Moroccan Journal of Chemistry
ISSN: 2351-812X
http://revues.imist.ma/?journal=morjchem&page=login
Lamrabet & al./ Mor. J. Chem. 5 N°3 (2017) 453-460

Investigation of radiological diagnostic reference levels in the University Hospital Center Hassan II, Fez

A. Lamrabet[(a)]*, M. Bencheikh[(a)], A. Maghnouj[(a)], J. Tajmouati[(a)], A. Benider[(b)], A. Zaafa[(c)]

[(a)]*Laboratory of Systems Integration and Advanced Technologies, University Sidi Mohamed Ben Abdellah, B.P.*1796 *Fez, Morocco*

[(b)]*Department of dosimetry, National Center of Radiation Protection, B.P 6286 Sale, Morocco*

[(c)]*Department of Radiology, University Hospital Center Hassan II ,B.P 30003 Fez, Morocco*

Abstract

The increasing use of ionizing radiation in the medical field, in Morocco, imposes the issues of the quality of radiological practices and standards for radiation protection especially for patients and manipulator. The present work is part of improving these practices. It constitutes one of the first steps in the process of setting up the diagnostic references levels (DRLs). This concept is considered as an optimization tool for the medical practices concerning the X-ray. This study has been devoted to the determination of diagnostic reference levels, relating to 10 examination types of medical imaging (at the university hospital center Hassan II). After the data collection, the DRL corresponding, have been raised, according to the method known as of 75th percentile. The analysis of the results and their comparison with literature data, allowed making a preliminary assessment of the quality of medical practices, in terms of radiation protection of patients, in the services concerned and outing with some recommendations and perspectives.

** Corresponding author:*
abdesslam.lamrabet@usmba.ac.ma.

Received 02 May 2016,
Revised 21 April 2017,
Accepted 15 May 2017

Keywords: *Diagnostic references levels, radiation protection, medical practices, patient.*

1. Introduction

The medical field in Morocco has known, in recent years, a remarkable evolution by introducing new techniques and equipment. Among these, there are those that involve ionizing radiation (computed tomography (CT), conventional/interventional radiology and interventional cardiology etc.).The increase of using the medical applications of ionizing radiation, leads eventually to the heterogeneity and the disparities of the application of the principles of radiation protection. Otherwise, the specificity of the medical irradiation (direct medical benefit) is incompatible with the notion of regulatory limit of dose. "It is not appropriate to apply dose limits to medical exposure of patients, because such limits would often do more harm than good." [1]. Then, an optimization tool is considered indispensable. The aim of the present work is the assessment of diagnostic reference levels relating to acts CT and interventional, in the radiology department and the cardiology department of the university hospital center Hassan II in Fez. It executed by the tripartite: the National Center of Radiation Protection (NCRP), the Faculty of Sciences Dhar EL Mahraz and the University Hospital Center Hassan II (UHC).The result obtained in this work show the necessity to respect the principles of radiation protection, in particular those relating to patients and the manipulator. Hence, the interest to develop the diagnostic reference levels as an optimization tool for the medical practices, relating to applications of ionizing radiation. Analysis, discussion and comparison of the results with the literature data, have enabled us to assess, locally, the medical practices in radiation protection of patients.

2. Materials and methods

2.1 Centers and Facilities

The present study is performed at the radiology and the cardiology services of the hospital center Hassan II Fez. The equipment involved are four in number: Two installations of computed tomography (CT), an installation of interventional radiology and an installation of interventional cardiology.

2.2 Choice of examinations

The types of examinations selected are the most practical and/or the more irradiating. They are, of 10 types: Five types in CT, three types in interventional radiology and two types in interventional cardiology. These examinations are shown in the table: 1

Table 1: Types of examinations selected

CT acts	Interventional acts
Abdomen pelvis(AP)	Coronarography (Coro)
Head	Angioplasty (Angiop)
Chest	Cerebral Angiography (CA)
Chest abdomen pelvis (CAP)	Lower member angiography (LMA)
Lumbar spine (LS)	Abdominal embolization(AE)

2.3 Sampling

The population included in this study is comprised of 626 patients. The range of the weight of this population is 70 ±20 kg. The table: 2 give the distribution of population according to the type of examination.

Table 2: Distribution of population by type of examination

CT examination	Number of patients	Interventional examination	Number of patients
AP	96	Coro	117
Head	127	Angiop	27
Chest	59	CA	45
CAP	100	ALM	20
LS	21	AE	14
Total = 626 Patients			

2.4 Choice of quantities

The determination of the DRL, need a judicious choice of appropriate dosimetric quantities: In computed tomography (CT): Computed tomography dose index in volume ($CTDI_{vol}$), and Dose-Length Product (DLP). In interventional radiology/cardiology: Dose-Area Product (DAP), Time of fluoroscopy (T), and Number of frames (N). In order to assess the level of radiological risk associated with the examinations considered, it was chosen also to calculate the average effective dose associated to each examination.

2.5 Method of determining the DRL

The main steps followed to assess the DRL are: Data Collection, statistical treatment of these data and determination of the DRL, by the method known as of 75th percentile (recommended by the European Commission [2]), then calculation of average values of the quantities concerned by the DRL, next deduction of values of average effective doses (using the conversion factors), finally comparison of results with those of the literature.

2.6 Results

The completion of work according to the above stages, made it possible to achieve the results given by: Tables 3 and 4 for the CT acts and tables 5 and 6 for the interventional radiology/cardiology acts.

Table 3: Average values and DRL by acquisition, relating to the CT acts

examination	$CTDI_{vol}$ (mGy)		DLP (mGy.cm)	
	Average	DRL	Average	DRL
Head	56.2	74.8	994	1283
Chest	16.2	19.8	581	728.5
AP	11.5	14.6	621	799.6
LS	16.69	19.14	450.3	535.9
CAP	11.0	15.1	740.5	1032

Table 4: Average effective doses estimated, associated to the CT acts

examination	DLP_{avg} (mGy.cm)	Conversion factor (msv/mGy.cm)[3]	Effective dose(msv)
Head	994	2,1.10 -3	2.09
Chest	581	14,8.10 -3	8.60
AP	621	15,2.10 -3	9.44
LS	450.3	15,2.10 -3	6.84
CAP	740.5	15.10 -3	11.11

Table 5: Average values and DRL relating to acts interventional

examination	DAP (Gy.cm^2)		T (min)		N (Images)	
	Average	DRL	Average	DRL	Average	DRL
Coro	33.04	36.21	4.76	5.4	660	735
Angiop	78.52	91.9	13.22	15.95	1069	1220
CA	41.99	50.47	11.93	13.38	343	401
LMA	42.16	52.95	5.16	8.33	245	274
AE	200.4	242.4	31.88	38.46	1944	2548

Table 6: Average effective doses estimated for the acts interventional

examination	DAP_{av} (Gy.cm^2)	Conversion Factor (msv/Gy.cm²)	Effective Dose(msv)
Coro	33.04	0.19 [4]	6.88
Angiop	78.52	0.19 [4]	17.46
CA	41.99	0.03 [5]	1.51
LMA	42.16	0.15 [5]	7.94
AE	200.4	0.25 [5]	60.60

3. Analysis and discussion

3.1 Collective of patients

According to the international standards, relating to the establishment of diagnostic reference levels, (Whose the minimum number of patients by type of examination, must be greater than or equal to 20 and their weight must belong to the range 70±20kg) , the population on which has focused this study is, in general, in framework of these standards. In effect, the number of patients, for all types of examinations, is higher than 20, except the case of the abdominal embolization, which this number is only 14, (table: 2).

3.2 Data collected

The data relating to the quantities concerned by the diagnostic reference levels (DRL) are all accessible without calculation, either on the console or in the report of the examination. However, other data necessary for the interpretation of the results, are not available, (including the charge delivered by the X-ray tube, the size of the patient and even, sometimes, their weight). This is due either to the lack of equipment, or to the routine whither the operators have not got used to keep all the appropriate data relating to the patient. Furthermore, the distribution of data collected, presents a significant dispersion, as shown in the figure 1 ((a) and (b)) below. This dispersion can be explained by: First, the influence of morphologies, of health states and of pathologies presented by patients, on the choice of acquisition parameters. Second, the influence of technology facilities (a scanner to 64 slices and another to only 4 slices) and/or services which are placed (one of the scanner is installed in the radiology department, the other in the service of pediatrics). Third, the heterogeneity of practices, induced by the large number of technicians handling the devices.

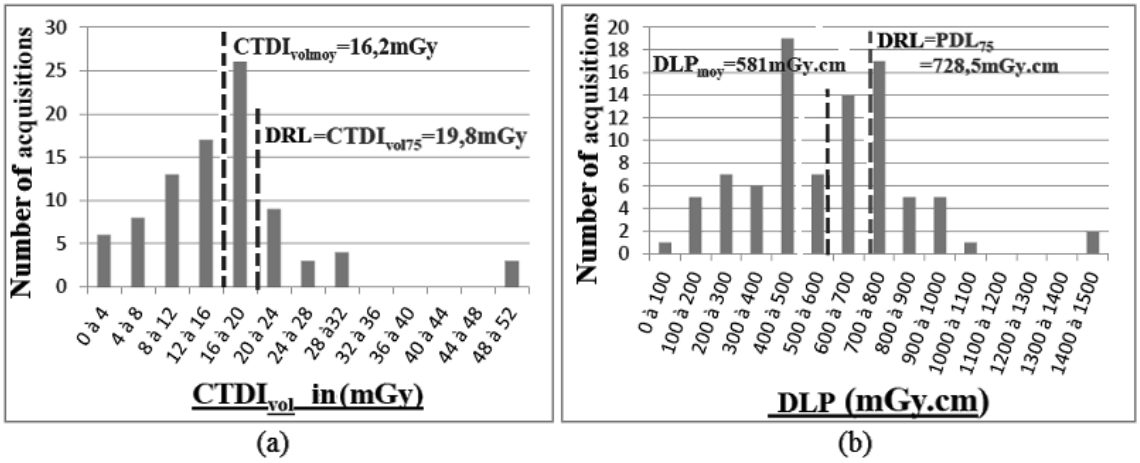

Figure 1: Distribution of $CTDI_{vol}$ (a) and DLP (b) by acquisition for the chest examination plus both of average and DRL values for each quantity.

3.3 Analysis of results

Diagnostic reference levels obtained (75th percentile of distributions), are all significantly higher than the average values (tables: 3 and 5). The marked differences are of 13% to 28% in CT, 8% to 17% in interventional cardiology and 11% to 38% in interventional radiology. These differences, more or less important, reflect the degree of dispersion of the distributions of data collected. The DRL associated with the examination of the head, are significantly higher than those associated with the other CT examinations. The gap reaches a factor of 5.1 for the $CTDI_{vol75}$ and 2.4 for the DLP_{75}. In addition, the doses index $CTDI_{vol75}$ relating to the chest and lumbar spine are comparable, as well as for the abdomen pelvis and the CAP (table: 3). The different anatomy of parts of the body subjected to irradiation, during examinations, is at the origin of the deviations remarked. For the interventional acts, the DRL associated to therapeutic examinations are much larger than those associated to diagnostic examinations (table: 5). The difference is by a factor more than 4.5 for the dose-area product and the fluoroscopy time, and more than 9 for the number of radiographic images. Regarding the average effective doses (tables 4 and 6), they are included between: 2.0 mSv and 12 mSv for the CT acts, 6 mSv and 18 mSv for acts of interventional cardiology and 1.5 mSv and 61 mSv for the acts of interventional radiology. It is noted that these doses are all superior to the annual limits, for the public and reach or exceed the annual limits relating to professionals [1]). It is therefore deduced that the resulting stochastic effect, is very important. Hence, the need to apply the principles of justification and of optimization, with as much more rigor, in the medical domain. Another finding rather important also, it is that the effective dose associated with the examination of the head, that is the lowest, although the average values of $CTDI_{vol}$ and PDL for this examination are the highest. This is explained by the fact that, the radio-sensitivity of the cranial tissue is lower in relation to those submitted to other examinations (table: 4).

4. Comparison of the results with the literature data

In order to assess the quality of practices and materials used, in terms of radiation protection of patients, we have made a comparison of the results obtained, with those of some recent studies. The studies selected for this comparison, are done by groups of experts to national scales, in the following countries: France, Switzerland and Canada. They are organized, either by official bodies (such as the ministry of health), either by recognized institutes or associations.

For the examinations, Chest, Abdomen Pelvis and CAP (table: 7); the results obtained are comparable to those of the literature.

Table 7: Comparison of the CT examination results

Examination	CHU[1] Fes 2013		MTES [6]		OFSP [8]		Security Code: 35 [7]	
	$CTDI_{vol75}$	DLP_{75}	$CTDI_{vol75}$	DLP_{75}	$CTDI_{vol75}$	DLP_{75}	$CTDI_{vol75}$	$CTDI_{vol75}$
Head	74.8	1283	65	1050	65	1000	60	60
Chest	19.8	728.5	15	475	15	600	30	30
AP	14.6	799.6	17	800	15	650	35	35
LS	19.14	535.9	45	700	30	850	-	-
CAP	15.1	1032	20	1000	15-20	1100	-	-

The marked differences for the examination of the head and the lumbar spine justify by: The influence of technology of the equipment and the service where it is placed, because most of the data on the cranium are taken from the scanner 64 slices (radiology department); whereas the majority of those, concerning the lumbar spine are taken from the scanner 4 slices (pediatric service). A kind of heterogeneity of practices, because both scanners are manipulated by several operators. It remains the influence of the sample size for the lumbar spine, because it is only 21 patients.

The results concerning the fluoroscopy time, and the number of images, for the interventional cardiology/radiology acts (Tables 8 to 12), are very consistent with those of the literature. Except in the case of the abdominal embolization which the size of the sample is very small (14 patients) and the data, with what is made the comparison, relate precisely the hepatic embolization [11]. However, the results concerning the dose-area product (DAP) are significantly lower than those of the literature. The quality of these results demonstrates the quality of the practices in the services concerned. This is quite normal, given that, the facilities of interventional cardiology/radiology are often manipulated by professors very experienced. In addition, two factors influencing the results are eliminated: The variation of technology and service. In fact, there is a single service and a single installation for the interventional cardiology and for interventional radiology. A term, the present study has focused on a limited number of patients, facilities and services, as well as it is done in a single center (UHC-Fez). By against the other studies, with which it has made the comparison, have focused on samples of large sizes and on the large numbers of installations, services and centers. Thing, which permit to say that the results obtained, are considerably consistent with those of the literature.

Table8: Comparison of the coronarography results

	CHU Fes2013	IRSN [9]	RAY'ACT [10]	OFSP[11]
$DAP_{75}(Gy.cm^2)$	36.21	47	45.2	70
T_{75} (min)	5.4	5.0	6.3	7
N_{75} (images)	735	730	769	1300

Table 9: Comparison of the Angioplasty results

	CHU Fes2013	IRSN [9]	RAY'ACT [10]
$DAP_{75}(Gy.cm^2)$	91.9	135	94.5
T_{75} (min)	15.95	17.5	16.2
N_{75} (images)	1220	1680	1193

Table 10: Comparison of the Cerebral Angiography results

	CHU Fes 2013	IRSN [12]	OFSP [11]
DAP_{75}(Gy.cm^2)	50.47	229	150
T_{75} (min)	13.38	15	15
N_{75} (images)	401	472	400

Table 11: Comparison of the of the lower member angiography results

	CHU Fes2013	IRSN[9]	OFSP[11]
DAP_{75}(Gy.cm^2)	52.95	120	200
T_{75} (min)	8.33	6	10
N_{75} (images)	274	190	150

Table 12: Comparison of the abdominal embolization results

	CHU Fes 2013	OFSP [11]
DAP_{75}(Gy.cm^2)	242.4	300
T_{75} (min)	38.46	20
N_{75} (images)	2548	200

5. Conclusion

The present study lead to significant results, as appear on the comparison made with the literature data. It seems clear that the practices, in interventional cardiology and interventional radiology, are well optimized, because the DRLs are considerably lower than those of the literature. In the other hand, the practices, in computed tomography (CT), must be reviewed and more optimized, given that the values of the DRLs are fairly high. In order to improve our medical practices in term of radiation protection of patients, it is recommended to standardize the protocols of the examinations to homogenize the practices and to limit the dispersion of data. Equally, a strong culture of the radiation protection among the operators is necessary to perfect the working climate in the services involve.

References

[1] ICRP, Radiological Protection in medicine, *ICRP Publication 105, Ann. ICRP* 37(6) (2007)

[2] European Commission, Guidance on diagnostic reference levels (DRLs) for medical exposures, *Env. Nuc. Saf. and Civ. Prot, Radiation protection 109*, (1999).

[3] M. Delchambre, Calcul de la dose efficace cumulée reçue par nos patients en tomodensitométrie diagnostique, thesis, *Medical School, Université Joseph Fourier, Grenoble* (2012).

[4] B.J.Radiol, The impact or cardiology on the collective effective dose in the North of England - *DA Broadhead*, 70 (1997), 492-497

[5] A. Aroua, J.-F. Valley, F.R. Verdun, Investigation de la pratique radiologique en suisse: fluoroscopie diagnostique et interventionnelle, *IURA, Lausanne, france* (2004).

[6] MTES, niveaux de référence diagnostiques en radiologie et en médecine nucléaire, *Official Journal of the French Republic*, (Jan. 2012), text 22 out of 147

[7] Health Canada, Safety Procedures for the Installation, Use and Control of X-ray Equipment

in Large Medical Radiological Facilities, *Safety Code 35*, (2008).
[8] OFSP, Niveaux de référence diagnostiques en tomodensitométrie, *Notice R-06-06, Suisse*, (2010).
[9] F. Magnier, J-L. Rehel, B. Aubert, Contribution à l'établissement des niveaux de référence en radiologie vasculaire diagnostique et interventionnelle, *7th congress of SFRP, Angers – France*, (2009)
[10] JL. Georges, B. Livarek, M. Hanssen, JL. Hirsch, F. Albert, M. Pansieri, L. Belle, Radioprotection du patient et cardiologie interventionnelle coronaire dans les centres hospitaliers français, *CNCH, étude RAY'ACT, France, version* 3 (2011).
[11] OFSP, Niveaux de référence diagnostiques en radiologie interventionnelle et en cardiologie, *Notice R-06-05, Suisse*, (2008).
[12] C. Etard, J-L. Rehel et B. Aubert France, Niveaux de référence et optimisation en radiologie interventionnelle, *Séminaire radiologie interventionnelle, Marseille, France* (16 nov 2012).