International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2015): 78.96 | Impact Factor (2015): 6.391

Diagnostic Reference Levels as a Quality Assurance Tool for Routine X-ray Examinations in Sudan

Nagla Abdllha Mansor[1], Ahmed AbuKuna[2], Naji I.Ali[3], Bader Abu Naib[4], Nadia S. Ali[5]

[1]Radiation Safety Officer (RSO), *Private Biomedical Engineer, K.S.A Jeddah*

[2]University of Sudan, College of Medical Radiological Science, Assistant Professor –Dean of the College

[3]University of Majmaah - K.S.A, College of Applied Medical Science, Associate Professor in Diagnostic Radiology Department

[4]University of Hail –K.S.A, College of Applied Medical Science, Assistant Professor in Diagnostic Radiology Department

[5]University of Hail –K.S.A, College of Applied Medical Science, Assistant Professor in Diagnostic Radiology Department

Abstract: ***Background**: The purpose of the study is to prove that diagnostic reference levels (DRLs) diagnostic radiology is the best optimizer of radiation dose to patients in Sudan, and improve quality assurance program of diagnostic imaging. The DRL is usually set at the third quartile value of the distribution of typical doses derived from those surveys both nationally and internationally. Using the third quartile or 75th percentile is a compromise between being overly stringent an overly complacent. The result of initial proposed DRL by calculating the entrance surface dose (ESD) for Conventional Radiological examinations. **Materials and Methods**: A total ten major hospital radiological department (eight governmental and two military), were assessed by estimating entrance surface dose (ESD) for seven radiographic examinations including: skull (AP, LAT), chest (PA, LAT), abdomen (AP), lumbar spines (LAT) and pelvis (AP) exam. The proposed DRLs values were compared with measure entrance surface dose in different countries and their results were compared with dose levels recommended by relevant organizations. National and international values in the world .The descriptive parameters such as, 1st quartile, mean, median, 3rd quartile, minimum, maximum and standard deviation of each DRL value are reported. **Results**: The results obtained in mGy were, 6.0 for the skull (AP), 7.1 for the skull (LAT), 0.9 for chest (PA), 9.2 for abdomen (AP), 18.3 for lumbar spines (LAT) and 8.1 for pelvis (AP). **Conclusion**: valuable for national DRLs can provide a database for future dose measurements and improve the image quality and eventually reducing the dose exposed to patents.*

Keywords: Diagnostic Reference Levels, Entrance Surface Dose, DRLs, Sudan

1. Introduction

Diagnostic reference levels (DRLs) were first introduced by the International Commission on Radiological Protection (ICRP) in 1990 [1] greater details in 1996. The use of DRL as an important dose optimization tool is confirmed by many professional and regulatory organizations, including the ICRP, American College of Radiology (ACR), American Association of Physicists in Medicine (AAPM), United Kingdom, Health Protection agency, International Atomic Energy Agency (IAEA) [2] and European Commission (EC) [3].

There have been a number of different quantities used for reference levels. The selected quantity is dependent on the type of clinical procedure, The quantity used is also dependent on the body setting the reference level, and relates to the desired aim, local preference and the unique irradiation conditions [4]. Data from European countries shows a wide variation in common. DRL which may be due to differences in socioeconomic. Conditions regulatory regime activeness of professional bodies and health care implementation.

The result of assessing image quality and patient radiation dose in 12 countries in Africa, Asia, and Eastern Europe covering 45 hospitals. There were high rate of unsatisfactory images. The image quality improved up to 16% in Africa, 13% in Asia, and 22% in Eastern Europe after implementation of a QC program [6]. The ESD for adult patients were determined and compared with diagnostic reference levels. The majority of doses were below diagnostic reference levels. The International Commission on Radiological Protection (ICRP) has produced a useful advisory document on DRLs [7].The following comments are extracted from this ICRP document. The objective of a DRL is to help avoid radiation dose to the patient that does not contribute to the clinical purpose of the image. This is accomplished by comparison between the numerical value of the DRL and the mean or other appropriate value observed for a suitable reference group of patients or a suitable reference phantom. A DRL does not apply to individual patients. DRLs should be applied with flexibility to allow higher doses when indicated by sound clinical judgment [8] .The guiding principles for setting a DRL are the regional, national or local objective is clearly defined, including the degree of specification of clinical and technical conditions for the medical imaging task. The selected value of the DRL is based on relevant regional, national or local data.

The definition by Donabedian "the quality of care in medicine as" That kind of care which expected to maximize an inclusive measure of patient welfare ,after one has taken account of the balance of expected gains and losses that attend the process of care in all parts" [9]. The ESD doses were compared with reference level values recommended by IAEA [2]. It is found that the measured values were greater than recommended values for the most X-ray unit, because the QA program in diagnostic radiology was not conducted in Sudan medical hospital.

2. Materials and Methods

Ten conventional radiological departments in public hospitals (eight Governmental and two military hospitals). ESD per examination was estimated from X-ray tube output parameters in ten hospitals comprising ten rooms and a sample of five most common X-ray examinations with 6 basic views and a total of 60 projections. Third quartile was calculated from the resultant distributed mean ESDs in each hospital surveyed used RraySafe XI R/F detector. Ten major hospitals (eight governmental and two military), were assed DRLs by evaluation of entrance surface dose (ESD) to X ray tube using phantom detector instead of patients. For the following seven radiographic examinants including: skull (AP, LAT), chest (PA), abdomen (AP), lumbar spines (LAT) and pelvis (AP. The assessed DRLs values were compared with national standard (DRLs) in the world (NRPB).Ginger It!

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Dosimeter methods:

RraySafe XI R/F detector is used as dosimeter tool positioned in the central beam axis of X-ray, the tube focal spot-detector distance of 100 cm. A radiographic exposure was made and the dosimeter reading recorded, this step was repeated three times at the same settings and the average dosimeter reading determined. The main goals for measurement of ESD to assess the radiation risk from a particular examination, and ensure that the patient doses agree with ICRP standards. The Raysafe Xi R/F detector is capable of measuring kVp, dose, dose rate, pulse, pulse rate, dose/frame, time, HVL, total filtration and waveforms simultaneously.

Each X-ray tube its output measured. This type of dose measurements is time effective and does not involve the patient directly. The Raysafe Xi R/F detector is placed at 100 cm from X-ray tube focus. For best accuracy, center the selected sensor field (R/F low or R/F high) and position the long axis of the sensor field perpendicular to the anode-cathode axis of the tube.

3. Results

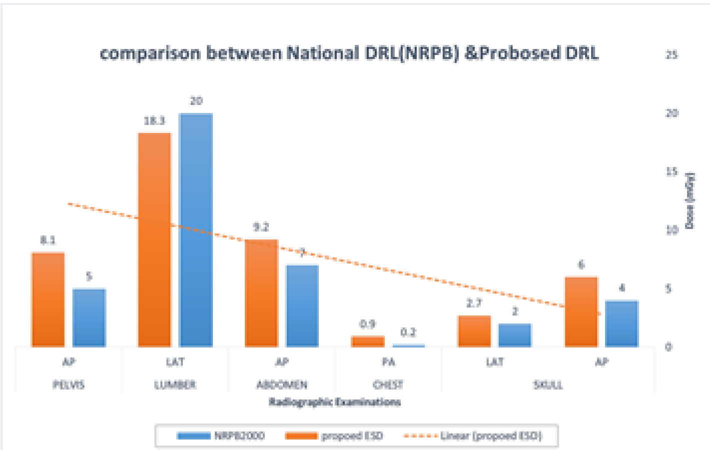

Figure 1: Proposed Diagnostic Reference Levels (DRLs) expressed in the third quartile of the mean entrance surface dose ESD (mGy)

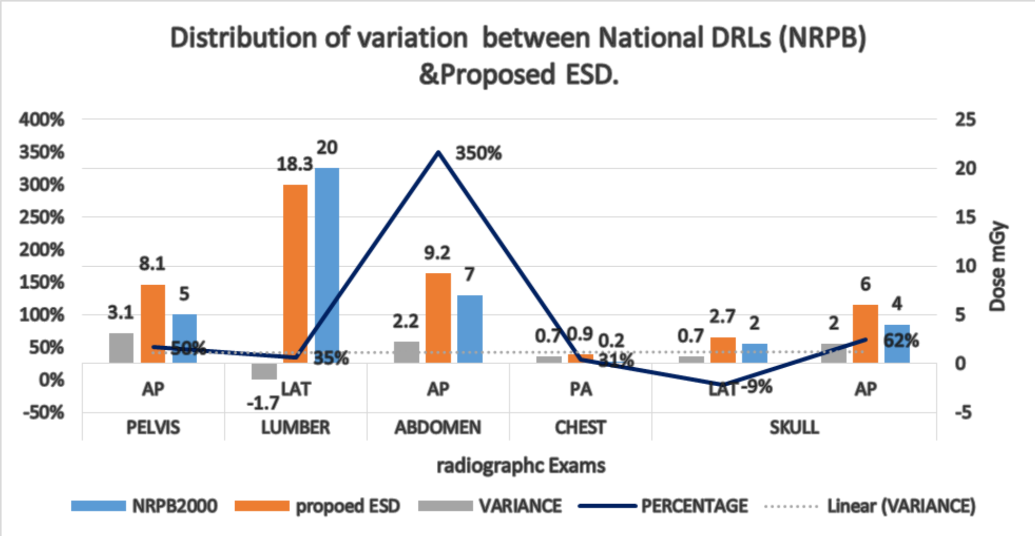

Figure 2: The distributing of variation between national DRLs (NRPB) &Proposed DRLs expressed in the third quartile of the mean entrance surface dose ESD (mGy)

Table 1: Descriptive of distributed the exposure parameters (kVp) from ten hospitals in Sudan

Routine Exam	Skul		Chest	Abdomen	Lumbar	Pelvis
Projection	AP	LAT	PA	AP	LAT	AP
Mean	73.39	66.97	76.70	75.29	88.65	76.26
Std. Deviation	4.30	5.08	11.90	6.12	7.66	4.65
Maximum	80.25	77.00	96.20	90.23	96.25	83.70
3rd Quartile	77.30	71.00	76.70	78.54	95.02	79.23

Table 2: Descriptive of distributed X-ray tube exposure parameters (mAs) from ten hospitals in Sudan

Routine Exam	Skul		Chest	Abdomen	Lumbar	Pelvis
Projection	AP	LAT	PA	AP	LAT	AP
Mean	25.7	21.1	29.2	33.6	49.3	37.0
Std. Deviation	11.5	7.6	19.2	15.3	10.3	11.6
Maximum	45.1	40.1	48.1	55.1	66.1	49.1
3rd Quartile	38.1	20.2	44.4	48.1	56.1	46.1

Table 3: The distribution of ESD for five routine X- ray examinations (six projections) from ten hospitals in Sudan

Routine Exam	Skull		Chest	Abdomen	Lumbar	Pelvis
Projection	AP	LAT	PA	AP	LAT	AP
Mean	5.4	5.6	2.7	8.5	16.7	6.9
Std. Deviation	1.0	1.1	2.0	0.7	1.4	1.0
Maximum	7.2	7.2	3.2	9.3	19.3	8.3
3rd Quartile	6.0	7.1	0.9	9.2	18.3	8.1

4. Discussion

The development of the DRL practice of diagnostic radiology within Sudan is still at an early stage as no national surveys have been carried out for any radiological examinations for the express purpose of establishing national DRL except a few studies done by (Khair et al 2016), At a local level, various organizations, regulatory authorities and individual practices have carried out limited at general radiography, fluoroscopy and CT surveys [10]. The results of this study provide valuable information about the patient dose in Sudan. The wide variations in the patient dose levels, even in the same procedures carried out by different radiographers are mainly due to the choice of different exposure setting, focus to film distance and finally output of the X-ray units. In the 2000 review [11] there are data from a sufficient Number of hospitals (or X-ray rooms) to set reference doses that are more representative of national practice for a much larger selection of examinations than was possible previously [12]. The ESD doses were compared with reference level values recommended by the IAEA, It is found that the measured values were greater than recommended values for the most X-ray unit, because the QA program in diagnostic radiology were not conducted in Iraq medical hospital. [13]. There is a clear need to manage (optimize) the radiation doses from diagnostic radiology in order to minimize the risks of radiation induced cancers. The establishment and use of DRL is recommended by international radiation protection organizations as an important component of the management of these doses and many countries have incorporated them into their radiation Protection regulations [14]. We can see from the given result (Table 1&2) descriptive statistics of X-ray tube exposure parameters (kVp & MAs) from ten hospitals in Sudan and represents the mean value of the minimum, maximum, mean, standard deviation and third quartile for each examination done in this survey. The big gap between the applied input exposure parameters and measured output exposure parameters. Reflects the wide variations in each projection. It is also apparent that, variation between the minimum and the maximum too big. The third quartile in each hospital can be used as applied used to assess the local DRL. As we can see from the given results (Table 3) a total ten major hospital radiological department (eight governmental and two military), were assessed by estimating entrance surface dose (ESD) for six radiographic examinations projections including: skull (AP, LAT), chest (PA, LAT), abdomen (AP), lumbar spines (LAT) and pelvis (AP) exam. The assessed DRLs values were compared with (DRLs) in the world especially (NRPB)The descriptive parameters such as, 1st quartile, mean, median, 3rd quartile, minimum, maximum and standard deviation of each DRL values are reported and compared to NRPB guide levels. The results obtained in my considering the value of third quartile in mGy were, 6.0 for the skull (AP), 7.1 for the skull (LAT), 0.9 for chest (PA), 9.2 for abdomen (AP), 18.3 for lumbar spines (LAT) and 8.1 for pelvis (AP). With exception of LAT lumbar spine in all hospitals. All values were greater than those reported by guideline levels.

Figure 1&2 showed that the distributing of variation between national DRLs (NRPB) &Proposed DRLs expressed in percentage were greater than national guideline levels DRLs (NRPB), skull AP is (≥50%), skull LAT is (≥35%), chest PA is (≥350%), abdomen AP is (≥31%), pelvis (AP) except lumbar spines LAT is lesser than national guideline levels DRLs (NRPB) is (≤-9%) [15].In this study The large variations in ESD values indicate that there is significant correlation between increasing exposure factors (kVp, mAs), this lead of greater gap and variation in proposed DRLs, Other reasons caused the greater variation in ESD like The technique adopted in each hospital has led to identification of great variations in ESD for the same procedure, rarely equipment calibration, inadequate processing environment, misusing film speed, did not use the anti-scatter grid, which made the dose several times lower and Tube specifications were also included, i.e. filtrations. Equipment calibration, acceptable film speed, Automatic Exposure Control was not used. [10]

5. Conclusion

This study has recommended that X-ray images must meet a certain level of quality, to minimize errors of interpretation and allowing an accurate diagnosis with low radiation dose. Bad quality image causes the repetition of imaging, duplication of radiation dose to the patient, and additional costs. Many workers investigate important parameters in diagnostic X-ray such as the linearity of exposure time, tube current, reproducibility of peak tube potential, and beam quality. The data collected during the investigations could be important as a useful baseline for future patient dose measurements in the field of the medical diagnostic radiology. The wide variations in the patient dose levels, even in the same procedures carried in different radiographers are mainly due to the Choice of different exposure setting, focus to film distance and output of the X-ray units (mAs & kVp). Periodic quality control testing and monitoring program is strongly recommended for technical performance of Radiographers might effectively improve the Image quality and reducing the dose to patients. Last not least the study could educate and train Radiographers, using a RraySafe XI R/F detector it is simple and it does not require a lot of additional measurements. It can be combined with average values of field-size and focus-skin distance, and that would make calculations even easier.

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Author Profile

Received the B.S. degrees in Biomedical engineering from the Sudan University of Science and technology in 2002 and her job from 2001-up to now, is Radiation Safety Officer (RSO) & Private Biomedical Engineer - K.S.A Jeddah