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

Determination of Diagnostic Reference Levels in Côte d'Ivoire: Case of the Adult Skull Computed Tomography in the District of Abidjan

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Abstract: ***This study which the objective is the establishment of the diagnostic reference levels (DRLs) in computed tomography (CT) for the examination of the skull in the district of Abidjan for adult, is a first study in Côte d'Ivoire. The analysis of the relative data to domestic surveys from October 2015 to January 2016 from the scanner consoles of 126 patients of two hospitals in Abidjan, Military Hospital of Abidjan (HMA) and the Universal Hospital of Cocody (CHUC) was carried out. This analysis provided an estimate of the exposure levels for the skull scan. For each hospital and for both, the mean value and the DRLs, obtained by the 75th percentile method in CTDIvol (50.9 mGy) and in DLP (982.879 mGy.cm), were calculated. For the whole study, the DRLs in CTDIvol obtained, is lower than the guidance value established in many countries such as Germany, Sweden, Switzerland, France, UK, USA and Ireland. For the DRLs in terms of DLP, the result is mitigated. It is higher than the ones found in Germany, UK and Ireland and lower than in the others. These results obtained only with two hospitals show the feasibility of this study to determine the DRLs at the national level and to plan their periodical review in Côte d'Ivoire.***

Keywords: computed tomography, skull scan, CTDIvol, PDL andDRLs

1. Introduction

According to a study carried out by the French Society of Radiology (SFR) [1], more than 60% of the routine imaging examinations on the skull, respiratory system and skeleton are performed on conventional X-ray systems. Thus, is irradiation of medical origin the main artificial source of ionizing radiation to which man is exposed? The optimization of doses delivered by the determination of the DRLs and the control of radiological facilities, enables minimizing the risks related to irradiation by reducing the dose of patients. In many countries, studies were carried outto determine the DRLs. The first DRLs were introduced in the French regulation in the decree of the 12th February 2004 on diagnostic reference levels in radiology and nuclear medicine, suite to the works done in common with IRSN, SFR,the French Society of Physical Medicine (SFPM) and the French Association of Paramedical Personnel Electroradiology (AFPPE) between 1999 and 2003 [2].

The study carried out by Beauvais et al between April 2001 and February 2003 in 24 services of radiology, was a first step for the determination of DRLs values specific to French practice [3].The various reports of the IRSN studies, often in collaboration with InVS concerning the CT data such as 2004-2006, 2007-2008, 2009-2010 and 2011-2012, are some illustrations of these studies. IRSN has proposed and obtained the possibility from the Ministry of Health to revise the DRLs in France [4]. Similarly, in Germany, Sweden, Switzerland, USA etc., studies were made to determine the DRLs. It's in this context that appears the idea of DRLs in Côte d'Ivoire (CI), the result of cooperation with IAEA. In fact, through a technical cooperation untitled: «Strengthening radiological protection of patients and control medical exposure (AIEA/ RAF/9/059)», the laboratory of nuclear physic and radiation protection (LPNR) of the University. F.H.B initiated a diagnostic radiology dosimetry (patient) campaign in collaboration with the LNSP's division for the protection against Ionizing Radiation (SDPRI) [5]. This campaign, for standard radiology, aimed at the following objectives:

- Optimize radiological practices by significantly reducing doses of medical exposure;
- Establish the national drls corresponding to the radiological practice in côte d'ivoire and provide for their periodical revisions.

However, CT scanning, now accounts for a major part of X-ray diagnostic exposures and more than one-third of medical exposures [6]. The price to pay for this technological change and the subsequent improvement of diagnostic information, is the increase in the doses delivered to patients. Particularly, in CI where the proliferation of scanners is a reality in recent years. Many changes are under way in the field of radiation protection at the national level, with the establishment of the ARSN [7]. In order to provide a basis for the feasibility of a national study of patient exposure measurement in CT of skull, it's necessary to carry this study whose general objective is to determine DRLs for CT scans of the skull in terms of dose-length product (DLP) and volume computed tomography dose index (CTDIvol).

2. Material and Methods

2.1 Frame and study population

This study was carried out in Côte d'Ivoire precisely in the health district of Abidjan.X-ray CT examinations were

carried out in the radiology departments of the Military Hospital of Abidjan (HMA) and CocodyTeaching Hospital (CHUC). Our work involved a sample of 126 adult patients of both sexes who had to perform the most common, skull scan. The study period runs from October 2015 to January 2016. CT examinations were performed on patients with body mass ranging from 45 kg to 102 kg, skull thickness ranging from 13.9 to 16.8 cm. The patients considered are adults, at least 15 years old in relation to the IRSN report [8]. The scanners used are all Hitachi helical scanners of the hatched series and equipped with 16 strips or detectors. The CHUC scanner was installed in 2007 and that of HMA in 2008.

2.2 Physical requirements and dosimetric methods

At the CT, several indices of measurement are known to assess, evaluate and control the doses of irradiation of patients. But unlike conventional radiology, dose calculations are more complex at the scanner. This is due to the principle of complex operation of the scanner: rotation of the beam around the patient instead of a fixed field and multicouple detectors. These dose indices are:

- computerized tomographic dose index (CTDI);
- the CT scan rate over 100 mm (CTDI 10cm);
- the weighted computerized tomographic dose index (CTDI), this size takes into account the difference between the doses at the centre and at the periphery of the irradiated organ (ghost). Depending on whether the CTDI is measured in a "head" or "body" phantom, it is denoted CTDI (t) or CTDI(c);
- volumic computerized tomographic dose index (CTDIvol). This size takes into account the pitch of the acquisition. It represents an average dose in the volume explored in mGy and the dose length product in mGy.cm (DLP). It is defined by the following equation [9] :

$$DLP = CTDIvol \times L \quad (1)$$

Where, L is the length of the exposed organ.

2.3 Diagnostic Reference Levels

Diagnostic reference levels (DRLs) are defined as "dose levels in medical diagnostic, or in the case of radiopharmaceuticals, activity levels, for standard examinations on typical patient groups or phantoms, for wide categories of facility types ". The numerical determination of DRLs is based on the statistical method known as the 75th percentile of the distribution of doses measured at the entrance surface for a given procedure, on a large number of patients distributed over a large number of centres representative of the practice of a country. Radiation protection of persons exposed for medical reasons rests exclusively on the principles of justification and optimization. Every act must first and foremost be justified, that is to say to bring a greater benefit to the risk potentially incurred. It must then be carried out in an optimized manner: This means that the delivered dose must be as low as possible compatible with the informative quality of the image, necessary for a good diagnosis. This hides any idea of dose limitation in diagnostic radiology.

3. Results and Discussion

The results are relative to the measurements of doses received by the patients between October 2015 and January 2016, the DLP obtained by calculation and the DRLs obtained by the 75th percentile for the examination of the skull with or without injection of contrast product. Table 1 presents the skull scan for each of the two services and their aggregate number of patients, patient weight, minimum and maximum mean and 75th percentile (DRLs) values of CTDIvoL and DLP. Table 2 summarizes the DRLs values in effect in other countries and those of the study (Côte d'Ivoire). The figure 1 shows the comparison of DRLs measured in this and those in other countries.

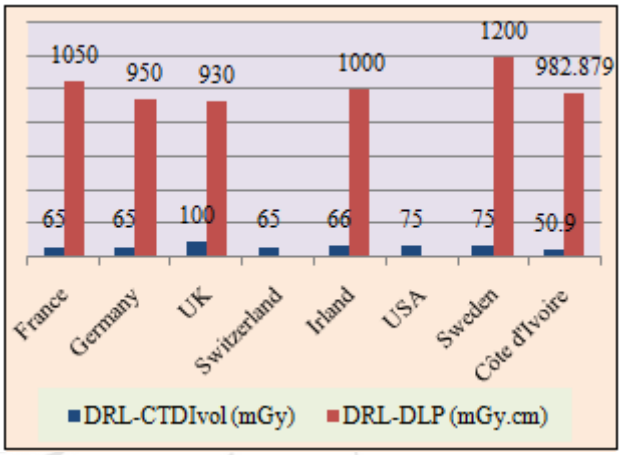

Figure 1: Comparison of the DRL values in force in some countries and those of this study

In this study which carried out only in two public hospitals in Abidjan, the number of patients per centre was not fixed, as was the case of Beauvais and al [3] have a reduced sampling on the whole study. Conversely, the various reports of the IRSN and lnVS studies on dosimetric data, the number of patients was fixed in accordance with French regulations. As part of the monitoring of radiation protection for patients, every person in charge or holder of CT scans must provide the IRSN with data on the exposures of 30 patients per examination in order to establish the DRLs and their revision every year [11]. This has resulted in a high level of data for these studies. Thus, regardless of weight, for the 126 adult patients (aged at least 15 years) who performed a cranial scan, it can be seen from table I that a large dispersion of CTDIvol and DLP for the same examination, The same centre, the same equipment and from one centre to another.

However, this should not be the case according to the IRSN report specifically for the cranial scan for adults [8]. For the CTDIvol at CHUC, it appears that the mean value of 51.54 mGy is greater than the DRLs of this service which is 50.9 mGy. For the PDL, the mean value of 916.8 mGy.cm is less than the DRLs of this service 1030.7 mGy.cm. At the military hospital of Abidjan (HMA), the mean value of the CTDIvol of 48.04 mGy and that of the DLP of 858.375 mGy.cm are all less than the 75th percentiles of this service respectively of 52.5 mGy and 937.5 mGy.cm. At the CHUC, dosimetric evaluations should be performed. If the results show a regular overrun of the DRLs, in terms of CTDIvol by the calculated mean dose for a significant number of patients,

a review of procedures and control of facilities is required. Corrective action should be considered if there is no justification for exceedance [12].

Moreover, compliance with reference levels is not the only criterion of good practice. On the one hand, the principle of justification of acts must first be respected; on the other hand, the non-exceeding of the reference levels does not eliminate the need to pursue the optimization approach, keeping the permanent objective, inseparable from Dosimetry, diagnostic or therapeutic quality. The results relating to the whole of the study recorded in Table I also reveal a great dispersion of the measurements studied. But in this case it is important to know that the mean values of CTDIvol and DLP are all lower than the DRLs of each of these measurements of the whole study. This is encouraging at the overall level. In order to be in line with international levels, Table II summarizes the DRLs of this work and those in force in other countries. It appears that these values are below the DRLs proposed by the European Commission in 1996 respectively 58 mGy for the IDSP and 1050 mGy.cm for the PDL [13]. The histogram allows comparing these values between them. The DRLs of our study in CTDIvol is lower than those in force in France, Germany, Sweden, Switzerland, USA and that propose by European commission (CE).These encouraging results are due to the fact that European and non-European DRL values have been established on the basis of a 10-year study, which reflects the state of the CT scans at that time. This is very different from the new system of current scanners. It would be amazing with the many possibilities of dose reduction offered by scanners (pitch, collimation, cutting thickness, etc.) that current DRL values are higher. The use of helical and multi-bar scanners and optimization methods can only lead to a downward revision of the DRLs [21].

Moreover, the DRLs values in DLP are lower than those in France and Sweden but are higher than in Germany, the United Kingdom, Switzerland and Ireland. The DRLs values obtained due to 50.9 mGy and 982.879 mGy.cm respectively for CTDIvol and DLP proves the feasibility and provide the basis for a dosimetric evaluation whose objective is the determination of the CT Scan DRLs It is therefore appropriate, within the framework of a national project, to extend the study throughout the country in order to have a representative sampling of the scanning practice in the country and in accordance with the organizational recommendations of other countries such as IRSN.

4. Conclusion

The study carried out from October 2015 to January 2016 in only two scanning services of hospitals in Abidjan under the initiative of the LPNR of the Félix HouphouëtBoigny University (U.FHB) gives guidance and an overview of the doses received by the patients during the CT scan. It is proof of the feasibility of a dosimetric CT scan in Côte d'Ivoire. However, this study should be extended to a large number of hospitals, all over the whole country and to the most widely scanned CT scans because of the proliferation of scanners in Cote d'Ivoire in recent years due to diagnostic quality which it offers for the management of patients. This will make it possible to establish the national DRLs and to foresee their revision through the ARSN which has just been set up in the Côte d'Ivoire in order to continue the optimization of the doses received by the patients.

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Table 1: Computed tomography dose index (CTDIvol) and Dose LengthProduc (DLP), for skull acquisition andfor the different departments involved in the study and their set

Scanning *Services*	*Number of Patients*	*weight (kg) Patients*	*Dose received by acquisition CTDIvol(mGy)*				*DLP by acquisition (mGy.cm)*			
			Min	Max	Mean	75thpercentile	Min	Max	Mean	75èmepercentile
HMA	54	40-100	36.3	63.6	48.04	52.5	604.395	1494.6	858.375	937.5
CHUC	72	40-102	25.4	63.8	51.54	50.9	419.1	1638.3	916.8	1030.725
Both services	126	40-102	25.4	63.8	49.9	50.9	419.1	1638.3	889.383	982.879

Table 2: The DRLs (CTDIvol and DLP) values in Côte d'Ivoire and other Countries

Country	*France (2011) [13]*	*Germany (2010) [13]*	*UK (2003) [13-14]*	*Switzerland (2011) [13-15]*	*Irland (2010) [13-16]*	*USA (2008) [13-17]*	*Sweden (2002) [13-18]*	*Côte d'Ivoire (2016)*
CTDIvol (mGy)	65	65	65_1/ 100_2	65	66_1/58_2	75	75	50,9
DLP (mGy.cm)	1050	950	930	1000	940	-	1200	982.879