International Journal of Advanced Biotechnology and Research (IJBR)
ISSN 0976-2612, Online ISSN 2278–599X,
Vol-8, Issue-3, 2017, pp2358-2363
http://www.bipublication.com

Research Article

Estimation of Diagnostic Reference Level (DRL) Dose inNine Current Radiography projections in Boyer-Ahmad District

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ABSTRACT

Background and purpose: Nowadays, ionizing radiations play an important role in diagnosis and treatment. In order to optimize the patient dose, the National Radiological Protection Board (NRPB) in England has introduced the Diagnostic Reference Level (DRL) dose as a standard parameter. Entrance skin dose (ESD) is the main parameter in determination of DRL dose in current radiography.

Material and Methods: This study was performed in both governmental and private imaging centers. The primary information such aspersonnel selected average peak voltage (kV) and mili ampere-second (mAs)were collected by a questionnaire from each center. Then the entrance skin dose was measured by usingof Barracuda dosimeter (RTI model). The entrance skin dose data were analyzed statistically and ascending sorted. Next, the third quarter estimated as the DRL in Boyer-Ahmad district and compared with other countries DRLs.

Results: The third quarter of entrance skin dose (DRL) was 2.67, 2.2, 0.43, 1.79, 6.57, 9.01, 4.97, 7.4 and 5.3 mGy for skull AP, skull LAT, chest AP, chest LAT, lumbar spine AP, lumbar spine LAT, thoracic spine AP, thoracic spine LAT, and pelvis AP, respectively.

Conclusion: It was found that our results were higher than those of England, except for the lumbar spine dose. To reduce the patient dose in medical diagnostic imaging, optimized procedures should be adopted. One of the most optimization methods is to estimate the DRL dose.

Keyword: Entrance Skin Dose, Diagnostic Reference Level, Radiology, X-ray dose out put

INTRODUCTION

More than one hundred years has been passed the discovery of X-ray radiation. Although imaging by non-ionizing radiation (such as MRI and ultrasound) has significantly advanced but the diagnostic imaging by ionizing radiation is still increasing and important. X-ray radiation is the main artificial source of general radiation exposure[1, 2].For example, in 2002, 18867000 radiological examinations were taken from 12963000 individuals in Mashhad city that in the other hand 1.5 radiography per person. Furthermore, diagnostic energy ranges in X-ray radiation is harmful for human health. Theseemphasison the importance of radiation protection[3, 4].

The aim of radiation protection is elimination or reduction of the unnecessary dose of patient. Therefore, the dose measurement and comparison

with the standard reference dose seems essential to achieve this goal[5, 6]. The National Radiological Protection Board(NRPB) has introduced standards as Diagnostic Reference Level (DRL)to optimize different diagnostic imaging methods and reduce the patient dose. DRLsfacilitate the standardization and optimization of imaging centersand also encourage various centers to decrease the organ doses in imaging.

One way to consider the patient exposure in diagnostic imaging centers is to measure the dose in each imaging center based on area and compare it with the standard reference. Because of the national diagnostic reference does not exist, then the standard from NRPB was employed. The first NRPB publication was issued in 1992, where the dose level was reported for some imaging techniques in England. Afterward, an inquiry showed 40% dose reduction in this country and subsequent publication. Ten years later, reports indicated 20% dose reduction thanthe 1992. According to these reports, introducing the DRL parameter in other countries could lead to dose reduction.

Likewise, DRL results obtained from different radiological centers in the world have been demonstrated the quality control deman[7-9]. DRLs are utilized by many professional organizations including ICRP, NRPB, EC, IAEA, AAPM, and ACR, as a mean for optimizing patient dose. One of important parameters for the DRLs measurement is the entrance skin dose (ESD)[6, 10]. The NRPB has proposed various methods to measure the ESD. Solid state dosimeter is one of these tools which were employed in this work. In different countries in the world, the DRL is measured based on the economics and health conditionsevery two years. For example, 72% of 36 European countries use DRL in the diagnostic radiology[11, 12]. However, in Iran, there are not extensive surveys except in a few provinces for short period of time [13, 14]. The currentstudyaimed to estimate the DRL in 9 radiological projections in Boyer-Ahmad district and compare with the results of NBPR in United Kingdom as well as of Australia and Japan.

MATERIAL AND METHODS

Area of study:

Boyer-Ahmad District is part of Kohgiluyeh and Boyer-AhmadProvince in southwestern Iran that Consist of four cities with population of three hundred thousand people.

In this study, 17 radiology systems of different types such as computed radiology (CR), direct digital radiography (DDR), and analog radiology were considered. The devices had produced by Mehran Teb (Iran), Aplem (Italy), General Electric's (USA), Toshiba (Japan) and Varian (USA). Above systems were found in all (governmental and private) medical imaging centers in the Boyer-Ahmad district. In order to calculate the entrance skin dose from 9current radiological projections, the dose should be measured exactly at the point of X-ray contact on the skin. Therefore, a standard patient questionnaire including exposure data (kVp, mAs, FSD) was distributed in each center. These questionnaires were completed by all employee based on their conditions of applied in any radiography examination. Completed questionnaires were collected from centers in all work shifts and calculated average exposure conditions. The calculated average exposure applied on the devices by researcher and entrance skin dose measured by dosimeter.A Barracuda solid-state dosimeter (RTI model) was employed to calculate the entrance skin dose. This dosimeter was calibrated in the SSDL laboratory of the atomic energy agency of Iran before measurements. Because only entrance of beams were considered, backscattered X-rays were shielded by creating a gap between the detector and table using a radiolucent material, and then removing the effect of these photons. Also, to reduce the impact of scattered radiation, the filed size was limited as much as the receiver[1, 15].

The place of putting of detector between tube and table was exactly that thepersonnel use for patient's organs in any radiography examination. Due to the effect of tube to skin surface distance on the entrance dose, the thickness of the imaged organ was subtracted from the distance to table surface (selected by the personnel) to find the actual tube to skin surface (FSD). For each measurement, kVp and mAs information, the entrance dose, tube filter, the number of phases in the generator were recorded. Each measurement was repeated three times and the average value was recorded as the entrance skin dose for each examination. The results were partitioned to four parts (quarters) ascending sorted and the third quarter was introduced as the DRL of each center.Finally, their average was calculated and was introduced as Boyer-Ahmad district DRL.

RESULTS

The third quarter of entrance skin dose (DRL) in Boyer-Ahmad district estimated 2.67 for skull AP , 2.2, 0.43, 1.79, 6.57, 9.01, 4.97 and 7.4 mGy for, skull LAT, chest AP, chest LAT, lumbar spine AP, lumbar spine LAT, thoracic spine AP, thoracic spine LAT, and pelvis AP. Table 1 showthe summarized results of entrance skin dose from 9 radiography projections in 17 medical imaging centers in the Boyer-Ahmad district. In table 2,Statistical calculations of entrance dose (e.g. minimum, maximum, mean, 1th, 2th and 3th quarter) has shown. Lower Maximum/Minimum ratio was obtained in lumbar spine AP (2.4 mGy) and the higher was in lumbar spine LAT (3.5 mGy).

Table 3 show the comparison between mean kVp, mAs and focus to film distance (FSD) in this study and the UK(2010) as a standard. Comparison between mean entrance skin dose in this studyandthe England, International Atomic Energy Agency, and three important Asian countries (South Korea, Malaysia, and India) is presented in Table 4.

Table 5 show comparison between Boyer-Ahmad DRLs and other references.

DISCUSSION

As observed in table 5, the DRL of Boyerahmad city is higher than that of NRPB in all tests, except for LAT lumbar spine. This value is not significant compared with Australia reports and in some cases, lower values (e.g. for thoracic spine, lumbar spine, and skull) are found. Comparing with DRL of Japan as a developed and healthy country in Asia, the value is higher in all cases except for skull and LAT skull. many factors that can explain this discrepancy among DRL of countries.

in chest PA radiography diagnostic reference level(DRL) estimated0.43 mGy and it was almost three times higher than the UK (0.15 mGy) as standard (table5).This is related to entrance conditions devices such as kVp and mAs, which in this study kVp was less than UK (63.3 vs 88) and mAs was four times higher than UK (21.5 vs 5)(table3). there are decrease of kVp by personnel in order to maintain the density, makes increasing of mAs and this sharp rise in mAscauses the difference between DRL in this study and the UK.So, it is suggested in order to reduce the dose, personnel can use above kVp to high decrease used mAs. This is based on 15% rule in radiology thatto maintain the density, with increasing of 15% kVp must mAs in half and the result will be decreasing the dose[16, 17].Furthermore, according to table 3, it show that increasing dose level in this study may be due to low focal-skin distance(FSD).[18, 19] On opposite side, For LAT lumbar spine, the mean dose was found to be 8.3 mGy, which indicates significant differences relative to reports from England (10 mGy), atomic energy agency (8.53 mGy), South Korea (16 mGy), Malaysia (18.6 mGy), and India (14.19 mGy). Considering the mean exposure conditions in present study and England reports, it can be found out that the mean kVp and mAs used for LAT lumbar spineare, respectively, 75.5 kV and 40 mAs for this work and 89 kV and 56 mAs for England reports, which is the main reason for the decreased dose in these study.

In addition to technical uses mentioned in this study, geometric parameters can be added to above, such as selection of FFD, field size, combination of intensifiers with film (in analogue systems), film speed, patient weight and physical condition, radiography technique, level of personnel training, and the type of film processing (in analogue systems). Likewise, it can be seen that the DRL value is associated with clinical equipment in radiology departments. The selection of a technique may not be applicable for other techniques and equipment. However, the patient dose in undeveloped countries is not necessarily higher than that in developed countries[8, 17, 20].

CONCLUSION

A pilot study to develop a protocol of patient dose evaluation was performed in this study. the main goal was to calculate the DRL of Boyerahmad city and compare it with other valid references like DRL of England. Determining the reference dose for X-ray diagnostic examinations is performed to provide the possibility for comparison among techniques as well as different centers, which can lead to optimization of radiological examinations. DRL can be considered as a guideline in studies with a dose reduction plan.

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Table 1. Entrance skin dosein 9 radiography projections in 17 medical imaging centers of Boyer-Ahmad district

Examination / Center	Chest PA	Chest LAT	Skull AP	Skull LAT	Lumbar Spine AP	Lumbar Spine LAT	Thoracic Spine AP	Thoracic Spine LAT	Pelvis AP
A	0.39	1	1.1	1	5	5.65	4.16	5.3	**3**
B	0.5	0.9	2.6	2.2	6.98	7.9	5.6	7.1	**5.3**
C	0.43	-	-	-	-	-	-	-	**5.3**
D	0.3	2	2.2	2	6.74	7.78	4.95	7.71	**4.9**
E	0.4	-	-	-	-	-	-	-	**4**
F	0.75	0.8	2.75	2.75	3.74	5.64	3.74	5.64	**3.01**
G	0.24	1.68	2.2	2	3.8	4.07	2.87	3.78	**2.03**
H	0.37	2.1	1.57	1.57	3.41	9.03	2.39	4.55	**2.84**
I	0.29	1.9	3	2	4.02	8.13	3.37	5.5	**3.01**
J	0.45	1.3	2.95	2.57	3.44	7.03	3.02	6.23	**5.03**
K	0.3	1.1	2.5	2.2	7	14	4.5	9.9	**5.3**
L	0.6	1.1	2	1.5	6.4	12	5.3	8.7	**5.3**
M	0.3	2.3	2.1	2.1	6.41	11.1	6.3	8.15	**5.8**
N	0.25	0.8	3.3	3.3	8.01	9	4.25	7	**4.31**
O	0.4	1.12	2.2	2.2	3.33	6.69	3.16	5.15	**4.3**
P	0.3	0.9	1.3	1	3.6	7.7	3.6	6.2	**5**
Q	0.3	0.7	1.7	1.21	3.6	8.7	5	6.5	**6.6**

Table 2. Statistical calculations of entrance dose (mGy) obtained from 9 radiography projections in radiology centers of Boyer-Ahmad district

Examination	Mean	Quartile One	Quartile Tow	Quartile Three	Min	Max	Max/Min Ratio
Chest PA	0.38	0.3	0.37	0.430	0.240	0.750	3.1
Chest LAT	1.31	0.9	1.1	1.79	0.70	2.3	3.2
Skull AP	2.23	1.85	2.2	2.67	1.1	3.3	3
Skull LAT	1.97	1.53	2	2.2	1	3.3	3.3
Lumbar Spine AP	5.03	3.6	4.02	6.57	3.33	8.01	2.4
Lumbar Spine LAT	8.3	6.86	7.9	9.01	4.07	14	3.5
Thoracic Spine AP	4.14	3.26	4.16	4.97	2.39	6.3	2.6
Thoracic Spine LAT	6.49	5.4	6.23	7.4	3.78	9.9	2.67
Pelvis AP	4.41	3.01	4.9	5.3	2.03	6.6	3.3

Table 3. Comparison between mean kVp, mAs and FSD in this study and the UK(2010) as a standard

Examination	Mean kVp	UK(2010)	Mean mAs	UK(2010)	Mean FSD	UK2010
Chest PA	63.33	88	21.5	5	142	145
Chest LAT	75.33	89	30.5	13	132	150
Skull AP	62.16	72	22.3	20	86	95
Skull LAT	63	66	22.3	11	86	94
Lumbar Spine AP	68.83	78	26	46	77	90
Lumbar Spine LAT	75.2	89	40	56	79	79
Thoracic Spine AP	70.5	78	23	33	75	85
Thoracic Spine LAT	67.5	74	24.5	30	86	80
Pelvis AP	72.6	-	-	-	81	80

Table 4. Comparison between mean entrance skin dose in this study and the England, International Atomic Energy Agency and three important Asian countries (South Korea, Malaysia and India)

Examination	Our study	UK(2010)	IAEA(21)	Korea(2007)	Malaysia(1998)	India(2010)
Chest PA	3.0/	0.150	0.330	0.210	0.280	0.530
Chest LAT	1.31	0.50	-	1.56	1.4	1.58
Skull AP	2.23	1.8	2.41	-	4.78	5.4
Skull LAT	1.97	1.1	-	1.5	3.34	4.11
Lumbar Spine AP	5.03	5.7	4.07	2.8	10.56	7.3
Lumbar Spine LAT	8.3	10	8.53	16.4	18.6	14.19
Thoracic Spine AP	4.14	0.80	7	2.1	7.03	6.37
Thoracic Spine LAT	6.49	1.3	12	6.17	16.54	7.31
Pelvis AP	4.41	4	3.68	2.4	8.41	6.34

Table 5. Comparison between Boyer-Ahmad DRLs and other references

Examination	Our study	UK(2010)	UK(2000)	Japan(2015)	Australia(2007)
Chest PA	0.430	0.150	0.180	0.30	0.20
Chest LAT	1.79	0.540	0.990	-	1
Skull AP	2.67	1.8	2.8	3	3
Skull LAT	2.2	1.1	1.6	2	1/5
Lumbar Spine AP	6.57	5.7	5.8	4	6
Lumbar Spine LAT	9.01	10	13.8	11	14
Thoracic Spine AP	4.97	3.3	3.4	3	3.5
Thoracic Spine LAT	7.4	7.2	10.4	6	10
Pelvis AP	5.3	3.9	4.2	3	4