A study to analyze local dose reference level values in Kohgiluyeh and Boyer-Ahmad as a deprived area

H. Vafapour[1], K. Dashtian[2], Z. Salehi[1*]

[1]Department of Radiation Sciences, Yasuj University of Medical Sciences, Yasuj, Iran
[2]Chemistry Department, Yasouj University, Yasouj 75918-74831, Iran

▸ ***Short report***

***Corresponding author:**
Zaker Salehi, Ph.D.,
***E-mail:** phyzaker@gmail.com*

Revised: December 2020
Accepted: January 2021

Int. J. Radiat. Res., October 2021; 19(4): 1041-1044

DOI: 10.29242/ijrr.19.4.1041

ABSTRACT

Background: Local Dose Reference Level (LDRL) values as the standard radiation dose of all radiography examinations are used in medical imaging to reveal the patient dose level or administered activity for a specified imaging procedure. ***Materials and Methods:*** The incident air kerma (Ki) was measured for five radiographic examinations (Skull AP/Lat, Chest AP/Lat, Lumbar AP/Lat, Thoracic AP/Lat and Pelvic AP) throughout the province of Kohgiluyeh and Boyer-ahmad (as a deprived area). The founding DRLs results were sort; the third quartile was selected as the average DRL and compared with the other DRLs provinces of Iran as well as the standard data of developed countries. ***Results:*** The radiographic LDRL were found to be 0.72, 1.62, 3.06, 2.96, 7.21, 9.99, 7.1, 8.42 and 5.56 mGy for Chest PA, Chest Lat, Skull AP, Skull Lat, Lumbar AP, Lumbar Lat, Thoracic AP, Thoracic Lat and Pelvic AP, respectively. ***Conclusion:*** The founding revealed that if the applied radiation protocols are as same as developed countries the DRL values in some projections such as the lumbar vertebrae could be close to international references.

Keywords: *LDRL, radiography, deprived area*

INTRODUCTION

Three major categories of radiation optimization, justification, and dose limit as radiation protection basic principles which amongst "dose limit" lead us to radiation optimizing in radiological examinations [1]. The concept of DRL has been theorized in report number 60 of the International Committee on Radiation Protection (ICRP) and subsequently recommended to use it in ICRP report 73 [2]. Since 2001, DRL was utilized as a practical standard indicator to optimize applied radiation dose for all radiological assessments and procedures [3, 4]. According to ICRP report 73, if the patient dose is more than DRL the DRL's optimization process needs to achieve the standard dose level [5]. Applied dose values in radiological assessments should always be less than local DRL values [6]. Therefore, the DRL accuracy data is remarkably important to control patient dose which modern technologies have been developed to achieve dose reduction without compromising image quality [7]. However, the locally measuring of DRL values is vital due to its vary from area to area. Besides, in deprived areas and countries, high disparity between local DRLs and global DRLs is due to lack of modern radiation devices. This study was focused on the investigation of applied DRL values in radiological centers in Kohgiluyeh and Boyer Ahmad, as an instance deprived area of Iran in comparison with standard universal data.

MATERIALS AND METHODS

This study was carried out in Kohgiluye and BoyerAhmad region located in the southwest of Iran with a population of six hundred and fifty thousand people which is a relatively weak economy, so-called a deprived region of the country. Considering the impact of the economy on health, this region has been selected for the study of a deprived area. Firstly, the information of all analog and digital devices radiology devices, total amounts of all applied filters, applied kVp and mAs of each procedure in public and private health centers and the examination date of quality control throughout the understudied area was collected. Understudy radiology centers were included 12 public health centers and 13 private clinics.

A questionnaire was given to all personnel involved in radiology imaging centers to record the technical information, including the average of mAs, kVp and Focus Film Distance (FFD), to perform five standard radiology examinations (Skull AP/Lat, Chest AP/Lat, Lumbar AP/Lat, Thoracic AP/Lat and Pelvic AP). The founding examination average values for FFD, mAs and kV were applied to calculating the Ki according to the ICRP reference man model [8, 9]. In all understudy radiation devices, the applied filter was set to be 2.5 mmAl and the speed of the used film was 400. A Barracuda solid-state dosimeter (RTI model) applied to measure the incident air kerma (Ki) and the DRL values. The dosimeter was calibrated on 27th August 2016 in the SSDL laboratory of the energy agency of Iran. The measured dose rate was set at 0.2 μGy/s-320 mGy/s with uncertainty less than 1.5%,

Statistical analysis

The mean obtained technical conditions from collected questionnaires were applied for each radiological examination and used for Ki (Kerma) calculation [10].The measurements (repeated three times) were performed based on kVp, mAs and FFT settings (see table 1). The obtained Ki values were sorted in ascending orders and then all the results were divided into four quartiles using SPSS version 9. The third quarter was considered as the local DRL value due to IAEA recommendation and then compared with the DRL values of Tehran, the capital city of Iran [11]. This comparison was carried out to find out if DRL values in developed cities have deviated from a deprived city. The obtained DRLs were also compared with recorded data of the India, UK, and Japan as the international references [12-14].

Table 1. The applied technical conditions in current work and other studies

Study	Projection	current study			Tehran (Iran) (11)			India(2017)(12)			UK (2010)(13)			Japan(2015)(14)		
		FFD (cm)	mAs	kVp	FFD (cm)	mAs	kVp	FFD (cm)	mAs	kVp	FFD (cm)	mAs	kVp	FFD (cm)	mAs	kVp
Chest	PA	149±5.3	25.4	62.4	176	21	62	-	18	65	145	5	88	-	3.2	123.3
	LAT	145±7.5	29.92	72.52	-	-	-	-	-	-	150	13	89	-	-	-
Skull	AP	75±4.4	23.56	62.84	101	51	62	-	48.42	67.78	95	20	72	-	18.1	73.2
	LAT	75±4.4	22.28	60.04	100	44	58	-	-	-	94	11	66	-	15.7	72.3
Lumbar	AP	77±4.5	26.12	75.76	102	58	70	-	70.83	71.8	90	46	78	-	34	74.5
	LAT	78±2.3	42.48	78.28	103	71	80	-	82.2	76.89	79	56	89	-	58.9	82.1
Thoracic	AP	75±4.1	26.08	70.2	102	28	63	-	61.5	69.2	85	33	78	-	24.3	73.3
	LA	78±2.1	38	72.72	104	54	70	-	69.8	75.1	80	30	74	-	35.6	75.2
Pelvic	AP	72±3.5	53.88	68.08	103	65	67	-	49.8	68.59	80	35	74	-	25.5	72.2

RESULTS

Since, kVp, mAs and FFD have a significant effect on delivered dose [15-17]; the applied technical conditions of Yasuj (understudy area), Tehran (Capital city of Iran), UK, Japan and India were listed in table 1. As seen in some of the graphies such as vertebra no significant disparity was seen between our FFD values and UK study (P=0.08) while the FFD values of Tehran has high deviation than Yasuj study (p <0.001). The lowest current study mAs and kVp applied for the skull procedure (lat), thus, the lowest DRL (see table 2) was obtained for chest procedure that indicates the effect of FFD on dose reduction. The disparity between our founding results, UK, Tehran, Japan and India is illustrated in table 2.

[DOI: 10.52547/ijrr.19.4.34]

Table 2. DRL values in current work and other studies.

Study	Pelvic (mGy)	Thoracic (mGy)		Lumbar (mGy)		Skull (mGy)		Chest (mGy)	
Projection	AP	Lat	AP	Lat	AP	Lat	AP	Lat	PA
This Study	5.56	8.42	7.1	9.92	7.21	2.96	3.06	1.62	0.72
Tehran(Iran) [11]	3.89	4.55	2.37	11.78	5.01	1.87	3.06	-	0.41
India (2017) [12]	5.39	11.28	7.27	15	8.55	-	4.7	-	0.43
UK 2010 [13]	3.9	7.2	3.3	10	5.7	1.1	1.8	0.54	0.15
Japan 2015 [14]	1.9	3.6	2.2	8.9	2.9	1.4	1.6	-	0.2

DISCUSSION

Generally, high-speed films and the same detectors were utilized for all analog machines and digital devices, thus, the disparity in results cannot be due to inaccuracy of the used instruments. While due to different thicknesses of tissue-equivalent phantoms the maximum and minimum DRLs (see table 2) were obtained in Lumbar (Lat) and Chest (PA) respectively.

Table 2 represents a significant divergence between Yasuj and Tehran [11] values due to technical conditions listed in Table 1. Our founding kVp for all examinations are similar to Tehran values while the FFD values of Tehran are higher than Yasuj which resulted in a decreasing absorbed dose in the Tehran study.

Table 2 shows the same DRLs results of the chest for Tehran and India [12], less than our calculated DRLs, and more than Japan and the UK while the calculated kVp and mAs of understudy and Tehran and India had equal values. Moreover, all three studies have lower kVp conditions and higher mAs than the UK [13] and Japan [14] studies. It should also be noted that the present study reports a higher dose in chest radiography rather than Tehran that is due to the lower used FFD for chest X-ray.

Diverse and complex results were obtained for lumbar vertebrae so that India has a higher rate than the other studies which is due to a significant increase in mA compared to others (see table 1). On the other hand, a lower kVp has been used to restitute of this increase, which makes film blackening and causes proximity of our data and other studies data. It can be concluded then that if the radiologists applied radiation conditions were set based on standard values, the radiation doses will tend to standard doses.

For the skull, the results of this study show a relative agreement with Tehran results, higher than the UK and Japan and significantly lower than India ($p < 0.001$). Since our calculated mAs did not significantly different from UK study and the increase in kVp was not very much, therefore, a possible reason for the dose reduction in the UK is the increase in FFD by 95 compared to the current study ($p < 0.001$).

In pelvic X-rays, the difference between our study and India was not significant while it was significantly different from UK and Tehran ($p < 0.001$) and obvious differences with Japan. The increase in FFD in Tehran and the UK compared to our study can be considered as a factor in the lower dose .Explaining the role of FFD in the received dose for facelift thoracic projection between our work and UK is an important case in which our results showed a higher DRL in thoracic imaging than UK (see table 2). We found that the UK results have a significant increase in FFD compared to our study, while the increase in the mAs and kVp of the UK is not significant and they are reasonably increased to reduce the dose. It can be seen that the slight increase in kVp and mAs can be compensated by FFD increasing and provides better conditions in terms of patient dose .

To decrease the delivered dose, some other factors such as the thickness of applied filters (2.5 mmAl as a filter for all devices), type and time of quality control of the devices (used factors in this study) need to be considered as well. Furthermore, continuous quality control of radiology devices has also a considerable impact on the output dose [18-20].

Due to the differences in our observed DRL values and other studies, it is possible with correct training of imaging staff conditions (kVp, mAs, FFD) to greatly reduce the dose without

[DOI: 10.52547/ijrr.19.4.34]

causing diagnostic power decreased in graphic interpretation. As mention about the lumbar vertebrae, if the radiation was set at proper conditions, a suitable dose can be reached in the size of international references. On the other hand, insisting on the misuse of conditions such as using of low dose and the highest number of graphs for chest image in hospitals, has a higher dose than the global reference conditions. Additionally, regular quality control of radiology devices and the use of appropriate filters can greatly help to bring the DRL of deprived areas closer to global references. Lack of quality control centers in deprived areas and long distances between these areas and cities having quality control centers will have a double effect on increasing the DRL of these areas with global references.

CONCLUSION

DRLs represent the national dose references level, which varies from place to place and can be confirmed applying standard protocols derived from International reports during calculating DRLs as well as significantly increase the accuracy of calculated DRL values. In this study, Yasuj as a deprived city of Iran was considered and founding indicated that the accuracy of obtained DRLs can be very close to the developed cities and countries if applied radiation conditions for examinations are similar to international standard conditions.

Conflicts of interest: *Declared none.*

REFERENCES

1. Paulo GdNN (2015) Optimisation and establishment of diagnostic reference levels in paediatric plain radiography: Universidade de Coimbra. *Dissertation Abstracts International, **75-01C**: 159 p*.
2. Cousins C, Miller D, Bernardi G, *et al.* (2011) International commission on radiological protection. *ICRP publication, **120**: 1-125.*
3. Strauss KJ and Kaste SC (2006) The ALARA (as low as reasonably achievable) concept in pediatric interventional and fluoroscopic imaging: striving to keep radiation doses as low as possible during fluoroscopy of pediatric patients—a white paper executive summary 1. *Radiology, **240**: 621-2*.
4. Directorate D (2014) Radiation Protection N° 180.
5. Protection R (2007) ICRP publication 103. *Ann ICRP, **37**: 2*.
6. Huda W, Nickoloff EL, Boone JM (2008) Overview of patient dosimetry in diagnostic radiology in the USA for the past 50years. *Medical physics, **35**: 5713-28*.
7. Suess C and Chen X (2002) Dose optimization in pediatric CT: current technology and future innovations. *Pediatric Radiology, **32**: 729-34*.
8. Tanaka GI and Kawamura H (2011) Reference man models based on normal data from human populations. *Asian Center for Reference Man Studies: 4-20*.
9. Edmonds K (2009) Diagnostic reference levels as a quality assurance tool. *Radiographer, **56**: 32-7*.
10. Kulašenkov R (2016) Panoraamröntgenseadmete tunnussuurused ja patsiendidoos: *Tartu Ülikool*.
11. Toosi MTB and Asadinezhad M (2007) Local diagnostic reference levels for some common diagnostic X-ray examinations in Tehran county of Iran. *Radiation Protection Dosimetry, **124**: 137-44*.
12. Uniyal SC, Chaturvedi V, Sharma SD, *et al.* (2017) Estimation of entrance surface air kerma due to diagnostic X-ray examinations of adult patients in Uttarakhand, India and establishment of local diagnostic reference levels. *Australasian Physical & Engineering Sciences in Medicine, **40**: 687-94*.
13. Hart D, Hillier M, Wall B (2009) National reference doses for common radiographic, fluoroscopic and dental X-ray examinations in the UK. *The British Journal of Radiology, **82**: 1-12*.
14. Yonekura Y (2015) Diagnostic reference levels based on latest surveys in Japan. Japan DRLs Report.
15. Mooney R and Thomas P (1998) Dose reduction in a paediatric X-ray department following optimization of radiographic technique. *The British Journal of Radiology, **71**: 852-60*.
16. Vafapour H and Salehi Z (2018) Comparison of incident air kerma (ki) of common digital and analog radiology procedures in Kohgiluyeh and Boyer-Ahmad province. *Polish Journal of Medical Physics and Engineering, **24**: 37-41*.
17. Khong P, Ringertz H, Donoghue V, *et al.* (2013) ICRP publication 121: radiological protection in paediatric diagnostic and interventional radiology. *Annals of the ICRP, **42**: 1-63*.
18. Pedrosa I, Saíz A, Arrazola J, *et al.* (2000) Hydatid Disease: Radiologic and Pathologic Features and Complications 1: (CME available in print version and on RSNA Link). *Radiographics, **20**: 795-817*.
19. Radiation UNSCotEoA (2008). Report of the United Nations Scientific Committee on the Effects of Atomic Radiation, Fifty-sixth Session, United Nations Publications.
20. Rapp-Bernhardt U, Roehl FW, Gibbs RC, *et al.* (2003) Flat-panel X-ray detector based on amorphous silicon versus asymmetric screen-film system: Phantom study of dose reduction and depiction of simulated findings 1. *Radiology, **227**: 484-92*.

[DOI: 10.52547/ijrr.19.4.34]