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Dosimetric study at the adult subjects in standard radiography of the neurological system at the Regional Hospital of Ngaoundéré, Cameroon

Authors: Mbo Amvene J, Gwiswe Gnowe, Ngaroua, Ekobena P.H, Neossi Guena M.

ABSTRACT:

Aim: Dosimetry is a match between image quality and the low dose process in order to ensure the radiation protection of patients. The aim of this study was to evaluate the exposure of patients according to radiographic investigations at the radiology service of the Regional Hospital of Ngaoundere.

Methods: The prospective study involved adult patients with a mass of 70 ± 10 kg, during four months. Our data collected using a form adapted according to the model of the Institute of Radioprotection and Nuclear Safety (IRSN) of dosimetric evaluation in classical radiography were compared with the referential of this institution. The analysis and the processing of the data of each radiographic exploration made it possible to estimate the entrance dose of skin (De) and to compare with those obtained by the same indirect approach and with the DRLs available.

Results: 100 patients were involved in our study. The doses at the entrance of the skin obtained in mGy were respectively 7.57 ± 2.1 and 9.52 ± 0.9 for the face and profile of the skull, 8.77 ± 0.9 for the face/profile incidences of the cervical spine, 6.75 ± 0.3 and 8.13 ± 0.3 for thoracic spine, 9.65 ± 1.5 and 15.77 ± 1.5 for the frontaland profile incidences of the lumbar spine. These results demonstrated that doses delivered to patients were not sufficiently optimized.

Conclusion: Although the radiological images remain interpretable;the elements, such as the technical absence of protocol, the inadequate profile of certain personnel, associated the inexistence of the texts in favour of the practices of protection against radiation, in spite of a permanent alternation of the trainees in radiology were identified like supporting an over-exposure of the patients to the ionizing radiations.

Key words: standard radiography, entrance dose, radioprotection, Diagnostic Reference Level (DRL)

INTRODUCTION

The irradiation related to the acts of radiodiagnosis constitutes the principal artificial source of ionizing radiations to which the man is exposed in hospital medium.The determination of the amounts delivered with the patients is like an adequacy of the quality of the image and the process of optimization of the radiations.The optimization of the amounts delivered during the radiological examinations, by the determination of the Levels of Diagnostic Reference (NRD) and it quality control of the installations and radiological procedure, make it possible to minimize the risk related to these irradiations by reducing the amount received by the patient [1] (Monnehan and *Al*, 2009).

The protection against radiation of the patients in radiodiagnosis is controlled by the principles of justification, optimization and limitation, including the consideration of the Levels of Diagnostic Reference NRD [2] (Gholami and *Al*, 2015).The three great principles of protection against radiation enacted by directive 96/29 Euratom are the justification of the exposures, their optimization and the limitation of the amounts [3] (Michel Bourguignon).Of these principles it should be noted that the justification of an act rests on the decision which awaited information is necessary to the orientation of the diagnostic strategy, it is to say that the benefit of the irradiant act, must be higher than that of another technique not or less irradiant.Optimization as for it consists in carrying out the examination which was decided at the best dosimetric cost without however reducing the quality of information necessary to the diagnosis.So the optimal realization should be in conformity with principle ALARA, *Have Low Have Reasonably Achievable, and* the delivered amounts confronted regularly at the diagnostic levels of reference.Taking into account individual specificities, the limitation of amount delivered with the patient remains a constant concern bus it does not have there lawful limit of amount to the patient as for the workers, the limitation of amount remains not easily applicable and from where its substitution for the diagnostic levels of references (NRD).
However, the linear relation without threshold is the ultimate justification and protection against radiation concerning the irradiations of low dose bases, i.e. the radiations delivered by acts of radiodiagnosis.Indeed, the effects for health with these amounts are not only low, but zero below a precise threshold which would remain to be defined [4] (Barrington and *Al*, 2004).These variations indicate that the good technique of imagery is necessary to reduce the amount to the patients to low the practicable level making it possible to answer the private clinic and to pose the diagnosis [5] (Dlama and *Al*, 2014).Indeed, the amounts delivered with the patients at the time of the procedures of the acts of radiodiagnosis are not sufficiently

controlled and the protocols of work for a given examination differ from a ward with another.Pursuant to the principle of optimization and without calling into question the diagnostic quality of the examination, the dosimetry of the patients remains function of the operational parameters the such high voltage or kilovoltage (Kv), the intensity of the current or milliampere which is a function of time (farmhouse), the morphotype, the incidence, Distance-Hearth-Skin (DFP), Distance-Hearth-Film (DFF).

In radiology, it should be noted that the diagnosis is depend on the quality of the radiological image consequently of the amount on the surface of entry of the skin.The concept of diagnostic level of reference (NRD) is specific to the medical exposures and does not have to be confused with that of "limit of the personal doses" which is applied in the fields of the protection against radiation of the workers and the public.The use of the ionizing radiations at diagnostic or therapeutic ends is indeed incompatible with a lawful limitation of the amounts.The level of irradiation is subordinated to the medical objective.It is to say, to impose "a priori" insuperable thresholds would be a misinterpretation prejudicial with the patients [6] (Beauvais and *Al*, 2004).The Levels of Diagnostic Reference (NRD) correspond to the 75ème percentile, 75% of the individuals receive amounts lower than this value [7] (Olowookere and *Al*, 2012).The NRD are indicators of the quality of the practices making it possible each one to locate its practice compared to the whole of the profession and to correct possible variations.

The NRD are tributary and depend for the majority of the delivered amount, the quality of the equipment, the level of knowledge of the manipulators, and constitute powerful and efficient tools for the optimization of the amount.As observed elsewhere, great variations of the amounts delivered with the patients for the same examination show a cardinal importance for the study of the variations of the amounts [8] (Gray and *Al*, 1999).The useful dosimetric sizes for the evaluation of the delivered amount are the amount at the entry (Of) and the Product Amount-Surface (PDS) [9] (Cordoliani and *Al*, 2002).The amount at the entry of the skin (Of) in conventional radiography can be obtained by calculation starting from the mathematical methods or be measured by a thermoluminescent dosemeter (TLD) [7] (Olowookere and *Al*, 2012).Several approaches (direct or indirect) make it possible to measure the amount at the entry of the skin.Direct approach where the amount at the entry of the skin of the patient is made using a thermoluminescent dosemeter (TLD) as deferred in the literature [10] (Nyathi and *Al*, 2009;[11] Egbe and *Al*, 2009;[12] Ogundare and *Al*, 2004).The indirect approach makes it possible to evaluate the amount at the entry of the skin starting from the parameters of exposure (Kv, farmhouse, and DFP) formulated in the semiempirical model. In a world becoming of more demanding and especially by the search of excellence as regards medical imagery and/or radiotherapy, the knowledge of the amount delivered with the skin, should take all its importance in our context through the technical parameters of realization of a standard radiography in neuroradiology and for a better protection against radiation of the subject.

➢ **General objective:**

To evaluate the amount at the entry of the skin in the adults during standard radiography in neuroradiology.

➢ **Specific objectives**:

- To arise the profile of the technical parameters used;
- To determine the amount of entry to the skin of the subjects using the empirical tool by the method of Davies;
- To compare this amount of entry with the skin at the diagnostic levels of reference, (NRD).

MATERIALS AND METHOD

It was about a monocentric, descriptive and transverse study, which proceeded between April and July 2016, in the service of radiology and medical imagery of the Regional Hospital of Ngaoundéré.

Were included in this study, all the subjects without reference to sex nor of age having undergone an examination of standard radiodiagnosis of neuroradiology for the aforementioned period.The data collected comprised the age, the sex, the anthropometric data of the patients with weights ranging between 70 ± 10 kg as well as the technical parameters used (Kv, farmhouse, DFF, DFP), on two X-ray emitting tubes of mark GENERAL ELECTRIC model 5192454 whose maximum tension at the boundaries was around 150 Kv.

The parameters of irradiation intervening in the calculation of the amount at the entry of the skin were the subject of a calculation of averages, 75èmes percentiles of standard deviations.The calculation of the amount at the entry of the skin consisted in calculating the power, the output (output) of the tube with x-ray [13] (Suchart and Montree, 2011) using parameters of irradiation directly implied in the realization of the examinations with;

$$O/P_{(\mathrm{Mr.})} = A \times 6.53\times10^{-4}\,(\mathrm{mR/mAs})(\mathrm{kVp2})^{-1} \times \mathrm{kVp2} \times \mathrm{farmhouse} \qquad (1)$$

where A a constant equalizes of 0,5;0,8 and 1 for the generator single-phase currents tubes, three-phase and high frequency.Within our framework of study, the tube with x-ray was three-phase.The outputs obtained were converted of (Mr.) in (mGy. farmhouse-1) by multiplication with a factor of 0,00877/mAs [14] (Faulkner et al.., 1999).The amount at the entry of the skin for each patient was calculated by using the parameters of irradiation of each radiographic exploration according to the model of Davies [15] (Olowookere and *Al*, 2009).

$$\mathbf{D_e(mGy) = \left({}^{O}/_{P}\right)\left(\frac{kV}{80}\right)^2 mAs \left(\frac{100}{DFP}\right)^2 BSF \quad (2)}$$

The data analysis and processing of the 75èmes percentiles of the parameters of irradiation as well as the calculation of amount at the entry of the skin (Of) of the patients were carried out by Excel 2010.

The data were collected, processed and analyzed by keeping the most strict anonymity.The data processing was carried out using the software Sphinx Plus² V.5.1.0.6. Only the images of good qualities having been used for the diagnosis were considered.

The study was authorized by the ethics committee of the aforementioned hospital structure.

Conflict of interest: None

RESULTS

Table 1:Sociodemographic characteristics

Radiography	Sex	amount	Age (year)	weight (kg)
			Min -Max	Min -Max
Cranium (head)	M	14	21-49 (32,57 ± 7,48)	62-78 (69,64 ± 4,93)
	F	11	21-44 (32,90 ± 7,10)	65-78 (71,36 ± 4,39)
Cervical Rachis	M	17	26-52 (37,83 ± 8,34)	62-79 (69,66 ± 5,51)
	F	7	24-55 (37,85 ± 9,49)	63-79 (71,57 ± 5,82)
Dorsal Rachis	M	18	28-56 (41,61 ± 8,13)	64-80 (70,38 ± 5,17)
	F	7	30-55 (42,85 ± 7,95)	67-76 (71,14 ± 2,69)
lombar Rachis	M	12	29-55 (43,41 ± 8,63)	63-78 (69,16 ± 3,67)
	F	14	35-54 (44,5 ± 6,13)	68-80 (75,78 ± 2,88

- For a total of 100 subjects, the men were represented than the women is 61%, for a sex ratio (H/F=1,56).

Being the male sex:

- the average age of the men was 32,57 and the standard deviation was 7,48 years, the age bracket lay between 21-49 years for cranium;
- the average age was 37,83 and the standard deviation was 8,34 years, the age bracket lay between 26-52 years for the cervical rachis;
- the average age was 41,61 and the standard deviation was 8,13 years, the age bracket lay between 28-56 years for the dorsal rachis;
- the average age was 43,41 and the standard deviation was 8,63 years, the age bracket lay between 29-55 years for the lumbar rachis.

Being the female sex;

- the average age of the women was 32,90 and the standard deviation was 7,10 years, the age bracket lay between 21-44 years for cranium;
- the average age was 37,85 and the standard deviation was 9,49 years, the age bracket lay between 24-55 years for the cervical rachis;
- the average age was 42,85 and the standard deviation was 7,95 years, the age bracket lay between 30-55 years for the dorsal rachis;
- the average age was 44,5 and the standard deviation was 6,13 years, the age bracket lay between 35-54 years for the lumbar rachis.

Table 2:Output of the tube in $\mathbf{mR}$ and $\mathbf{mGy.(mAs)^{-1}}$

Radiography	Incidence	Output $(\mathbf{mR})$		Output $\mathbf{mGy.(mAs)^{-1}}$	
		Min	**Max**	**Min**	**Max**
Cranium (head)	F	22,07	25,59	0,19	0,22
	P	22,08	29,38	0,19	0,25
cervical Rachis	AP/P	21,39	29,38	0,18	0,25
dorsal Rachis	AP	22,07	29,38	0,19	0,25
	P	22,07	9,38	0,19	0,25
lombar Rachis	AP	22,07	29,38	0,19	0,25
	P	25,59	33,43	0,22	0,29

These values constitute essential parameters in the process of optimization of the delivered amount and the quality of the stereotypes.They are directly a function of the high voltage (Kv) and the load (farmhouse).

- **For cranium,** in mGy.(mAs) $^{-1}$, output went from 0,19 to 0,22 from face and 0,19 to 0,25 of Profile;
- **For the cervical rachis,** in mGy.(mAs) $^{-1}$, output went from 0,18 to 0,25 in AP that out of P;
- **For the dorsal rachis,** in mGy.(mAs) $^{-1}$, output went from 0,19 to 0,22 in AP that out of P;
- **For the lumbar rachis,** in mGy.(mAs) $^{-1}$, output went from 0,19 to 0,25 in AP and 0,22 to 0,29 of Profile.

Table 3:Technical parameters used

Radiography	Incidence	kV	mAs	DFF	DFP	De		3ème quartile	SD
						Min	Max		
Crânium	F	65-70 (63,3 ± 3,6)	50-64 (54,2±2,5)	1,1-1,4 (1,1 ± 0,00)	1,3-1,6 (1,49±0,09)	7,5	9,0	7,57	2,1
	P	65-75 (66,7 ± 2,1)	50-65 (55,8±1,9)	1,1-1,4 (1,1± 0,00)	1,3-1,6 (1,49±0,09)	9,7	10,4	9,52	0,9
Cervical rachis	AP/P	64-75 (69,5±3,2)	32-40 (35,9±3,8)	1,0-1,2 (1,0±0,05)	1,2-1,5 (1,31±0,10)	5,3	8,7	8,77	0,9
Dorsal rachis	AP	65-75 (67±2,1)	40-60 (46,7±3,7)	1,0-1,4 (1,2±0,06)	1,4-1,7 (1,53±0,07)	7,2	9,6	6,75	0,3
	P	65-75 (70,2±1,0)	45-60 (49±1,9)	1,0-1,4 (1,2±0,06)	1,4-1,7 (1,53±0,07)	8,1	10,4	8,13	0,3
Lombar rachis	AP	65-75 (67,1 ± 2,4)	50-65 (55,9±4,2)	1,0-1,4 (1,1 ± 0,10)	1,3-1,7 (1,49 ± 0,09)	9,0	10,4	9,65	1,5
	P	70-80 (74,5 ± 2,77)	60-65 (60,4 ± 1,2)	1,0-14 (1,1± 0,10)	1,3-1,7 (1,49 ± 0,09)	13,7	14,5	15,77	1,5

kV : kilovolt ; mAs : milliampère seconde ; DFF: Distance-Foyer-Film; DFP: Distance-Film Peau; De: Dose à l'entrée; SD: Standard Déviation

For cranium, and in mGy, the third quartile was 7,57, the standard deviation was 2,1 and the amount minimum and maximum at the entry of the skin varied between 7,5 and 9,0 in AP;the third quartile was 9,52, the standard deviation was 0,9 and the amount minimum and maximum at the entry of the skin went from 9,7 to 10,4 of Profile.

- **For the cervical rachis,** and in mGy, the third quartile varied between 8,77, the standard deviation was 0,9 and the amount minimum and maximum at the entry of the skin varied between 5,3 to 8,4 in AP in AP that out of P.
- **For the dorsal rachis,** and in mGy, the third quartile varied between 6,75, the standard deviation was 0,3 and the amount minimum and maximum at the entry of the skin varied between 7,2 to 9,6 in AP;the third quartile was 8,13, the standard deviation was 0,3 and the amount minimum and maximum at the entry of the skin varied between 8,1 to 10,4 of Profile.>.>.
- **For the lumbar rachis,** and in mGy, the third quartile varied between 9,65, the standard deviation was 1,5 and the amount minimum and maximum at the entry of the skin varied between 9,0 to 10,4 in AP; the third quartile was 15,77, the standard deviation was 1,55 and the amount minimum and maximum at the entry of the skin varied between 13,7 to 14,5 of Profile.

Table 4: Comparison between our values and certain referential values

		De (mGy)				
Radiography	**Incidence**	**Notre étude**	**NRD**	**Soudan 2016**	**Iran 2016**	**Iran 2015**
			Européen	Abu Khiar et *al.*[16]	Khoshdel-Navi et *al.*[17]	Gholami et *al.*[2]
Crânium (head)	F	**7,57 ± 2,1**	3	1,9 ± 0,164	3,05 ± 0,98	3,48 ± 2,87
	P	**9,52 ± 0,9**	5	1,2 ± 0,193	1,42 ± 0,79	2,73 ± 1,34
Cervical rachis	AP/P	**8,77 ± 0,9**	4	1,35 ± 0,267	1,07 ± 0,38	2,13 ± 1,80
		-	-	1,67 ± 1,130	1,17 ± 0,37	1,53 ± 1,06
Dorsal rachis	AP	**6,75 ±0,3**	5	-	3,1 ± 0,73	12,47 ± 8,69
	P	**8,13 ±0,3**	7	-	4,61 ± 3,14	3,73 ± 0,82
Lombar rachis	AP	**9,65 ±1,5**	10	4,9 ± 0,625	3,55 ± 0,82	9,57 ± 8,73
	P	**15,77 ± 1,5**	25	18,5 ± 1,661	4,69 ± 0,78	18,99 ± 23,89

The values obtained were compared with the referential values and those obtained elsewhere for the same approaches.

- **For cranium,** in mGy, the amount at the entry of the skin was of 7,57 ± 2,1 of face and 9,52 ± 0,9 of Profile.
- **For the cervical rachis,** in mGy, the amount at the entry of the skin was of 8,77 ± 0,9 in AP that out of P

- **For the dorsal rachis,** in mGy, the amount at the entry of the skin was of 6,75 ± 0,3 AP and 8,13 ± 0,3 of Profile
- **For the lumbar rachis,** in mGy, the amount at the entry of the skin was of 9,65 ± 1,5 AP and 15,77 ± 1,5 of Profile.

DISCUSSION

In standard neuroradiology, the knowledge of the amount of entry to the skin becomes more and more a need in a more demanding world but also in perpetual change.The standard examinations of neuroradiology occupy the daily newspaper of radiographies after the exploration of the thorax.The good radiographic practice implies of this fact a permanent adaptation of the technical procedure related on the sociodemographic data, the equipment and the choice of the parameters (irradiation and geometry) which constantly influence the amount received by the patient and in bond with the irradiation and the geometry of the beam of X-radiation.

The contribution of the sociodemographic data of the patients remains paramount, for the good technical realization.Indeed, the age of the patient is a significant parameter in the choice of the technical parameters and the interpretation of the examinations carried out as well as the means of protection against radiation.In that, our results approach those of Moifo (Moifo and *Al*, 2014) [18].Indeed, one is brought more and more to work in the conformity of the bulletins of examination by laying a stress in his good filling and while insisting on the administrative elements [18], in particular the name and the age with their corollary in context, the school level and the problems involved in the communication, all things which can resound on the absence of conformity in the filling of bulletins of examinations.

Moreover, the protection against radiation of the patients through the evaluation in dosimetric term in a structure located at the heart of the medical activities of the area of Adamaoua.These results cannot be extrapolated with the whole of the radiological services Camerounais insofar as the participation in the dosimetric study of this service were based on principle of voluntariate.Nevertheless, they constitute actual values and indicative because they relate to the standardized procedures carried out on patients of morphotypes well defined (mass ranging between 60 and 80 kg).The calculation of the average sizes dependent on (mGy) starting from the 75ème percentile has as a principal objective to illustrate a determination of the NRD by an indirect approach in order to indicate existing margins between the values suggested like referential and those estimated elsewhere by the same approach.However, in spite of the existence of a law framing protection against radiation and an agency in main road of protection against radiation [19] (Ongolo-Zogo and *Al*, 2011), the absence of the technical protocols in the room of examination makes difficult the maitrise of the amounts delivered to the patients.As observed elsewhere, the absence of the texts in favour of protection against radiation and or extracted in this service from radiology proves the embryonic state of the protection against radiation of the patients in this service of radiology.In practice, while posting and by applying the latter, it is possible to avoid an useless irradiation in spite of the routine frequentation of the trainees in radiology obliged to carry out stereotypes of good quality without any indicative knowledge of the properties of the X-ray emitting tube.This report is still very alarming, when radiographies are carried out with the daily newspaper by some assistance-looking after which do not have any profile "background" of the field but rather converted into manipulators in radiology.The latter do not have then is any idea or then an approximate knowledge of the texts in favour of protection against radiation.These observations bring to note that contrary to the developed countries, in the countries of sub-Saharan Africa, in particular at Cameroun the legislative and regulatory executives either non-existent or are implemented in an approximate way and the practices of the protection against radiation of the patients are documented little [19] (Ongolo-Zogo and *Al*, 2011) in a context of expansion of the medical imagery.If the report is real through this study, it is advisable to raise the embryonic and precarious state of the standards and devices in favour of the protection against radiation of the patients in the process of optimization of the amount received by the latter during examinations of radiodiagnoses.Much more, it is advisable to retain that at the time when the imagery extends in the zones most moved back from the country, it is urgent to optimize the protocols of work.This optimization of the protocols could be carried out by the formation continues, posting in the rooms of examinations of the protocols of work and a permanent comparison of the values to the references and measurements of permanent correction could partly reduce the variations observed.However, the reduction of the amounts delivered with the patients could be effective well by the setting places of a lawful framework with obligation of designation and of qualified training of people in protection against radiation (PCR) which would not only make it possible to improve protection against radiation of the patients but also of the personnel, equipping more than the console of handling offers a platform of adjustment of the parameters of irradiation and dosimetric controls.

Conformity with the reference frames and values besides

Table 4 draws up a comparative state between the results obtained, the reference frames (NRD) and the values estimated elsewhere.This table indicates that the values obtained are well above the standards referential and higher than those estimated elsewhere by the same method.These variations were in a specific way associated the going beyond of the face values as suggested by the manufacturer in spite of the absence of protocols.

The radiographic resumption of the examinations is a significant avoidable or at least reducible factor of over-exposure of the patients.It is necessary to consider measurements of efficient correction and reduction such as the periodic evaluation and the control of the dosimetric values.

CONCLUSION

This evaluation study according the dosimetric term of the procedures of the acts of radiodiagnosis of the neurological system. However, the analysis relating to the posting of the protocols of work in the rooms of examinations in particular to the service of radiology of the regional hospital of Ngaoundéré associated with the reinforcement with competences (formation continues and recycling) as regards protection against radiation remains very alarming in a context where this discipline is practised more and more by personnel not having any knowledge of the ionizing radiations.In radiology, the dosimetry of the patients is like an adequacy between the quality of the image and the process at low dose.The permanent evaluation with the periodic means of controls and the professional practices, the fight for the reduction of the delivered amounts should be in the center of the daily activities of the structure in load through effective follow-ups on the ground and in all the structures equipped with the tubes with x-ray.

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