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Patient dose in routine X-ray examinations in Yazd state

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ABSTRACT

Background: Medical x-rays are the largest man-made source of public exposure to ionizing radiation. It is important to avoid conditions where the amount of radiation used is more than that needed for the procedure.
Materials and Methods: The Entrance Skin Exposure (ESE) measurement was conducted for quality control of x-ray machines and survey of operator's experimental techniques. The ESEs were measured by UNFORS dosimeter for five common types (12 projections) of x-ray procedures in standard man for the 18 public hospitals of Yazd province.
Results: The median, 3rd quartile, minimum, and maximum values of each ESEs distributions are reported. The 12 histograms are presented showing wide distribution of measured ESE in each examination. The survey results are compared with guide levels that reported by CRCPD or NRPB. The sum of ESEs measurements such as in skull, Th-spine and L-spine are projection out of the guide levels. One of reasons of the wide ESEs distribution is miss unique role in selection of techniques for the same procedure and same patient size by operators in each center and even for one x-ray machine.
Conclusion: The findings support the importance of the on-going quality assurance program to ensure doses are kept to a level consistence with optimum imaging quality. *Iran. J. Radiat. Res., 2004; 1(4): 199-204*

***Key words:** ESE, medical x-ray, patient dose, quality control.*

INTRODUCTION

X-ray diagnostics gives the largest contribution to the population dose from man-made radiation sources. Strategies for reduction of patient doses without loss of diagnostic accuracy are therefore of great interest to society and have been focused in general terms by the ICRP (ICRP 1996) through the introduction of the concept of diagnostic reference levels. The European Union has stimulated research in the field, and based on patient dose measurements and radiologists, appreciation of acceptable image quality, good radiographic techniques have been identified and recommended (EUR 1996) for conventional screen-film imaging. These efforts have resulted in notable dose reductions in clinical practices (Hart *et al*. 1996).
In spite of 100 years of use of x-rays for diagnosis, the choice of technical parameters still relies on experience to a great extent. Scientific efforts to optimize the choice, in terms of finding the parameter settings, which yield sufficient image quality at the lowest possible cost in dose, are still rare. The goal of radiation protection is to prevent or minimize exposures that have no benefit; therefore so patient dose measurement is essential in radiation protection and quality assurance programs (Morgan *et al*. 1999).

A wide range of patient exposure occurs in diagnostic radiology. This wide range of exposures is expected. What is surprising is that even for the same routine procedure and for the same average patient size, exposures may be varied substantially between facilities and operators. Worldwide interest in patient dose

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measurement was stimulated by the 1990 publication of Patient Dose Reduction in Diagnostic by the UK National Radiological Protection Board (Hillier *et al.* 1990). NRPB has surveyed patient dose from 1980 throughout UK. NRPB-W14 is the second in a series of five, yearly reviews of the national patient dose database during the period of 1996 to 2000. The third quartile values observed for National Patient Dose Data (NPDD) base was recommended as national reference dose (Hart *et al.* 2002, 1996). Several major dose surveys have been reported especially from developed countries (Brugmans and Buijs 2002, Maccia 1988, NCRP 1989). A national survey has been conducted in Malaysia from 1993-1995 to establish baseline patient dose data for seven routine type of x-ray examinations (NG 1998).

Nationwide Evaluation of X-ray Trends (NEXT) is a program conducted annually to measure the x-ray examinations. This program is conducted jointly by the conference of radiation control program directors (CRCPD) and FDA center (Winston 2003). Guideline reference values based on the results of national surveys by NRPB are provided as a practical aid to identify those radiology departments in most urgent need of better quality control (Hart *et al.* 2002).

The first essential step in optimizing patient dose is to make radiologists and radiographers aware of their own performance in this regard and how it relates to the publically accepted practice. It is consequently recommended that as a part of routine QA program periodic measurements to be done- of the patient entrance surface dose for a few common x-ray projections; we accomplished a measurement patient dose for routine x-ray examinations in all of general hospitals radiology centers of Yazd province.

MATERIALS AND METHODS

Patient exposure from diagnostic x-ray is often reported as the Entrance Skin Exposure (ESE). In this survey ESEs measurements were accomplished by solid state dosimeter (6001 model of UNFORS). This study was conducted in 27 x-ray rooms of the 18 public hospitals at 8 cities of Yazd province. For each x- ray units specific data such as type of machine, film-screen speed, grid of cassette stand and out put were recorded.

The ESEs of following six routine types (12 projections) of x-ray examinations were measured: (AP and Lat) chest (with and without grid), skull, cervical, thoracic and lumbar spine. For each projection the following parameters for standard size patients were recorded: Source–Skin Distance (SSD), kV_p, mAs, and ESE. The UNFORS dosimeter was calibrated by Iran Secondary Standard Dosimeter Laboratory (SSDL) (Nuclear Research Center of Karaj) and found to be capable of performing within recommended level of precision and accuracy. It was placed in center of the beam with fixed field size (10×10 cm) without the presence of the patient at SSD distance on the table; so, ESEs values are from measurements Free-in-air; i.e., without phantom and backscatter. In the radiology centers with several radiographers the selection of exposure factors (kV_p, mAs and SSD) by each operator for the same projection was different, so the operators of radiology centers were selected randomly and requested them to select their exposure factors. The mean patient frequency per month in each of projections was considered as a weighting factor in ESEs statistical calculations.

RESULTS

The 27 stationary x-ray unit including: Varian (500, 600, 1000), Ziemens (500, 1000, 1200), Parspad (500, 650, 800), Toshiba (500, 650) and Shimadzu (500, 1000) in the 18 public hospital of Yazd province were participated in this study. Two x-ray unite through their inaccuracy of timer were omitted from our survey. The exposure parameters for each of the projections include of kV_p, mAs and frequency of patients per month are shown in table1.

To compare the exposure parameters for the same radiographs with the standard reported by NRPB (NRPB-W14 2002) refer to table 2. The column headed ‘kV_p’ or ‘mAs’ contains the kVp or mAs mean values (in parenthesis, range of values) for each type of exposure projection.

Table 1. The distribution of individual entrance surface exposure (ESE) for five routine x-ray examinations (10 projections) from 18 hospitals in Yazd state. The values of first, second and third quartile, mean ,max. and min. of ESEs relative to reference levels.

Radiograph	Projection	Entrance Surface Exposure (mR)						Standard[+]
		1st quartile	Median	Mean	3rd quartile	Min.	Max.	
Lumbar spine	AP	218	285	343.9	462	89	1093	680
	LAT	522	881	880	1224	346	1861	1600
Thoracic spine	AP	159	214	242.6	288	100	924	400
	LAT	250	447	500	643	148	1462	1150
Cervical spine	AP	78	105	131	177	18	298	125*
	LAT	45	64	89.3	144	10	260	-
Skull	AP	174	232	275	365	60	534	340
	LAT	102	129	155	191	51	336	180
Chest with grid	PA	30.5	38	39.6	48	17	62	25
Chest without grid	PA	7	8	14.4	23	4	39	20**

[+]Standard values are rounded of 3rd quartile of ESEs distribution were reviewed by NRPB in 2000.

*Standard of care limit per radiograph Michigan department of community health radiation safety section MDCH.

**Standard levels are 3rd quartile of ESEs distributions measurement by CRCPD, 2003

Table 2. The exposure parameters for five routine x-ray examinations (10 projections). Mean values and range (in parentheses) and the frequency of radiographs per month are given.

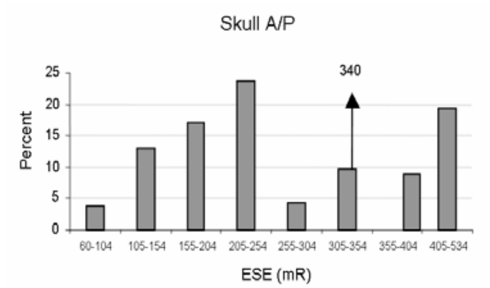
Radiograph	Projection	kV_p	mAs	Frequency/month
Lumbar spine	AP	72 (58-85)	44 (20-100)	1465
	LAT	85 (70-103)	68.5 (25-160)	1465
Thoracic spine	AP	69.4 (56-88)	44.5 (10-100)	500
	LAT	77 (62-95)	64.7 (16-157)	500
Cervical spine	AP	63.3 (52-76)	38 (10-100)	995
	LAT	64.7 (48-80)	32.2 (10-75)	995
Skull	AP	68.5 (57-85)	44.8 (14-126)	1535
	LAT	63.3 (53-85)	38 (10-100)	1535
Chest with grid	PA	76.4 (52-95)	23 (4-38)	2790
Chest no grid	PA	61.7 (46-71)	16.7 (10-30)	2880

The 'frequency' column contains mean of patients, number in all of the 18 hospitals for each of the type of radiographs. The key parameters of ESE distribution which are shown in table 3 include first quartile, median, mean, third quartile, minimum and maximum values for each type of projection. The last column of table 3 shows the third quartile of patient ESE distribution from medical x-ray examinations in the UK-2000 review (NRPB-W14) and (CRCPD 2003) as guide levels.

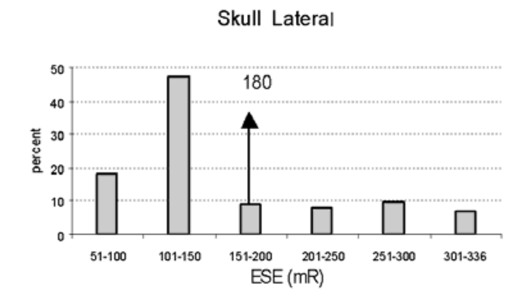
Table 3. Radiographs exposure parameters from medical x-ray examinations in UK –2000 review, NRPB-W14 publication 2002.

Radiograph	Projection	kV_p	mAs
Lumbar spine	AP	77 (55-110)	42 (5-400)
	LAT	88 (65-125)	72 (1-500)
Thoracic spine	AP	76 (53-105)	31 (4-219)
	LAT	73 (50-109)	66 (3-400)
Cervical spine	AP	-	-
	LAT	-	-
Skull	AP	72 (55-85)	30 (6-80)
	LAT	66 (54-90)	19 (4-50)
Chest with grid	PA	85 (50-150)	5 (0.5-69)
Chest no grid	PA	76 (60-95)	3 (1.2-9)

Figure1 shows histograms of ESEs distributions in selected projections and the solid line on the histograms indicates references guide levels. Wide distributions of ESEs are shown in all the histograms and some of them exceed guide levels.



A



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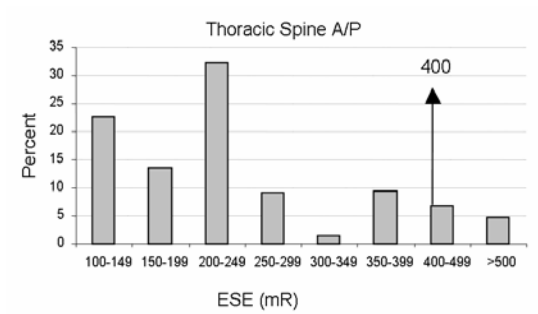

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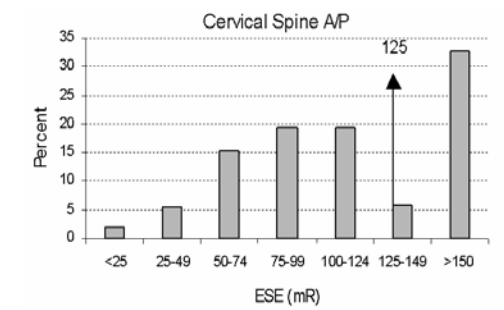

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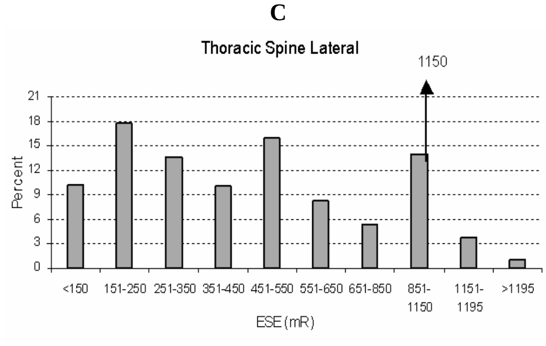

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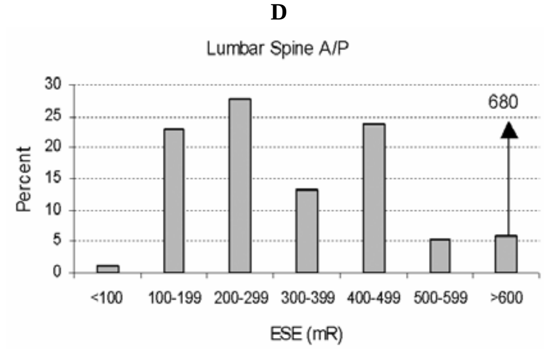

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Figure 1. Histograms of entrance skin exposure (ESE) per radiograph for selected common x-ray projections in Yazd. Solid lines indicate reference values. (A and B) skull, (C, E) Thoracic spine, (D) Cervical spine and (F) lumbar spine.

DISCUSSION

The use of radiation in medicine may be one of the most difficult areas for ensuring a balance between risk and benefit. Medical professionals are responsible for evaluating the risk and benefit to determine if an x-ray procedure is warranted. Some of contributing factors in the observed variation of patients' exposure can be attributed to the use of suboptimal imaging equipment, poor choice of technical factors and/or incorrect film processing procedures.

The results of this dose survey provide valuable primary data for awareness from situation of patient dose in Yazd province. It is the first step in reduction of patient dose program. The wide variations of patient dose for the same types of x-ray examination carried out even by different radiographers suggested that significant reductions in the dose from these spread is mainly due to the choice of exposure factors, technique, focus-to-film distance, filter, film-screen speed and the out put of the x-ray units and processor quality were used. This survey indicates that there is considerable scope for dose reduction in the skull, cervical and chest examinations. One way to reduce ESEs is increasing speed of the image receptor. This change to a faster film-screen combination is an important factor in reducing the ESE by 30 to 40% (Hart *et al.* 1996). The most x-ray centers in our survey had used fast speed film-screen and we had obliged the rest to use the same. Reduction in ESE with increasing speed of the image receptor has been demonstrated in the UK (Hart *et al*. 1996, Warren-Forward 1995). A wide range of exposure levels has been observed due to the large variety of radiographic techniques. For example the range of kV_p and mAs values respectively are 58 to 85 kV_p and 20 to 100 mAs in the AP lumbar spine. The other wide ranges of values are shown in the table 1. Comparing the ESEs values of the skin, thoracic and chest examinations with the guide levels of NRPB references reveals that more than 30% of these ESEs data are above the guide levels. The major reason for these over dose is discrepancy in their mAs and kV_p values as are shown in tables 2 and 3. It has been estimated that increasing the tube potential from 60 to 90 kV_p and decrease of mAs will result in an ESE saving of 60% (Warren-Forward 1995). Martin *et al.* 1993 found that increasing tube potentials by 8-13 in lumbar and thoracic spine examination resulted in a dose reduction of 26-30%.

The use of low mAs technique may cause low optical density of radiograph and decrease patient dose without adversely affecting image quality so this technique propose to operators.

X-ray exposure is minimized and image quality is improved when X-ray systems and operators perform properly. Therefore, the Radiation Control Rules require regular inspection of X-ray units. Operators of X-ray equipment designed for human use must be also controlled for their experimental technique. This survey may lead to an increased awareness amongst professionals for reduction of patient dose in diagnostic radiology in Yazd province.

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