The Pharmaceutical and Chemical Journal, 2015, 2(3):1-5

Available online www.tpcj.org

Research Article

ISSN: 2349-7092
CODEN(USA): PCJHBA

Patient Doses Assessment for Conventional Radiography in Madagascar

Marie Jeanne Ramanandraibe*, Tiana Randriamora, Mbolatiana Ralaivelo, Raoelina Andriambololona

Institut National des Sciences et Techniques Nucléaires (INSTN-MADAGASCAR), BP 4279, Antananarivo, Madagascar

Abstract The increasing use of ionizing radiation in medical field is at present by far the largest source of exposure of the population. For this reason, radiation protection measures should be taken by each country to prevent unnecessary radiation exposure. Medical Physicists play a key role in patient dose management. Entrance skin dose (ESD) is one of the basic dosimetry quantities for patient dose assessment in diagnostic radiology. The purpose of this work is to survey patient doses undergoing radiographic examinations and to perform comparisons with the international Diagnostic Reference Levels (DRL). The study was done in nine (9) hospitals. Results showed that patient doses were below the reference doses published by the International Atomic Energy Agency (IAEA) and the European Commission (EC) for seven hospitals and higher than these reference levels for two hospitals. It was derived that obtained values can be useful for the implementation of the regulation with regards to patient protection from medical exposure in Madagascar.

Keywords Diagnostic radiology, entrance skin dose, patient protection, reference level

Introduction

The increasing use of ionizing radiation in medical field is at present by far the largest source of exposure of the population. For this reason, radiation protection measures should be taken by each country to prevent unnecessary radiation exposure. The international Commission on Radiological Protection (ICRP) has stressed that all medical exposures should be subjected to the radiation safety principles of justification and optimization, and consideration be given to the use of dose constraints for applications in the relevant diagnostic procedures [1]. For diagnostic medical exposure optimization is interpreted as being a dose as low as possible, which is consistent with the required image quality [2] and necessary for obtaining the desired diagnostic information.

In the context of optimization of patient protection in diagnostic radiology, an important step was the introduction of Diagnostic Reference Levels (DRL), following the recommendations of the ICRP in its publication 73 [3]. The International Atomic Energy Agency (IAEA) [4] has published reference levels for medical exposure, in order to achieve adequate image quality, while delivering reasonably low radiation dose per examination to the patient.

In diagnostic radiology, medical physicists are responsible for monitoring and evaluating the patient exposure. The Entrance Skin Dose (ESD) is still by far the simplest indicator for patient's injury.

A national survey of patient dose for diagnostic radiology was planned in Madagascar. ESD for five types of common radiographic adult examinations: chest, skull, lumbar spine, pelvis and abdomen were evaluated.

This work presents a pilot study for this survey to develop a protocol of the doses assessment. This study was done in nine hospitals.

The purpose of this work is to survey patient doses undergoing radiographic examinations and to perform comparisons with the international reference levels. This study is a part of an IAEA project untitled "Strengthening Radiological Protection of Patients and control of Medical Exposure".

Materials and Methods

Entrance skin dose (ESD) is an important parameter in assessing the dose received by a patient in a single radiographic exposure. The European Commission has identified this physical quantity as one to be monitored as a diagnostic reference level in the hope of optimizing patient dose [2, 5].

It is possible to evaluate ESD either by direct measurements (on suitable phantoms using ionization chambers or on patients using thermoluminescent dosimeters, TLD) or using calculations based on X-ray tube output [2]. In this work, ESD were evaluated using both measurements taken by ionization chambers and values determined by calculation.

To determine the machine output in terms of kerma free-in-air, many mathematical models have been suggested [6, 7]. In this study, the model proposed by Harpen [6] was adopted.

$$ESAK(kVp, mAs) = \alpha\ (kVp)^{\beta}\ .mAs \quad (1)$$

Where ESAK is the Entrance skin air kerma (ESAK) and the parameters α and β depend on the type of X-ray generator, anode material, focus skin distance, X-ray tube filtration, kVp mAs are respectively, the peak voltage and the tube-current-time product.

According to Gaetano's work [8], typical values of β used in equation (1) were ranging from 1.988 to 2.084, a simple value of 2 for β was taken in this study.

Harpen's formula gives the air kerma free-in-air, to determine ESD, some corrections must be made for backscatter factors (BSF).

The following equation based on the European Commission [2] is used to calculate ESD.

$$ESD = ESAK\ .\ BSF \quad (2)$$

Where BSF is the backscatter factor

Doses delivered to patients were determined in terms of entrance skin dose (ESD) based on X-ray tube output measurements and X-ray exposure parameters. Before patient dose assessment, information on X-ray exposure parameters (kVp, mAs) and geometric parameters (focus-skin distance) used in radiographic examinations of the patients was collected. The surveyed X-ray exposure parameters were used later to estimate patient doses through two steps protocol: X-ray tube output measurement and entrance skin dose calculation.

X-ray tube output measurements

X-ray tube output measurements were conducted using a Ratemeter- Timer, Model 3036, with an internal ionization chamber. The dosimeter was positioned in central beam axis such that the X-ray tube focal spot –detector-distance (FDD) was 100 cm. The radiation field size (FS) at FDD was set just to cover the dosimeter in order to avoid the possible influence of scatter radiation to the dosimeter. The tube potential was set at 50 kVp and any mAs value (depending on convenient tube load conditions). For each X-ray exposure, the dosimeter reading was recorded. This step was repeated once more at same kVp and mAs settings and the average dosimeter reading was taken. The X-ray tube output was determined as the ratio of average dosimeter reading, to the tube current-time product. Similar X-ray tube output measurements were determined for 60, 70, 80, 90, 100 and 120 kVp settings or closest values depending on typical selectable kVp values. The values of X-ray tube output were plotted against tube potential and the resulting output-kVp curve was fitted to a square function.

ESD Calculation

The entrance skin air kerma (ESAK) for each adult patient undergoing particular X-ray examination was determined from the product of X-ray tube output (derived from output-kVp curve corrected for the inverse square effects

between the patient‘s distance from the X-ray focus and distance of output measurements) and the mAs used during X-ray examination. The ESAK value was converted to Entrance Skin Doses (ESD) by multiplying with the appropriate back scatter factor (BSF). The BSF value of 1.35 was used in this work, as suggested in the European Guidelines [2].

The average ESD were compared to the International Reference Guidance Levels for each examination.

Results and Discussion

For each examination, average ESD values were calculated for these nine hospitals.

Results of the study are summarized in table 1 and table 2.

Table 1: ESD values (mGy) for hospital number 1 to 5

Examination	H1 (mGy)	H2 (mGy)	H3 (mGy)	H4 (mGy)	H5 (mGy)
Chest PA	0.27	0.74	0.35	0.61	0.46
Lumbar spine AP	4.39	-	5.62	3.10	22.79
Lumbar spine LAT	8.80	-	14.71	3.92	39.88
Pelvis AP	2.18	7.05	5.62	3.51	18.45
Abdomen AP	4.34	7.05	5.62	3.78	29.17
Skull PA	3.75	3.27	7.97	2.30	7.38

Table 2: ESD values (mGy) for hospitals number 6 to 9

Examination	H6 R1 (mGy)	H6 R2 (mGy)	H7 (mGy)	H8 (mGy)	H9 (mGy)
Chest PA	0.90	1.07	0.41	0.09	0.42
Lumbar spine AP	18.01	19.71	8.13	1.08	4.21
Lumbar spine LAT	71.35	75.25	12.97	3.37	7.41
Pelvis AP	15.26	20.01	5.64	2.72	2.88
Abdomen AP	15.33	17.77	6.72	0.75	2.88
Skull PA	14.49	17.52	7.11	0.38	2.92

H: hospital *R: Room*

Table 3: DRL values published by the IAEA, European Commission, CRCPD and HPA.

Examination	IAEA 1996[4] (mGy)	EC 1996[4] (mGy)	CRCPD 1992[9] (mGy)	HPA 2000[10] (mGy)	HPA 2005[11] (mGy)
Chest PA	0.3	0.3	0.17	0.2	0.15
Lumbar spine AP	10	10	6.4	6	5
	30	30	-	14	11
Lumbar spine LAT	10	10	-	4	4
	10	-	5.6	6	4
Pelvis AP	5	5	-	3	2
Abdomen AP					
Skull PA					

Results showed that there is a large variation of patient doses for common examination in these nine hospitals. Comparisons of dose levels with international DRL showed that patient doses are lower than reference levels published by the IAEA [4] and the EC [2] in seven hospitals and higher than reference level for two hospitals.
The values reported by CRCPD [9] and HPA [10, 11] for all the radiographic examinations are found to be lower than values obtained in this study, they are also lower than those published by IAEA [4] and the EC [2].
It can be seen that ESD values for chest examination in this study are higher than those published by CRCPD [9] and HPA [10, 11].
Although the majority of entrance skin doses were lower than international values, the existence of high entrance skin doses needs a regular patient dose assessment for optimal results. By comparing local practice against international reference levels of patient doses, it was demonstrated that reference levels are important for the optimization of patient protection in diagnostic radiology.

Conclusion

A pilot study to develop a protocol of patient dose assessment was performed in this work. Patient doses assessment for adult type were studied, survey of practices in pediatrics radiology will be done in the near future.
This study was only realized in nine hospitals. Actions are under way to extend measurements into a national level in order to establish DRL in Madagascar. Establishment of national Diagnostic Reference Levels (DRL) in medical exposure should be given a high priority in the country.
As guidance levels from basic safety standards are based on investigations in some developed countries, reference levels adapted to each country should be established.
The reference levels should be understood as guidelines, rather than standards in medical diagnostic radiology, and they should be evaluated in relation with quality assurance programme in each country by professionals from both Medical and Regulatory Body.

Acknowledgments

The work was supported by the International Atomic Energy Agency through the regional project for African Countries on "Strengthening Radiological Protection of Patients and Control of Medical Exposure". Thanks are due to the Staff of all hospitals participating in the project.

References

1. International Commission on Radiological Protection, Recommendations of the Commission on Radiological Protection. *ICRP publication 60,* Ann.ICRP 21(1-3) (1990): 42-43
2. European Commission. European guidelines on quality criteria for diagnostic radiographic images EUR 16260 EN. Luxembourg: Official Publication of the European Communities, (1996).
3. International Commission on Radiological Protection, Radiological Protection and Safety in Medicine, Publication 73, (1996).
4. IAEA/PAHO/WHO/FAO/ILO/OECD-NEA. International Basic Safety Standards for protection against ionizing radiation and for the safety of radiation sources, *IAEA Safety Series No. 115*, Vienna, (1996).
5. Muhogora WE, Nyanda AM, Kazema RR. Experiences with the European guidelines on quality criteria for radiographic images in Tanzania. *J appl Clin Med Phys,* 2(4) (2001): 219-226.
6. Harpen MD. A mathematical spread sheet application for production of entrance skin exposure nomograms. *Med Phys*.; 23(2) (1996): 241-242.
7. Meguire EL, Dickson PA. Exposure and organ dose estimation in diagnostic radiology. ,13(6) (1986): 913-916.
8. Gaetano Compagnons, Laura Pagan, Carlo Bergamini. Comparison of six phantoms for entrance skin dose evaluation in 11 standard X-ray examinations. *J appl Clin Med Phys,* 6(1) 2005: 101-113.
9. CRCPD. Average patient exposure/dose guides. *Conference of Radiation Control Program*

Directors/Center for Devices and Radiological Health, CRCPD, Pub 92-04 (Frankfurt:CRCPD , 1992.

10. Hart.D. Miller, M.C and Wall, B.F. Doses to patients from medical X-ray examination in UK-2000 review, W14 Chilton: *NRPB*, (2002).
11. Hart.D. Miller, M.C and Wall, B.F. Doses to patients from radiographic and fluoroscopic X-ray imaging procedures in the UK-2005. Review HPA-RAD-029.