The Effectiveness of Thermoluminescent Crystals for Calculation of Required Barrier Against Radiation at the Diagnostic X-ray Units

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Abstract–**Regarding the importance of radiographic techniques in diagnosis and expansion of its usage with development of new techniques on the one hand and inappropriate administration of these methods, including patient and personnel exposure to undesirable effects of radiation on the other hand, it appears that measurement of exposure dose in routine radiographic examinations and presentation of essential information, with guidance are necessary. The aim of this research was the measurement of the surface skin doses of the patients concerning examination chest and skull radiographic and the comparison of the measures with National and International organization standards.**

In this cross sectional study, six X-ray generators in six Mazandaran University of Medical Sciences Hospitals were studied. 120 patients who were referred to the radiology wards for radiographic examinations of chest and skull with normal BMI were chosen, (20 patients for each radiography unit). In addition, six generators were matched for mAs, kvp, type of amplifier sheets, and technical conditions as much as possible, so the amount of surface dose would not depend on the mentioned items.

We used thermo luminescence dosimeters for measurement of the surface skin dose (Lif-100). Calibrated Thermo luminescence dosimeters (TLD) were placed on the back skin of patients' and then the results were read by TLD readers after radiation.The results the measurement of the surface skin dose were 0.51 milli Gray for 1PA 2CXR, 3.36 milli Gray for 3LAT CXR, 7.25 milli Gray for 4AP or PA skull X-rays, and 7.59 milli Gray for LAT skull X-rays. The measured values were higher than the National and International organization standards.

The results of this research revealed that the condition of the X-ray generators have to be evaluated and modified periodically. With modifying of the X-ray generators and also the promotion of the technician's skills, the radiation exposure and its side effects would reduce in patients concerning radiographic examination.

Keywords – Radiographic standards, Dosimetry, Radiography, TLD.

I. Introduction

RADIOGRAPHY is one of the most important diagnostic modalities in medicine and its effective use of this technology is only possible under definite organized methods. Studies on current conditions of the radiographic units and comparing it with valid standards. Make this technique more useful and harmless (1).

Radiology departments are among the most fundamental and expensive wards of each medical center. It should be noted that investment in these wards is much more than the others. Protection against ionizing radiation, ventilation of the ionized air, and providing the physical space needed for various radiographic equipments, impose great expenditures on medical system. Personnel, patients and their companions are exposed to biologic side effects of radiation (2).

Statistics show that more than 80% of patients referred to Hospitals need a radiographic examination (3). Problems in using radiographic units will lead to inaccurate radiographic reports. That may lead to misdiagnosis and/or the repetition of the radiography which both effect on patient's health (4).

Diagnostic X-ray units are one of the sources which exert large amounts of man made radiation to people and personnel. It depends on the type of diagnostic X-ray examinations and times of exposure within the population (4).

For example, in the United States, approximately 12% of human radiation exposure is due to different modalities of using X-ray machines, which is the highest radiation source made by human (5). In all, studies on radiation dose in patients especially in radiology wards, due to its great importance, are one of the highest priorities in research studies that work on this subject from different aspects (6).

Radiation from diagnostic radiographic units can cause harmful effects on patients and personnel, especially when security points and recommendations of International Commission on Radiology Protection (ICRP) are not considered in the wards.

Measurement of the exposure dose in patients and personnel, along with comparing it with published data by ICRP and protocol of the National Radiological Protection Board(NRPB) regarding the safe range of exposure dose in a year, will help to protect patients and personnel from radiation side effects(7).

Iran is among the few countries which has not presented data and lacks a database in this field, due to limited studies being carried out. However, it should be noted that in a few Provinces these measurements have been done. A complete report of these values and exposure doses, especially for patients, does not exist yet. Thus, the comparison between exposure dose in Iranian patients and international standards is not possible at present. Therefore, lack of information and a database indicate the importance of research in this field.

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Results of these measurements highlight the importance of the observance of protection rules against radiation. For to reduce harmful side effects in patients and personnel. The objective of this research was the measurements the surface skin dose in patients concerning radiographic techniques of chest and skull in radiology wards of Mazandaran University of Medical Science Hospitals, to obtain the necessary data about radiation exposure in society and present it to related organizations.

Cross-sectional qualitative in this study, six X-ray generators in six hospitals related to Medical University of Mazandaran (which had the most referrals during the year of 2006-2007 among the all related hospitals) were studied. The used method to measure the surface skin dose was on the base of the protocol of NRPB in 1992(8). In this protocol, there is comprehensive information for choosing the TLD, calibrating the TLD, selecting the patients and recommended radiographies and analyzing methods of the data. The sample size was calculated 120, according to the protocol of NRPB with 95% confidence coefficient. In each Hospital, 20 patients of both genders referring to radiology wards mean age of 40(SD ± 10 years) with normal BMI (20 - 25) were selected.

As the intensity of the absorbed radiation of film is conversely related to dimensions of the body, the patients with normal BMI were selected for study (8).

The measurement of surface skin dose was PA and LAT chest X-rays (CXR) and PA or AP and LAT skull radiographies. This selection was according to the data of hospitals which showed that the radiographies were the must frequency among the referred patients to the hospitals of of Mazandaran University of Medical Science in 2006-2007. For each one of the mentioned radiographies five patients were sleeted (totally 20 patients for a hospital) for measurement of surface skin dose radiographies.

The generators were matched as much as possible for the combination conditions of mAs, kvp, type of amplifier sheets, daily work load in the hospitals, so the measurements would not depend on these items.

TLD was used for measurement of the skin surface dose, we used TLD.The chosen type was type Lif(TLD-100), because its atomic number equals that of the tissue and it has a high sensitivity and small size (1* 3* 3 mm) and in low energies, it has a better response compared to other dosimeters(9). TLD response for radiation depends on different factors, therefore, TLD chips and the reader systems must be calibrated. In this research, calibration was preformed in three stages and prior to starting the calibration, all TLDs were aniled.

For this, we used the standard two-stage method of anil. In the first stage, TLD chips each of them which had a special number were arranged on a metal sheet by number and placed in 400 'C for one hour and during the second stage, when their temperature reached 80 'C, the door of the kiln was closed and this temperature was maintained for 24 hours. Then, the kiln was turned off and the TLD chips were left in room temperature to cool. According to the two-stage method of anil, cooling of the chips between the two stages was performed slowly.

In the third stage, as TLD chips of one type don't response equally do not have an equal response in receiving equal amounts of radiation, for each TLD chip, an Element Correction Coefficient (ECC) was determined. For this, TLDs were arranged on a sheet by number in several rows and were radiated by the radiography units of the radiology ward.

The amount of radiation in this stage was not important. It was enough to ensure that all TLD chips were at the center of the radiation field and had the least possible distance from each other to prevent the of Heal Effect of anode on radiation amount. Then, the TLDs were read by TLD readers. The values were shown with (Qi).

The average (Q1) and standard deviation (SD) of Qi amounts were calculated. TLDs that had Qi amounts were higher or lower than Q1 ± 1SD were excluded and the average of remaining values were calculated again (Q) and also, the ECC of each chip was computed using formula (1):

$$ECCi=Q/Qi \qquad (1)$$

After calibrating TLDs, they were transmitted to radiology wards for measurement. Dosimeters were placed on patients' back skin and after radiation, all TLDs were read by TLD reader and the results were extracted. In this research, 140 TLD chips were used, of which 20 were preserved in a special box with other TLDs, as environmental dose controls (background radiation).

These TLDs were not exposed to radiation and also, in each reading, the average TLD values were subtracted from the amounts read on TLDs placed on patients' back skin, so environmental background radiation would not effect so it would not effect the end measures of skin surface dose.

II. Results

The results of measuring surface skin dose in X-ray examinations of chest and skull in different projections are shown in table (1):

Our measured values that show, the maximum skin surface dose was for radiographic units of Emam Sajad hospital of Ramsar and Shohada of Noshahr. Table (2) shows measured skin surface doses for different KVps.

III. Discussion

The results of the measurement of the skin surface dose of patients referred to radiology wards of Mazandaran University of Medical Sciences hospitals are higher than established standard of National and International organizations. Under the same workload and conditions our measured values the higher than doses recommended by NRPB.

These values are similar to those of some other countries such as China and Tanzania. But they are higher than those measured in United States, Greece, Nigeria, and Bangladesh (12, 13). The average skin surface dose in second group countries were reported as 0.25 milli Gray for PA CXR, 0.61

milli Gray for LAT CXR, 1.69 milli Gray for PA and AP skull X-ray, and 1.14 milli Gray for LAT skull X-ray.

Comparing these values with results in table (2), reveals that surface skin doses measured in this study are high and the maximum skin surface dose of patients were measured in Emam Sajad Hospital of Ramsar and Shohada Hospital of Noshahr (table 1).

The high skin surface dose may relate to the improper work of the units especially in high KVPs, outdated and old unit that are in use in some hospital of developing countries and lack of periodic quality control of X-ray generators.

On the other hand the role of the human factors and careless radiology technicians is very important and low effect on the values of skin surface doses.

As the radiation is an established carcinogenic agent, it is necessary to reduce the exposure rate of the patients.

According to the importance of the complication and our research outcome. For the safety and health of the patients and radiologist technicians we recommend replacement of out dated units by new X-ray generators, periodic quality control by international protocols and continuous education and observation of radiologist technicians.

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REFERENCES

[1] Muhogora WE, Nyanda AM, Kazema RR.Experiences with the European guidelines on quality criteria for radiographic images in Tanzania. J Appl Clin Med Phys. 2001; 2(4):219- 226.

[2] Almen A, Tingberg A, Mathson S, et AL. Influence of different technique factor s on image quality of lumbar spine radiographs as evaluated by establisher CEC image criteria. Br J Radiol. 2000; 73(875):1192-1199.

[3] Archer BR, Wagner LK. Protecting patients by training physicians in fluoroscopy radiation management. J Appl Clin Med Phys. 2000.1(1):32-37.

[4] Krutz C, Czapp W, Jrampe I, Leppek R, Klose KJ. X-Ray taken by radiologists influence on a continuous quality improvement process.Rojo Fortschr Geb Rontgenstr Neuen Bildgeb Verfahr.2000; 172(4):391-396.

[5] Brucel.Reiner.SCAR Radiologic technologist survey.2000.http: WWW.scarnet.org.

[6] Gogos KA, Yakoumakis EN, Tsalafoutus lA, Makri TK.Radiation dose consideration in common pediatric X-ray examination. Pediatric Radiol. 2003; 33(4):236-240.

[7] Ember H. Radiation dosimetry. Cember H. Introduction to health physics. 1 Ed. New York: Pergamon Press; 1993. p. 135-76.

[8] National protocol for patient dose measurements in diagnostic radiology. Prepared by dosimetry working party of the institute of physical sciences in medical publication 1992.

[9] Benini A. Medical radiation exposure, IAEA regional workshop radiation and quality assurance in diagnostic radiology. Nicosia Cyprus. 1993; 14-25.

[10] Benini A. Quality control measurements in diagnostic X –ray. IAEA Vienna. 1992; 100.

[11] Benini S. Computer- assisted quality assurance for radiographic equipment. Med phys. 1980; 7(4):386-9.

[12] Hourdakis CJ. A national survey: performance of medical x- ray systems in Greece. Radiat protect Dosim. 1999; 81(3): 205-19.

[13] United Nations scientific committee on the effects of atomic radiations Sources. Effects of ionizing radiation. New York: United Nations; 2000.30.

[14] Declan R, Kyrio J. Radiation protection in interventional radiology.Clin Radiol. 2001; 56:99-106.

[15] k. Introduction to constancy check protocols in fluoroscopic systems. Radiat prot Dosim. 2001; 94(1-2):65-8.

[16] Begum Z. Entrance surface, organ and effective dose for some of the patients undergoing different types of X-ray procedures in Bangladesh. Radiat Prot Dosim. 200 I; 95(3): 257-62.

[17] Zhll XR. Entrance surface dose measurements for in vivo diode-dosimctry: comparison of correction factors for two types of commercial silicon diode detector. J Appl Clin Med Phys. 2000; 1(3): 100-7.

[18] Li LB, Wang JP, Yu XR, et al. Medical radiation usage and exposures from medical X-ray diagnosis in shandong province of China. Radiat Prot Dosim. 2001; 93: 261-6.

[19] Michel R, Perle Se. Effective dose equivalent estimates in diagnostic radiology with single dosimetry. Health Phys. 2002; 79:] 7-19.

[20] Ogunseyinde AO, Adeniran SA, abed RI, et al. Comparison of entrance surface doses of some X-ray examinations with CEC reference doses. Radiat Prot Dosim. 2002; 98: 231-4.

[21] Papadimitriou 0, Perris A, Molfetas MG, et al. Patient dose, image quality and radiographic techniques for common X-ray examinations in two Greek hospitals and comparison with European guidelines. Radiat Prot Dosim. 2002; 95: 43-8.

[22] Muhogora WE, Nyanda AM. The potential for reduction of radiation doses to patients undergoing some common X-ray examinations in Tanzania. Radiat Prot Dosim. 2002; 94: 381-4.

[23] Rahimi S.A, Sarkar S,Abolhasani M.J, Salar S.Design of a computer software for calculation of required barrier against radiation at the diagnostic x-ray units. Journal of Mazandaran University of Medical Sciences 2005; 15(47):90-97.

[24] Rahimi S.A, Salar S. Study on the Performance of Recommended Standards in the Diagnostic Radiology Units of the Hospitals Affiliated to the Mazandaran University of Medical sciences. Journal of Mazandaran University of Medical Sciences 2006; 15(49):65-72.

Table 1 The results of surface skin dose in different routine radiographic examinations of chest and skull on m Gray and comparing them with standard values of NRPB.

HOSPITALS	PA CXR MEAN± SD	LAT CXR MEAN±SD	AP OR PA SKULL X-RAY MEAN± SD	LAT SKULL X-RAY MEAN± SD
Emem Ali Amol	0.33±0.12	1.19± 0.12	3.19± 0.27	1.92± 0.57
Emam Khomeini Sari	0.53± 0.13	1.61± 0.81	2.36± 0.68	1.69± 0.14
17Shahrivar Amol	0.59± 0.45	1.25± 0.49	2.69± 0.37	1.75± 0.36
Shohada Noshahr	0.72± 0.66	1.27± 0.63	3.57± 0.31	2.03± 0.17
Emam Reza Amol	0.49±0.21	1.82± 0.52	2.87± 0.82	1.14±0.20
Emam Sajad Ramsar	0.75± 0.57	1.46± 0.28	3.85±0.19	2.01±0.47
National Radiological Protection Board(DRL)	0.15	0.75	2.3	1.2

Table 2 Surface skin **doses** of patients in different radiographic examinations of chest and skull in milli Gray for maximum KVps (70-105).

ADIOGRAPHIC EXAMINATION	MAXIMUM DOSE	MAXIMUM AND MINIMUM SURFACE DOSE	NRPB(DRL)
PA CXR	0.56±0.35	0.19_1.32	0.15
LAT CXR	1.4±0.47	0.80_2.34	0.75
PA or AP skull X-ray	3.08±0.44	1.68_4.04	2.3
LAT skull X-ray	1.47±0.32	1.35_2.48	1.2