DOSE EVALUATION IN CHEST X-RAYS

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ABSTRACT

Objective: A study was carried out to determine whether the dose delivered to the patient during chest X-ray in two positions, posteroanterior and lateral, is in accordance with the value recommended by RDC 611/2022 (IN No. 90). Methodology: An exploratory and descriptive study was carried out based on data previously collected in an observational way in a hospital in the city of Salvador-BA. A total of 200 exposure parameters (voltage and current-time product) were collected from the 100 patients, 50 females and 50 males. These collected data were reproduced in the digital fixed X-ray equipment, belonging to the school clinic of the Federal Institute of Bahia. An X-ray measurement system with an ionization chamber and solid-state dose sensors specific for X-rays was used, which indicated the value of the skin entry dose (DEP) in software installed on a laptop. Results: It was found that the value of EPD delivered to patients is in accordance with the maximum reference value established by RDC 611/2022 (IN No. 90). The values for the current product-time (mAs) showed a great discrepancy between the positions, with an increase of 210%, while the voltage (kV) remained almost unchanged. Conclusion: It is noteworthy that although the value is below the recommended value, there is still the possibility of improvement with the implementation of a quality control and assurance program to contribute to the standardization of procedures and the use of a thickness meter for a better selection of the technical parameters used. Consolidating the application of protocols on an individual basis, taking into account the thickness of the structure to be studied to determine the technical parameters to be applied.

Keywords: Radiography. Thorax. Skin Entry Dose. Placements.

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INTRODUCTION

Since they were discovered, X-rays have played a significant role for diagnostic purposes, being increasingly used as new technologies are implemented to ensure greater safety and better image quality. According to a publication by the United Nations Scientific Committee on the Effects of Atomic Radiation, the total annual number of tests in the world is 4.2 billion. On average, a little more than 574 diagnostic medical examinations per 1,000 inhabitants are carried out per year (Unscear, 2020).

Among them, chest X-rays, as it is a useful, fast, non-invasive, and low-cost exam, continue to be one of the most requested in Brazil, corresponding to about 30% to 50% of X-rays (Guimieri, 2018). This view aims to serve as a record for the investigation of possible health changes in symptomatic or asymptomatic patients.

The quality of the image and the amount of radiation in a radiographic examination are closely linked to the specific technical characteristics, including the exposure parameters of the radiographic techniques such as voltage and current applied to the tube, effective collimation, focal point, patient positioning, focus-film and object-film distance, the operator's technical knowledge and the patient's physical and psychological state (Silva et al., 2013).

A good definition image must be produced with the lowest possible dose for the patient, compatible with an adequate diagnosis (Peixoto, 1999). Radiation will interact with matter through two mechanisms: direct, when radiation interacts directly with important molecules such as DNA, and can cause everything from genetic mutation to cell death; and indirect, when the radiation breaks down the water molecule, thus forming free radicals that can attack other important molecules. This mechanism is important, since our body is made up of more than 70% water (Okuno, 2013)

These interactions, however small, can cause damage to the cell, the biological effects caused by the interaction of ionizing radiation with matter can be of two types: deterministic and stochastic. Deterministic effects occur when irradiation in the body, general or localized, causes more cell death than can be compensated for by the body (threshold of clinical effects). Above this threshold, the severity of the damage increases with dose (Navarro et al., 2008), while stochastic effects are those whose probability of occurrence is a function of dose, with no threshold, as is the case with cancer. Thus, for any irradiated individual there is a chance that certain effects attributable to radiation will manifest themselves (CNEN, 2014). Thus, the higher the dose to which the patient is exposed, the greater the probability of occurrence. The need then arises to ascertain whether the dose delivered to the patient during the examination is in accordance with the principle of optimization, presented by the International Commission on Radiation Protection (ICRP), which defines the dose as being "as low as reasonably practicable".

In view of the factors mentioned above, and with the increasing number of chest X-rays, the present study aims to assess the value of the Skin Entry Dose (PED) to which patients are exposed during chest X-rays performed in conventional X-ray equipment, in two positions, posteroanterior (PA) and lateral.

METHODOLOGY

This study consists of an exploratory and descriptive research. In which, mixed methods combine quantitative and qualitative techniques in the same research design (CRESWELL and CLARK, 2011). In this study, the exploratory method investigates a problem by providing information for a more accurate investigation, which combined with the descriptive method provides additional information on the researched topic, associating effectively (QUALYBEST, 2020).

DATA COLLECTION

The study was carried out based on data previously collected with authorization through a letter of consent from the Institution's Teaching and Research Board in an observational manner in a private hospital in the city of Salvador – BA.

Chest X-rays in two positions, posteroanterior and lateral (routine), were conducted by radiology technicians and technologists. In all, 200 exposure parameters were collected, namely voltage (kV) and current-time product (milliamperes per second, mAs), from 100 patients, 50 females and 50 males. These parameters were collected from the conventional fixed X-ray equipment of the SIEMENS® Multix B model with a constant of 40kV and PHILLIPS® Compact Plus 500 with a constant of 30kV.

As inclusion criteria, typical adult patients of both genders and aged 18 years or older were selected for sampling. RDC 611/2022 (IN No. 90), defines the typical individual as one in whom the biometric characteristics are: weight between 60 and 75 kg and height between 1.60 and 1.75 m.

As an exclusion criterion, patients who did not fit this established profile were discarded. An electronic spreadsheet was used to compile the data (Chart 1).

Chart 1 – data in spreadsheet

PCT	kV	mAs	Incidencia
1	92	7	PA
	92	23	PERFIL
2	95	3	PA
	97	13	PERFIL
3	92	5	PA
	92	16	PERFIL
4	90	10	PA
	90	25	PERFIL
5	95	5	PA
	95	18	PERFIL

Source: Survey data, 2020.

PARAMETER TESTING

With the data on the technical factors (kV and mAs) collected from the equipment belonging to the private hospital, these were inserted into the digital fixed X-ray equipment, of the Konica Minolta® model XRD model (Figure 1), belonging to the LAFIR 2 laboratory of the teaching clinic of the Federal Institute of Bahia.

Figure 1 - Konica Minolta® conventional digital X-ray equipment model DRX

Source: Author, 2024.

To simulate the presence of the patient, a commercial Pixy Phantom model RSD 101 (Figure 2) and an X-ray measurement system with an ionization chamber, and specific solid-state dose sensors for X-rays, model RADCAL® Accu-Gold (Figure 3)

Figure 2 – Chest Phantom in PA position

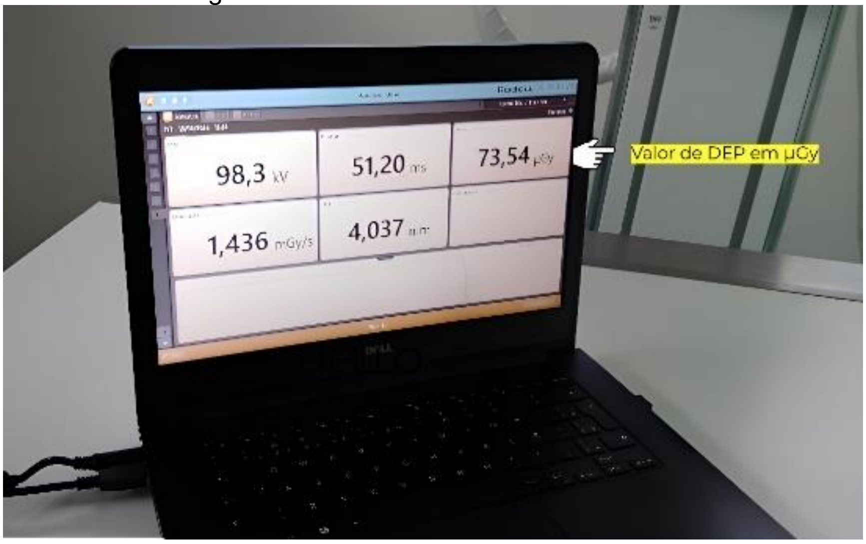
Source: Author, 2024.

Figure 3 – Radcal® AccuGold® Solid State Sensor and Ionization Chamber

Source: Author, 2024.

The DEP value was indicated in software installed on a laptop (Figure 4), with the value given in microgray (μGy) and later converted to milligray (mGy). For each of the views, 3 radiographs were taken and then the average was made to have a greater reliability in the result.

Figure 4 – *software* RADCAL® Accu-Gold



Source: Author, 2024.

The results were compiled and presented in absolute numbers and percentages, in the form of tables.

RESULTS

Of the 100 patients included in the study, 50 were women and 50 were men. In the comparison of the mean skin entry dose (EPD) by sex, it was found that in the views referring to the male gender (Table 1), there was an increase in the kilovoltage or voltage (kV) both in the posteroanterior and lateral positioning, probably due to the larger size of the male rib cage when compared to the female one, while the milliamperes or current time product (mAs), there was a greater increase in BP incidence than in lateral exposure, which presented a lower value than that found in female patients (Table 2), which led to a small increase in the dose, being clearer in BP.

Table 1 – Mean dose for the 50 male patients.

Average			
INCIDENCE	kV	mAs	DEP – mGy
PA	93,82	6,2	0,10
PROFILE	94,76	17,69	0,26

Source: Author, 2024.

Table 2 – Mean dose for the 50 female patients.

Average			
INCIDENCE	kV	mAs	DEP – mGy
PA	93,46	5,06	0,07
PROFILE	94,34	17,79	0,24

Source: Author, 2024.

The mean values of kV and mAs obtained from all the incidences (Table 3) showed a value below the maximum reference established by RDC 611/22 IN No. 90 (Table 4).

Table 3 - Total mean by incidences and their DEP values in reference.

Average			
INCIDENCE	kV	mAs	DEP – mGy
PA	93,64	5,70	0,09
PROFILE	94,55	17,74	0,25

Source: Author, 2024.

Table 4 - Maximum reference value for chest X-ray - RDC 611/22 IN nº 90

Radiography	
INCIDENCE	DEP – mGy
PA	0,4
PROFILE	1,4

Source: Author, 2024.

The mean value of the absorbed dose per organ was evaluated separately using a computer program available free of charge on the internet CALDose_X version 5.0 (2010), more specifically the lung, and it was noted that the increase in the parameters from one incidence to the other led to an increase in the dose (Table 5).

Table 5 - Mean dose absorbed in the lung by incidence.

Average	
INCIDENCE	DEP – mGy
PA	0,02
PROFILE	0,04

Source: Author, 2024.

DISCUSSION

The emission of X-rays during radiographic examination requires special attention with regard to radioprotection for humans against possible undesirable effects caused by ionizing radiation. Radiological protection aims to minimize the risks of deterministic effects and decrease the likelihood of stochastic effects appearing (López, 2021).

Thus, an effective radiological protection program must be grounded in the Institution as a whole and its management staff must assume a commitment to safety, that is: the management structure must be efficient, the authorities, responsibilities and task descriptions must be clearly designated and documented, the resources for the safety area must be adequate and all employees must have a commitment to the principle of keeping radiation doses as as far as reasonably feasible (CNEN, 2014).

The results found show that the mean values of EPD to which patients are exposed during chest X-rays are below the maximum reference values established by RDC 611/22 IN No. 90, precisely individuals have a value 77.5% lower in their radiographs in the PA view, while in lateral this value reaches 82.14%. On the other hand, for the selected technical parameters, it was found that in the change between the incidences, even with the variation in the size of the structure to be radiographed, from the PA to the Profile, the voltage (kV) was practically maintained, with a small increase of 0.91 kV, while the current product-time (mAs) had an increase of 12.04 (increase of approximately 211%), which led to an increase in the dose by 180% between the incidences.

In addition, the same evaluation was made separately for female patients, which showed an increase in voltage (kV) of 0.88 kV, while the current-time product (mAs) had an increase of 12.73 mAs (an increase of approximately 239%). For male patients, the voltage (kV) increased by 0.94 kV and the current-time product (mAs) by 11.49 mAs (an increase of approximately 180%), highlighting that the correction was only evidenced in only 13% of the patients.

These alterations demonstrated that with the increase in mAs there was a directly proportional increase in the dose. The amount of X-rays is directly proportional to the current-time product (mAs). Because, when this product is doubled, the number of electrons that reach the target of the tube also doubles and, therefore, twice the number of X-rays is emitted (Bushong, 2010)

Previously, in the same population, the value of the entry dose into the skin was calculated using a computer program CALDose_X version 5.0 (2010). The values presented by CALDose X indicated that the dose delivered to the patient was higher than that recommended by the current standard, for BP in male patients it had an average value of 0.41 kV and for females the value was also 0.41 mGy, in Profile the value reached 1.539 mGy for both. Thus, the value presented by the *software* (Table 6) was higher than that obtained by the ionization camera, which was properly calibrated (Table 7).

Table 6 - Mean by incidence and its reference EPD values (CALDose X)

Average							
		PA		-		PROFILE	
PATIENT	kV	mAs	DEP – mGy	-	kV	mAs	DEP – mGy
Man	94	6	0,41	-	95	17	1,539
Woman	93	5	0,41	-	94	17	1,539

Source: Santos (2020)

Table - 7 Means by incidence and their reference EPD values (ionization chamber)

Average							
		PA		-		PROFILE	
PATIENT	kV	mAs	DEP – mGy	-	kV	mAs	DEP – mGy
Man	93,82	6,2	0,10	-	94,76	17,69	0,26
Woman	93,46	5,06	0,07	-	94,34	17,19	0,24

Source: Author, 2024.

CONCLUSION

The conclusion of this study is that the values of the entry dose into the skin to which the patients are exposed during their chest X-rays are below the maximum reference value recommended by RDC 611/22 IN No. 90. However, the large discrepancy in the mean values of the current product-time suggests that there should be a better choice of technical parameters for each patient, seeking to further optimize the dose delivered.

This result shows the need to implement a quality control and assurance program to contribute to the standardization of procedures and the use of a thickness tester, an instrument used to measure the thickness of a patient's limb that will be X-rayed, for better selection of the technical parameters to be used, thus ensuring a reduction in the dose.

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