Patient doses in radiographic examinations in Western and Eastern Azerbyjan provinces of Iran

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ABSTRACT

This study was a part of national project to establish and optimize local and national diagnostic guidance levels. This work intends to evaluate image quality and entrance surface air kerma (ESAK) for patients' radiographic examinations in two north western provinces of country. Two hospitals got involved in the present study. The rate of the rejected images and image quality grades were determined. The ESAK were calculated by X-ray tube output measurements and X-ray exposure parameters (kVp, mAS, FFD, as well as patients thicknesses) for common radiographic examinations including: chest, skull, thoracic, lumbar in two projections and also abdomen and pelvis in one projection. The rate of images categorized as poor was 40%. Patients' dose in radiographic examination varied by a factor of up to 6.9, 13.84, 9.76, 11.33, 6.15, 8.69, 2.85, 3.05, 12.41, and 5.51 in chest (PA), chest (LAT), lumbar (AP), lumbar (LAT), thoracic (AP), thoracic (LAT), skull (PA), skull (LAT), abdomen and pelvis, respectively. The mean ESAK values for above mentioned techniques were 0.3, 0.7, 2.85, 6.87, 2.3, 4.9, 1.32, 1.05, 2.9 and 2.2 mGy, respectively. Poor image quality plays a major role in unnecessary radiation dose to the patients but in compare with other studies stated that patient dose levels in radiographic examinations in our study aren't higher than those in developed countries.

Key words: Patient dose; ESAK; Radiographic examination; Western Azerbyjan; Eastern Azerbyjan

INTRODUCTION

Although, there are variety of modern imaging techniques such as ultrasound and MRI, but conventional radiography has played an important role in diagnostic imaging methods. Generally population exposure by medical radiation is increasing; however, lots of advances are derived from it [1]. The fact which should be noticed is that the radiation dose level to patients in radiographic examination is assumed to be small. But from the radiation protection point of view there are two topics that remain alarming. The first one is poor image quality generated in radiographic examination .These will lead to additional radiation exposure to patients through repeated radiographic examination and more costs to the economics. The second alarming topic is dose levels to patients of the same size undergoing the similar type of radiographic examination vary significantly [2-4]. In 1982, International Commission on Radiological Protection (ICRP) reported that the dose to patients from a special type of procedure may differ among hospitals by a factor of 2 to 10 [2]. Due to these problems, the standards need the establishment of diagnostic reference levels (DRLs) or guidance levels for medical exposure by proper professional bodies in consultation with national health and regulatory authorities [5, 6]. The ICRP and the European Commission (EC) have recommended the use of DRLs [5, 7].

It is proved that comparison of dose level with DRLs has led to a drop in patient dose [8-10]. Therefore the use of this optimization tools should be widely expanded. Establishment of a quality assurance program concentrating on image quality and patient dose could be a rational approach ahead.

This article represents the outcomes on image quality evaluation, typical dose levels to patients having the most common radiographic examinations to assess the patient dose in terms of ESAK and compare the results with other studies toward establishing Local and National Diagnostic Reference Levels (LDRLs, NDRLs) for mentioned examinations.

MATERIALS AND METODS

Present study was done in two hospitals in Urmia, Western Azerbyjan (Hospital A) with 4 radiographic rooms and Tabriz, Eastern Azerbyjan (Hospital B) with 2 radiographic rooms. In both hospitals film-screen speed was 400. This study was conducted in July 2011 for one month.

Image quality evaluation

Image quality evaluation in 2-weeks interval was performed. The EC quality criteria for diagnostic radiographic images [6] were supplied to the participating centers for use by experienced radiologists in image quality assessment. Radiographic images were divided into 3 groups; A, B and C [11]. Images of grade A were those completely acceptable by reporting radiologist. Images of grade B were those that were acceptable with some remarks or reservation and images of grade C were those which must be rejected. Additionally the involved centers were requested to note the major cause of grade B and C images such as over exposure or under exposure artifacts, field size misplacement, processing problems and so on [11, 12].

Patient dose evaluation in radiology

Main dosimetric quantity for the estimation of patient exposure in conventional radiographic procedures in diagnostic radiology is Kerma on patient skin surface (ESAK). In this study the methodology used was as per International Atomic Energy Agency (IAEA) protocol and guidelines on indirect patient dose measurements [22]. ESAK have been calculated for the most common radiographic examinations, including: chest (PA, LAT), lumbar spine (AP, LAT), thoracic (AP, LAT), skull (PA, LAT), abdomen (AP) and pelvis (AP) [13, 14]. All x-ray devices passed quality control (QC) tests using approved procedures, staff and calibrated semiconductor Multi-Purposeed Detector (MPD) as a part of QC kit (Barracuda, RTI AB electronics, Sweden). For patient dose assessment, three steps were followed:

1) Survey of X-ray exposure parameters of adult patients
2) Measurement of the X-ray tube output
3) ESAK Calculation

Evaluation of X-ray exposure parameters of adult patients

For each participating patient in the most ten radiographic examination (at least 10 normal weight and height patients) [15], the following information was recorded: X-ray exposure parameters (kVp, mAS) and geometric parameters (Focus to Film Distance (FFD), Focus to Skin Distance (FSD) and field sizes), and also patients related parameters (sex, height and weight). A weight restriction criterion of 70±10 Kg was applied as recommended [15].

Measurements of the X-ray tube output

The MPD was put on a radiographic table in the central beam axis. The distance of focal spot to detector (FDD) was 100 cm and field size was 10 × 10 cm^2 to cover the dosimeter, to reduce the effect of scatter radiations to the detector, however backscatter radiations from table was absorbing by MPD high z material back plate. The kVp calibration curves have been derived for each X-ray devices using kVp ranges from 50-110 in 10 kVp steps and fixed mAS [14]. These curves were used to calculate the X-ray tube output per mAS for different kVp setting.

Incident air kerma and ESAK calculation

For each radiographic examination, incident air kerma was calculated using the kVp related output from kVp calibration curves, applied mAS and correction factor for distances $[(FDD/FSD)^2]$ in each projection. Then the ESAK value was calculated by multiplying incident air kerma to the field sizes appropriate backscatter factor (BSF) [13] (Table 3).

Entrance surface air kerma (ESAK) = Incident air kerma × BSF

RESULTS

Image quality evaluation

The results of image quality evaluations in two hospitals are summarized in Table 1. The rate of images categorized as poor (B+C) was 40% for both hospitals.

Table1. Image quality result in hospitals.

Hospital names	**Image quality (%)**		
	A	B	C
A	60	36	4
B	60	22	18

Patient dose evaluation in radiology

X-ray tube output per mAS for each participating room has been shown in Table 2. For each radiographic examination, ESAK was calculated (Table 3). The mean ESAK values were 0.3, 0.7, 2.85, 6.87, 2.3, 4.9, 1.32, 1.05, 2.9 and 2.2 mGy for chest (PA), chest (LAT), lumbar (AP), lumbar (LAT), thoracic (AP), thoracic (LAT), skull (PA), skull (LAT) abdomen and pelvis, respectively.

Table2. X-ray tube output per mAS in participating hospitals

Exposure parameters			Hospital A					Hospital B		
			Y(μGy/mAS)							
kVp	**mAS**	**FDD**	**Room1**	**Room2**	**Room3**	**Room4**	**Mean**	**Room1**	**Room2**	**Mean**
40	10	100	6.40	13.30	11.50	12.70	10.97	8.07	2.68	5.69
50	10	100	15.20	25.80	22.50	24.50	22	15.62	7.16	11.39
60	10	100	24.50	40.40	35.20	37.80	34.47	23.77	13.12	18.44
70	10	100	36.50	56.00	48.20	54.40	48.77	33.49	20.24	26.86
81	10	100	49.10	76.90	61.80	72.60	65.1	43.44	28.48	35.96
90	10	100	62.30	93.70	77.70	92.00	81.42	55.86	36.72	46.29
102	10	100	80.60	119.90	95.70	114.60	102.7	67.47	50.36	36.41
109	10	100	91.10	137.70	115.50	131.20	118.87	80.75	58.48	69.61

Table3. Mean entrance surface air kerma of common radiographic examination in participating hospitals.

Radiographic projection	ESAK (mGy)										
	Room no.s of hospital A					Room no.s of hospital B			Min	Max	Max/Min
	1	2	3	4	Mean	1	2	Mean			
Chest(PA)	0.32	0.51	0.42	0.49	0.43	0.16	0.2	0.18	0.097	0.67	6.9
Chest(LAT)	0.81	1.2	1.03	1.2	1.07	0.4	0.4	0.4	0.13	1.8	13.84
Lumbar(AP)	2.9	4.5	3.7	4.3	3.8	1.6	2.2	1.9	0.85	8.3	9.76
Lumbar(LAT)	6.6	10.1	8.2	8.2	8.3	4.7	6.2	5.45	1.8	20.4	11.33
Thoracic(AP)	2.3	3.6	2.9	3.4	3.05	1.3	1.9	1.6	0.99	6.09	6.15
Thoracic(LAT)	4.3	6.7	5.5	6.4	5.7	3.5	4.7	4.1	1.65	14.35	8.69
Skull(PA)	0.87	1.4	1.1	1.3	1.2	1.2	1.7	1.45	0.72	2.054	2.85
Skull(LAT)	0.7	1.1	0.9	1.05	0.9	1.04	1.3	1.2	0.51	1.56	3.05
Abdomen(AP)	2.5	4	3.3	3.8	3.4	2.5	2.4	2.45	0.58	7.2	12.41
Pelvis(AP)	1.9	3.1	2.6	2.9	2.7	1.9	1.5	1.7	0.87	4.8	5.51

Table4. Comparison of mean ESAK among national and international recommendation

Dose quantities	Examination	Urmia W-A	Tabriz E-A	Tehran [16]	Iran 2008 [21]	UK 2005 [19]	EC [17]	Sistan and Baluchestan	Montenegro [23]	Canada [20]		IAEA BSS 1996 [18]
										CR	DR	
ESAK (mGy)	Chest(PA)	0.43	0.18	0.37	0.41	0.15	0.3	0.37	0.9	0.92	0.08	0.4
	Chest(lat)	1.07	0.4	-	2.07	0.6	1.5	-	2	3.43	0.33	1.5
	Lumbar(AP)	3.8	1.9	3.41	3.43	5.00	10	3.13	4.5	9.1	3.89	10
	Lumbar(lat)	8.3	5.45	9.03	8.41	11	30	-	7.8	25.66	8.47	30
	Thoracic(AP)	3.05	1.6	1.66	2.72	4	-	-	3.1	-	-	7
	Thoracic(lat)	5.7	4.1	4.55	5.29	7	-	-	4.3	-	-	20
	Skull(PA)	1.2	1.45	2.79	2.83	2	5	2.1	2.8	-	-	5
	Skull(lat)	0.9	1.2	1.57	1.93	1.3	3	1.43	2.1	-	-	3
	Abdomen(AP)	3.4	2.45	3.87	4.06	4	-	3.34	4	5.15	4.14	10
	Pelvis(AP)	2.7	1.7	2.84	3.18	4	10	2.71	4.7	3.2	2.5	10

CR= computed radiography; DR= digital radiography

DISCUSSION

In this study for the measurment of X-ray tube output, solid state detector was used. The measurement using semiconductor dosimeter is real time but thermoluminescence dosimeters (TLDs) are passive detectors and it is a time consuming procedure, and in these detectors the annealing regime can affect the dose measurement. There are many factors that influence the final result of a TLD measurement. However, TLD materials are very sensitive to radiation, small in diameter, approximately tissue equivalent, but semiconductor dosimeters are not tissue equivalent material [22, 23].

In present study large dose variations for the same radiographic examinations have been observed. Patients' dose in radiographic examination varied by a factor of up to 6.9, 13.84, 9.76, 11.33, 6.15, 8.69, 2.85, 3.05, 12.41 and 5.51 in chest (PA), chest (LAT), lumbar (AP), lumbar (LAT), thoracic (AP), thoracic (LAT), skull (PA), skull (LAT) abdomen and

pelvis, respectively. Large dose variations are a common feature in most wide-scale surveys [2-4, 6]. ESAK variations could be attributed to different levels of training in radiology, the choice of radiographic technique, the film–screen combination type in use, human physique and importantly the status of implementation of radiation protection standards.
Results from this survey have shown that ESAK values in all radiographic examinations in hospital A were higher than in hospital B (except for lateral skull). ESAK values in the most radiographic examinations in participating hospitals were lower than in Tehran [16], and also were well below recommended DRLs by the IAEA and European commission (EC) [17, 18].
Moreover, ESAK values in Western and Eastern Azerbyjan (W-A, E-A) provinces were lower than in UK and CR (computed radiography) systems in Canada (Table 4) [19, 20]. ESAK values in the all radiographic examinations in Montenegro were higher than in Western and Eastern Azerbyjan (except for lateral thoracic in Western Azarbyjan) [23], and also this value in all radiographic examinations in Eastern Azerbyjan were lower than in Sistan and Baluchestan, but in Western Azerbyjan ESAK values in the most radiographic examinations were higher than in Sistan and Baluchestan [24].
The results of image quality assessment have shown a high frequency of poor-quality radiographs (both grade B and C images) in participating hospitals. Although QC tests have been passed for x-ray devices but observed high percentage of poor image quality is likely due to an absent or ineffective QA program at hospitals which participated in this survey. So these hospitals do need QA program including staff on the job training to decrease the dose received by patients as much as possible. Data measurements show that X-ray tube output are slightly different in two hospitals (it is lower in hospital B).
From the other side C grade films which should be rejected, have a higher number in hospital B. So it is obvious that low tube output doesn't necessarily guarantee the patient dose reduction.
That is highly needed to apply a QA program in this hospital in order to help the operators to select the reasonable exposure parameters and avoid repeating films.
QA in diagnostic radiology are proven to be powerful tool for decreasing doses and increasing diagnostic efficiency. Another noticeable point which must be mentioned is that X-ray tube outputs are a bit different in X-ray rooms of hospital A with the same systems (it is noticeably high in room2) (Table 2), although the operators use the common exposure parameters for the same projection. It might be due to tube aging. Efforts should be apply to decrease patients' dose without degrading image quality.

CONCLUSION

Poor image quality plays a major role in unnecessary radiation to patients of developing countries but comparison with other studies proves that patient dose levels and ESAK in these two hospitals aren't higher than those in developed countries, and also QA program in diagnostic radiology are proven to be powerful tool for decreasing doses and increasing diagnostic efficiency.

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