fetal Doses for Diagnostic Radiology, Proc. Natl. Sci. Counc. ROC(B), (**1999**) , 23(3):107-113.

[5] ICRP - International Commission on Radiological Protection (**1991**), Recommendations of the International Commission on Radiological Protection. ICRP Publication 60. Annals of the ICRP 21, No. 1-3 (Pergamon Press, Oxford)

[6] IAEA - International Atomic Energy Agency (**2011**), Implementation of the International Code of Practice on Dosimetry in Diagnostic Radiology (TRS 457): Review of Test Results. IAEA human health series, ISSN 2074–7667; no. 4, Vienna

[7] IAEA - 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