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Study of Radiological Practices in Côte d'Ivoire: Case of the Frontal Chest Examination

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Abstract

Objective: The aim of our work is to study radiological practices in Côte d'Ivoire regarding the examination of the frontal chest in order to optimize the dose received by patients. **Materials and Methods:** The work was carried out in 11 of the most frequented radiology centers and involved 330 patients. The equipment used in addition to those that can be found in an X-ray room is the DAP-meter. Using the DAP-meter, we measured the Dose in the air (Dair) then we calculated the Entrance Surface Dose (De). **Results:** We have by the statistical method of the 75th percentile determined the Diagnostic Reference Level (DRL): 0.28 ± 0.03 mGy and by the arithmetic average, the average of the entrance surface dose (Dem): 0.23 ± 0.03 mGy. Since the DRL is lower than the Dem, the dose is said to be optimized. However by comparing the DRL of our work to the DRL values obtained in other countries, we can say that efforts can be made to further protect patients from unnecessary doses. This involves increasing the voltage, decreasing the load, increasing the detector focal point distance, and increasing additional filtration.

Keywords

Optimization, DAP-Meter, DRL, De, Dem

1. Introduction

Human exposure to ionizing radiation also comes from man-made sources, ranging from facilities producing nuclear energy, to medical uses of radiation [1]. In medicine, ionizing radiation is used for diagnosis and treatment.

According to the Institute for Radiation Protection and Nuclear Safety (IRNS) [2], on the distribution of the main categories of radiological examinations, conventional radiology represents 54% of the examinations performed. Conventional radiology thus remains a major source of human exposure to ionizing radiation. However, as beneficial as it is, conventional radiology like all medical uses of ionizing radiation, carries risks due to their potentially deleterious biological effects on health. Studies have shown that people of the same build undergoing the same examination often in the same radiology room receive different doses [3]. This anomaly leads the International Commission of Radiation Protection (ICRP) to sound the alarm bells by introducing the concept of DRL at the beginning of the 1990 [4] and by recommending in 1996 its implementation in the member states [5], to reinforce the principle of optimization of doses received by patients during radiology examinations [6]. In 1997, the European Union made this an obligation for member states by Directive 97/43. In Côte d'Ivoire, similar work was carried out by Monnehan *et al.* [7] in two towns in the South and by Issa Konaté *et al.* [8] in the West of the country on a small sample.

The general objective of our work is to study the radiological practices during frontal chest examinations on all the regions of the Ivory Coast by determining the DRL and the Dem received to analyze X-ray dose received by patients and consider corrective actions if necessary.

2. Materials and Methods

2.1. Sampling Method

We have chosen eleven (11) conventional radiology rooms corresponding to 11 hospitals: Cocody University Hospital Center, Yopougon University Hospital Center, Abidjan Military Hospital, Abidjan Cardiology Institute, International Polyclinic Sainte Anne Marie, Bouaké University Hospital Center, Korhogo Regional Hospital Center, Abengourou Regional Hospital Center, Daloa Regional Hospital Center, San-Pédro Regional Hospital Center, Bangolo General Hospital, thus designated in the order in which we visited them during our study. These centers are spread over all the major regions of the country, namely the North, the South, the East and the West. All the rooms in our study comply with Ivorian standards, namely a surface area at least 25 m^2, a ceiling height at least 3.50 m [9] and have undergone an inspection and quality control by the organization regulatory.

In each of the rooms, we focused on posterior-anterior (PA) frontal chest radiology, which is the most common examination.

For each of the rooms, we collected data for 30 patients, based on IRNS recommendations [10], all over 18 years of age (considered adults). Only adults who can stand up and have a medical prescription including a frontal chest X-ray were considered, in order of arrival. The examinations were performed by the medical imaging technician on duty. Our study involved a total of 330 patients.

2.2. Data Collection Method

We have sent letters to each of the General Managers of the eleven (11) hospitals housing each of the examination rooms. It was after their agreement that our study began. During the 14 months, we went to the radiology rooms selected according to the criteria indicated in the sampling method. The data collection consisted in noting the name of the establishment, the type of examination carried out with the effects, the last inspection date and for each device the year of installation, the make, the model, the filtration total and the Focus-Detector distance (FDD).

The medical imaging technician fixed from the desk, the radiological parameters (voltage in kV and load in mAs) and triggered the X-rays. We could thus record these values and also the dose values in the air (Dair), on the electrometer of the DAP-meter.

2.3. Materials

The materials we used for our work are those existing in a conventional radiology room (X-ray tube and generators, wall stand, X-ray viewer, desk, leaded screen, lead aprons). However, we used for our measurements the Diamentor M4KDK brand DAP-meter type 11017, manufactured in Germany by the company PTW, donated by the International Atomic Energy Agency (IAEA) to the Ivory Coast through the National Public Health Laboratory (NPHL). The DAP-meter has been previously calibrated at the PTW laboratory in Germany-Freiburg.

It consists of a Diamentor brand ionization chamber, size B and an electrometer (DAP meter reading device) from Diamentor.

The ionization chamber is placed at the exit of the tube at the level of the collimator and the electrometer is placed at the level of the desk behind the leaded screen. The ionization chamber and the electrometer are connected by two cords.

The ionization chamber is the main instrument for measuring the dose received by a patient. It is a plastic enclosure containing a gas (air) and two electrodes between which a potential difference is established. When the X-rays pass through this enclosure, they ionize the gas. A current whose intensity is proportional to the flux of X-rays is established in the ionization chamber. This current is conducted by the leads to the electrometer which converts it into Dair [11].

3. Results

3.1. Determination of the DRL in Côte d'Ivoire

The DAP-meter gives us the measurement of Dair then we calculate the dose at the entrance of the patient (De) by the following formula:

$$De = Dair * BSF.$$

BSF = backscattering factor which is 1.35 between 60 kV and 80 kV and 1.5 above 80 kV [12].

From De, we obtained the DRL of De (**Table 1**) for our sample of 330 patients by the 75th percentile method. In descriptive statistics, we define the *p*th percentile as being the rank value $k = \frac{p \times n}{100}$ with n = sample size [13].

Applying it to the 75th percentile, $k = \frac{75 \times n}{100}$ with n = sample size. In our case, for a given examination, the doses of n = 300 patients are classified in ascending order. The DRL corresponds to the dose De of rank

$$k = \frac{75 \times n}{100} \quad (1)$$

3.2. Average Entrance Surface Dose (Dem)

Using the statistical average formula [14], we calculated the average of entrance surface dose for 330 patients (**Table 1**). We find Dem. This value of Dem corresponds to the radiological practices of the rooms of our study [15].

For our study we use the arithmetic average that is to say the sum of the numerical values of doses (sample) divided by the number of these numerical values (see Equation (2)):

$$\text{Dem} = \frac{1}{n}\sum_{1}^{n} xi \quad (2)$$

Each xi represents De for our exam, and n represents the number 330 of patients for the exam.

This DRL value was obtained from all the rooms in our study. It corresponds to the national DRL in Côte d'Ivoire for the De. We can see that DRL is higher than the Dem.

3.3. Voltage and Charge Used

Table 2 includes the average value (see Equation (3)) of the voltage used and the voltage interval (minimum-maximum), the average value of the charge and the charge interval (minimum-maximum) respectively from voltages and charge recorded during the experiment in all the rooms of our study. The average value of FDD and (minimum-maximum),

$$\text{Average} = \frac{1}{n}\sum_{1}^{n} xi \quad (3)$$

Table 1. Comparison of the DRL from De to Dem for the frontal thorax examination in Côte d'Ivoire.

DRL of De (mGy)	Dem (mGy)
0.28 ± 0.03	0.23 ± 0.03

Table 2. Radiological parameters for all the rooms in our study.

Examination	Average Voltage (min-max)	Average Charge (min-max)	Average FDD (min-max)
Chest (P/A)	104.4 kV (57 - 130) kV	7.152 mAs (0.8 - 64) mAs	160 cm (150 - 200) cm

xi (voltage or charge) or FDD.

3.4. DRL from Our Study and DRL Obtained in Other Countries

Table 3. Comparison of the DRL in De obtained in our study with those obtained in other countries and by IAEA.

Examination	Diagnostic Reference Levels in mGy				
	Côte d'Ivoire	Italia [16]	UK [17]	IAEA [18]	France [19]
Chest (P/A)	0.28	0.40	0.15	0.33	0.30

Table 4. Comparison of the DRL in De obtained in our study with those obtained in other African countries.

	Diagnostic Référence Level in mGy					
Examination	Côte d'Ivoire	Cameroun [20]	Soudan [21]	Nigeria [22]	Madagascar [23]	Ghana [23]
Chest (P/A)	0.28	0.35	0.21	0.47	0.29	0.1

3.5. Values of Filtration for the Tube in Our Study

Table 5. Total filtration of the tube in each of the radiology room.

Radiology rooms	CHU Cocody	CHU Yopougon	Hôpital Militaire	Cardiology	Sainte Anne	CHU Bouaké
Total Filtration	1 mm Al	2 mm Al	1 mm Al	0.5 mm Al	1 mm Al	1 mm Al

Radiology rooms	CHR Kgo	CHR, Abengour	CHR Daloa	CHR San-pedro	HG Bangolo
Total Filtration	1 mm d'Al	2.5 mm d'Al	1 mm d'Al	2 mm d'Al	1 mm d'Al

4. Discussion

According to Table 1, the average exposure for the frontal chest examination is located below the DRL, which means that the dose is optimized [15] for this examination in the radiology rooms of Côte d'Ivoire.

By comparing the DRL of the De in our study with that of the IAEA and those of other countries (Table 3 and Table 4), we observe that our value is approximately equal to those of France and Madagascar. However, it is lower than those of the IAEA, Nigeria and Cameroon. In addition, our value is higher than those of Sudan, Ghana and United Kingdom indicating that we can do better in Côte d'Ivoire.

Indeed, the analysis of the values of the voltages and charges used in the rooms of our study (Table 2) shows us that the doses of De can be further optimized. For this it is necessary to choose a higher voltage and a lower charge than those used. Indeed, according to the French Society of Radiology (FSR) [24], the voltage required for a chest examination must be in the range [115 - 140] kV with an average voltage of 125 kV and the charge required for this examination must be in the range [1.5 - 3] mAs. An increase in voltage from 115 to 140 kV leads to a decrease in De from 15% to 20% and a decrease in charge from 3mAs to 1.5 mAs reduces the dose by half. The tendency should be to increase the voltage and decrease the charge, while respecting the required intervals. The average focus-to-film distance is approximately 160 cm. For this examination, only 18% of the centers in our study do so at a focus-detector distance of 200 cm, 18% do so at 180 cm and 64% at 150 cm. The FSR recommends a minimum distance of 150 cm and maximum of 200 cm. The greater the distance, the lower the dose received by the patient. In addition, out of the 11 rooms in our study, for the chest X-ray, only 3 rooms have a total filtration greater than or equal to 2 mm; all the other rooms have a lower filtration (**Table 5**). The existence and increase of additional filtration results in a decrease in De. The total filtration recommended by learned radiological societies is at least 2 mm Al [25].

In our study, our examinations were performed on patients with an average mass of between [70 - 74] kg. In France, the current DRL is obtained for a sample with an average mass in the range [70 - 72] kg [19] and in Cameroon the average mass of patients is 71 kg [20], for the DRL obtained by the work of N. Odette *et al.* On average the masses are identical, which can justify that the DRL of our study for the examination of the frontal thorax is identical to that of France and Cameroon.

5. Conclusion

Our study on radiological practices in Côte d'Ivoire for frontal chest examination allows us to say that the doses received by patients for this examination are optimized by comparing the average of the Entrance Surface Dose Dem to the DRL of the dose at the entrance. It is also observed that the DRL is smaller than or equal to the values obtained by the IAEA and in many countries. However, the dose received by the patients can be further reduced by acting on the radiological parameters, namely voltage, charge, focus-skin distance and filtration of the tube.

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Conflicts of Interest

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

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