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Diagnostic Reference Levels for Adult Patients Undergoing Cranioencephalic and Abdominal Pelvic CT-Scans at the University Hospital of Treichville in Côte d'Ivoire

Issa Konaté[1], Koutoua Joseph Anouan[1], Aka Antonin Koua[1], Vas Souleymane Bakayoko[2]

[1]Nuclear Physics and Radiation Protection Team, Training and Research Unit-Sciences of the Structures of Matter and Technology, University Félix Houphouët-Boigny of Abidjan, Abidjan, Côte d'Ivoire
[2]Direction des établissements privés et des Professions Sanitaires (DEPPS) du Ministère Ivoirien de la Santé, Abidjan, Côte d'Ivoire
Email: anouan.koutoua@ufhb.edu.ci

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Abstract

Objectives: To investigate the dose delivered to adult patients during cranioencephalic and abdominal-pelvic examinations in computed tomography (CT) in order to set up the Local Dosimetric Reference Levels (LDRLs) of the University Hospital of Treichville (UHT) for the radiation protection of patients undergoing CT scans. **Methods**: This study was prospectively performed on 153 CT images of adult patients including 120 CT images of cranioencephalic (CE) and 33 CT images of the abdominal pelvic (AP) examinations. These images were acquired on the CT system INSITUM with 64 bars, manufactured by the company SINOVISION and commissioned in 2021 at UHT. Then the volume computed tomography index ($CTDI_{vol}$) and the dose-length product (DLP) were determined. **Results**: Based on the statistical method of 75th percentile, the obtained LDRLs as $CTDI_{vol}$ and DLP are 54.37 mGy and 28.07 mGy, 1716 mGy.cm and 1490.8 mGy.cm respectively for CE and AP examinations. Comparing our results with those from different international studies, $CTDI_{vol}$ and DLP values obtained in the present work are higher. **Conclusion**: LDRLs for dosimetric quantities such as $CTDI_{vol}$ and DLP for CE and AP examinations have been set up in this study. It will contribute with further studies to the national diagnostic reference levels of cranioencephalic and abdominal pelvis CT exams for strengthening the radiation protection of patients in Côte d'Ivoire.

Keywords

Computed Tomography, Cranioencephalic, Abdominal Pelvic, Radiation Protection, Diagnostic Reference Levels

1. Introduction

Diagnostic Reference Levels (DRLs) are internationally recommended standards aimed at minimizing patient exposure to radiation during medical imaging procedures, particularly in high-dose exams like computed tomography (CT) scans [1]. The International Commission on Radiological Protection (ICRP) first proposed DRLs, and these guidelines have since been incorporated into global safety frameworks, including the International Atomic Energy Agency's (IAEA) safety standards [1]. In Europe, DRLs were formally integrated into regulations in 1997 and further strengthened by the 2013 directive (2013/59/Euratom).

In Cote d'Ivoire, DRL studies have primarily focused on conventional radiology, largely through collaboration with the IAEA [2]. However, there is limited data on DRLs for CT scans, despite CT being one of the highest sources of radiation exposure in medical Imaging [3]. This study aims to establish local DRLs for cranioencephalic (CE) and abdominal pelvic (AP) CT examinations at the University Hospital of Treichville (UHT). High or low radiation doses from CT scans could involve specific health risk for patient such as cancers or leukaemia. The local DRLs developed here will be compared with international measurements to inform and improve radiation safety protocols in Cote d'Ivoire.

2. Materials and Methods

Our study was carried out using the CT-scan device INSITUM of 64 bars manufactured by the company SINOVISION and commissioned in 2021 at the University Hospital of Treichville. The technical characteristics of this CT device are as follows: the current varies from 10 to 420 mA, the slice thickness varies from 0.625 to 1 mm, the X-ray tube rotation time is 100 s continuous max, the pitch is from 0.2 to 1.75. There is a private company providing subcontracting for external maintenance of this CT device at the diagnosis and medical imaging department of UHT. The checking, the quality control and the calibration of this CT device before the beginning of our study was led by a biomedical engineer of this maintenance company.

This study was conducted from 19 July to 03 September 2023, corresponding to 47 days of survey. It consists of 153 adult patients over 18 years old who came to perform their CT scan at the radiodiagnosis and medical imaging department of the UHT. The most frequently performed examinations and the most irradiating (CE) and the AP examinations are taken into account in our study. The data collection plan considers an outreach to technicians and physicians before collecting and compiling the data for analysis and interpretation.

We worked essentially on patient records on which the physical parameters of acquisition and patient dosimetry are recorded for each of the CT scans selected in our study. It concerned the CE exam without contrast materials for 120 patients and the AP one also without contrast materials for 33 patients. We recorded acquisition parameters such as kV, mAs, pitch, $CTDI_{vol}$ and DLP from the INSITUM CT-scan console after the examination of each patient in our cohort.

3. Results

This study included a sample of 153 patients with 50 women (32.7%) and 103 men (67.3%) of the study population. Their ages ranged from 18 to 92 years. Their weight varied between 55 and 85 kg. We calculated the arithmetic mean of $CTDI_{vol}$ ($CTDI_{vol,moy}$) and the mean of DLP rated (DLP_{moy}). We found that for the CE examination, $CTDI_{vol,moy}$ = 52.49 mGy and DLP_{moy} = 1503.18 mGy.cm. For the AP exam, we obtained $CTDI_{vol,moy}$ = 20.52 mGy and DLP_{moy} = 1128.06 mGy.cm (**Table 1**). These results indicate that the values of $CTDI_{vol,moy}$ and DLP_{moy} for CE exam are larger than those of AP CT-scan.

Using the 75th percentile statistical method [4] for each of the two types of CT-scan including CE exams on a sample of 120 patients and AP on a sample of 33 patients, the DRLs of $CTDI_{vol}$ and DLP for CE and AP were calculated.

Table 1. DRLs and mean values for the $CTDI_{vol}$ and DLP for the CE and AP.

CT-Exams	$CTDI_{vol}$ (mGy)		DLP (mGy.cm)	
	AVERAGES	DRLS	AVERAGES	DRLS
CE	52.49	54.37	1503.18	1716
AP	20.52	28.07	1128.06	1490.8

Table 2. Value of DRLs obtained in studies performed in Côte d'Ivoire.

CT-exams	Our study (mGy.cm)	CHUC (Monnehan *et al.*, 2017) (mGy.cm)	HMA (Monnehan *et al.*, 2017) (mGy.cm)
CE	1713.9	1030.73	937.5
AP	1490.75	-	-

Our study showed that the DRLs values for CE are the highest compared to those of the AP (**Table 1**). For each of the two examinations, the mean of each dosimetric quantity considered ($CTDI_{vol}$ and DLP) is lower than the corresponding DRLs. We observed in (**Table 2**) for the CE CT-scans that our value of DRLs, for DLP, is higher than those obtained in Côte d'Ivoire at the University Hospital of Cocody (CHUC) 1312 mGy.cm and at the Military Hospital of Abidjan (HMA) 937 mGy.cm [5]. Moreover, in **Figure 1**, our DLP value is also higher than those obtained in Togo [6], Jordan [7], Switzerland [8], France [9], and Australia [10], for both CE and AP CT-scans. Our obtained value of $CTDI_{vol}$ as DRL is lower than the corresponding values from international studies except that of Australia for CE, and is the highest value of DRL for AP. The average $CTDI_{vol}$ are 51.5 mGy and 52.9 mGy and the average DLP are 1437.8 mGy.cm and 1530.1 mGy.cm respectively for women and men for cranioencephalic exams. And it's the same trend for abdomen pelvis exams with averages values such as 19.6 mGY and 21.3 mGy as $CTDI_{vol}$ followed by 1076.5 mGy.cm and 1171.01 mGy.cm as DLP. These values suggest that there could have no notable differences in radiation doses between male and female patients.

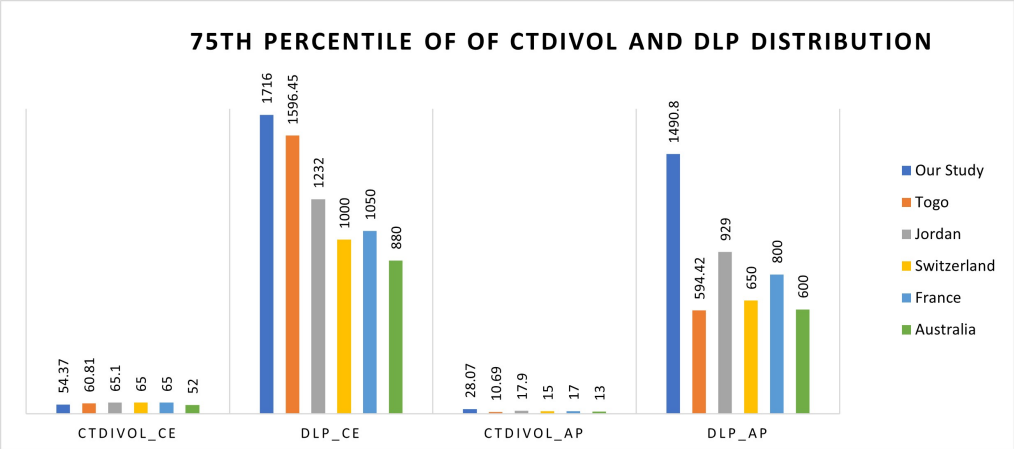

Figure 1. Comparison of $CTDI_{vol}$ and DLP values for CE and AP of our study with international values.

4. Discussion

The intrinsic factors that are not user-modifiable and specific to each device (focus and beam geometry, collimation, detector property) produce invariable, constant dosimetric data related to the device. But, the extrinsic factors thus modifiable by the user such as kV, mAs and pitch act differently on the final dosimetric data such as $CTDI_{vol}$ and DLP according to the choices of acquisition parameters performed by the operators [7]. We used average value of $CTDI_{vol}$ an DLP to compare these parameters with respect to patient sex male or female because there are no sufficient data to get separately the DRLs of women and men who underwent CT-exams in this study. Based on the obtained values, we could conclude that there are no notable differences in radiation doses between male and female patients. The highest value of DRLs for CE compared to that of AP is due to the increasing of the $CTDI_{vol}$ with the thickness of the scanned anatomic region of the patient, any other parameter kept constant [11]. The mean values of $CTDI_{vol}$ and DLP smaller than the corresponding DRLs values suggest that practices are optimized [8]. But in practice, the high value of DRLs determined in our study for CE and AP compared to values obtained in international studies [6]-[10] and to those of local DRLs established by Monnehan *et al.* at CHUC and HMA [5], local structures in Côte d'Ivoire, could be explained by the lack of optimized clinical protocols. The high DRLs found in this study are likely due to specific practices at UHT as it's not the same CT system used across Côte d'Ivoire and the same clinical staff. Indeed, the results found by Anouan *et al.* are comparable to international standard for a study carried out at the University Hospital of Angré [12]. Moreover, imaging technicians are free in the choice of acquisition parameters such as voltage, load, pitch and FOV, etc. This is due to the lack of written and posted protocols for performing different types of CT scans in the department, and also to the empowerment of the teams assigned to the CT station. This situation suggests to assign a medical physicist to radiological questions in radiodiagnosis and medical imaging departments of Côte d'Ivoire and a periodic training of imaging techni-

cians on the importance and interest of the different acquisition parameters and on working methods and procedures. Despite our results showing high DRL levels, they actually not exceed international safety standards because DRLs are optimization tools. These are used to standardize practices, to limit dose dispersion and to remove unnecessary doses. DRLs are not limits, but values that should not be exceeded without special technical or medical justification. DRLs will help to improve clinical practices in radiology in Côte d'Ivoire.

5. Conclusion

We have determined the DRLs of the CT scan for the $CTDI_{vol}$ and DLP at the University Hospital of Treichville. The imaging examinations considered were CE (120 patients) and abdominal pelvic (33 patients). We compared these DRLs values to the mean of each of these dosimetric quantities. This comparison showed that the $CTDI_{vol}$ and DLP are optimized. However, when comparing these DRLs values with those of other studies obtained elsewhere, our values are large. Efforts should be made in our diagnosis and medical imaging department for these two exams by improving CT imaging procedures.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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