DOSE ASSESSMENT ASSOCIATED WITH PATHOLOGY

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ABSTRACT

Objective: This study aimed to evaluate how changes in exposure parameters due to pathological suspicions can increase the dose on chest X-rays in two positions, posteroanterior and lateral, and whether the dose delivered to the patient 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, and which pathologies were associated with each of them. 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 of the exposure parameters showed that even due to the physiological change caused by the pathogens, the voltage (kV) was little altered, while the value of the current product-time (mAs) had a large increase of 210% between the incidences. Conclusion: Although the value found for the entry dose into the skin was in accordance with the established limits, it was noted that for each pathology, little was done for a proportional change of the selected parameters, not only for the pathological suspicions, but also between the incidences, while the penetrability of the beam was little altered, the amount of X-rays produced was doubled, increasing the dose without actually having a diagnostic value for imaging.

Keywords: Tension. Pathologies. Incidences.

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INTRODUCTION

The image recorded by the exposure of any of the image receptors to X-rays is called radiography, remembering that at each step in the performance of a radiographic procedure, it must be completed accurately to ensure that the maximum amount of information is recorded in the image, as the information obtained through the radiographic examination can reveal the presence or absence of anomalies or traumas, this information in turn helps in the diagnosis and treatment of the patient (Frank et al, 2016). But despite its great importance in medical diagnosis, radiation has its risks, which operating professionals should always seek to minimize, so that the benefit of the exam is always greater than the risk.

Since there are risks arising from radiation, the biological effects of radiation can be divided into two, the deterministic: these effects are somatic and result from exposure to a high dose of radiation and usually manifest themselves above a certain dose, the threshold dose, which is determined according to the irradiated tissue. These effects are more severe the higher the radiation doses are (López, 2021). Stochastic effects, on the other hand, are those that do not have a threshold to occur, so any imaging procedure or therapy that involves the use of radiation involves some risk (Singh and Neutze, 2011).

Thus, with the growing increase in medical exposures to ionizing radiation, in 2020 it exceeded 4 million exams performed in a year worldwide (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). Thus, the radiology technician or technologist should seek to minimize the radiation dose to the patient, to himself, and to others, according to the ALARA principle, which defines that the dose delivered to the patient should be as low as reasonably feasible (Fauber, 2017).

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). Another factor that can lead to changes in the parameters is the pathological suspicion, which can interfere in the choice of parameters already presented, because depending on the pathology, it may be necessary to have a greater or lesser penetrability of the X-ray beam, for better visualization of the affected structure or organ.

The penetrability of the beam is defined by means of the voltage (Kilovoltage, kV), the voltage is responsible for controlling the energy (penetrating power) of the X-ray beam, and the current-time product (Milliamperes per second, mAs), is responsible for controlling the amount or number of X-rays produced and the exposure time (Bontrager, 2015),

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) associated with the pathological suspicion of the patient, during chest X-ray examinations performed in conventional X-ray equipment, in two positions, posteroanterior (PA) and lateral.

METHODOLOGY

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, exposure parameters were collected, namely voltage (kV) and current-time product (milliamperes per second, mAs), of 100 patients, with pathological suspicions (Pneumonia, Atelectasis, Tuberculosis, Chronic obstructive pulmonary disease, Pleural effusion, Respiratory tract infection) of each one. 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. A table was used to compile the exposure parameters (Chart 1), and to evaluate the pathologies, a table was used for the number of patients under suspicion (Table 1).

Chart 1 – data on technical parameters in a 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.

Table 1 – data from the study population, associated with each pathology

Average	
PATHOLOGICAL SUSPICION	Number of patients
PNEUMONIA	15
ATELECTASIA	16
TUBERCULOSIS	17
CHRONIC OBSTRUCTIVE PULMONARY DISEASE	19
DERRAME PLEURAL	15
RESPIRATORY TRACT INFECTION	18

Source: Survey data, 2024.

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 Konica Minolta® digital fixed X-ray equipment, model XRD model (Figure 1), belonging to the LAFIR 2 laboratory of the teaching clinic of the Federal Institute of Bahia. In addition, the pathological suspicion of each of the patients was recorded, 100 patients.

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 solid-state dose sensors specific for X-rays, model RADCAL® Accu-Gold (Figure 3), were used.

Figure 2 – Chest Phantom in PA position

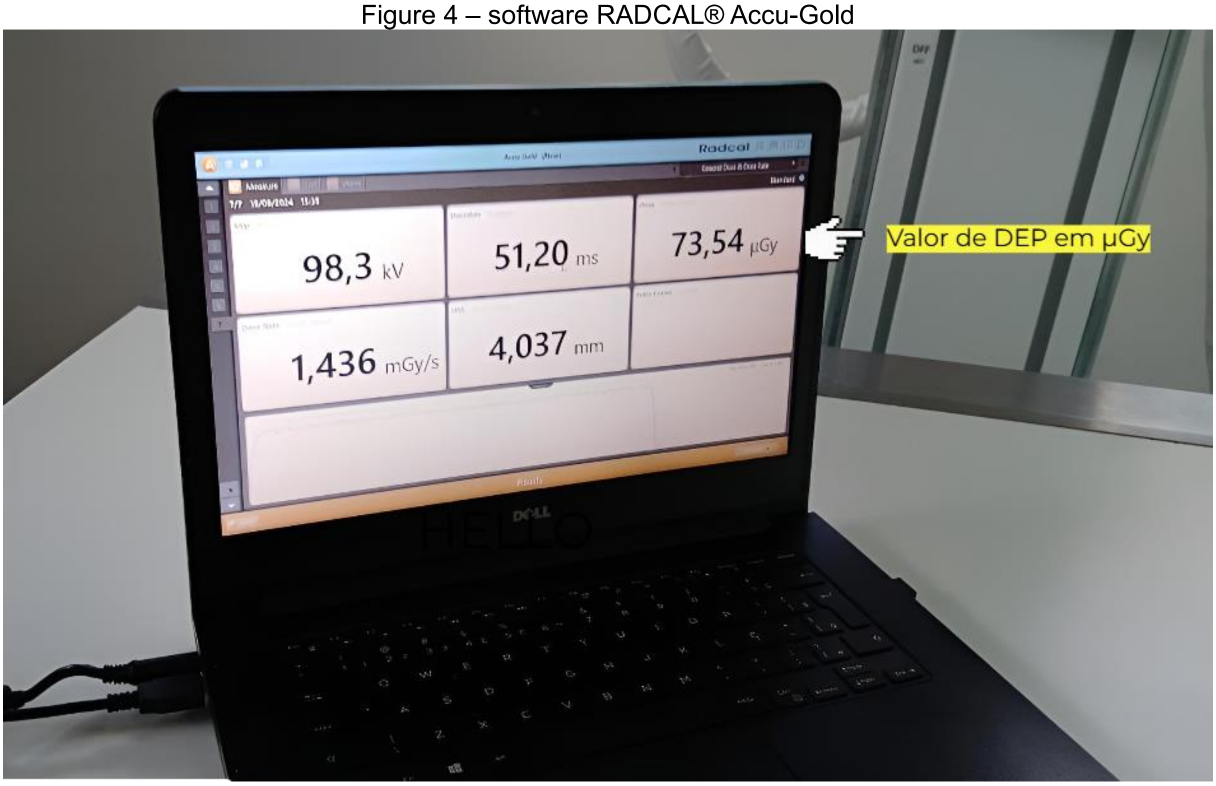
Source: Author, 2024.

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

In view of each pathological suspicion, an average of the technical parameters (voltage and product, current-time) and an average for the skin entry dose (EPD) were performed from this division. Each pathology was separated by the total number of patients suspected of having the same pathologie. Taking as a reference the maximum reference value established by RDC 611/22 IN No. 90 (Table 2).

Table 2 - Maximum reference value for chest X-ray - RDC 611/22 IN nº 90

Chest X-ray	
INCIDENCE	DEP – mGy
PA	0,4
PROFILE	1,4

Source: Author, 2024

For the 15 patients with suspected pneumonia at the mean (Table 3), it was found that the difference in voltage (kV) between the incidences had a small increase, with an increase of 0.67 kV, while the mAs had an increase of 11.76 (an increase of approximately 177%), which led to a large increase in the dose.

Table 3 - Mean for patients with suspected pneumonia.

Average			
INCIDENCE	kV	mAs	DEP – mGy
PA	93,73	4,11	0,07
PROFILE	94,4	15,87	0,22

Source: Author, 2024.

For the 16 patients with suspected atelectasis, for the mean (Table 4), the same logic was followed in the choice, while the voltage (kV) increased by 2 kV, while the mAs increased by 12.12 (an increase of approximately 253%).

Table 4 - Mean for patients with suspected atelectasis.

Average			
INCIDENCE	kV	mAs	DEP – mGy
PA	95,06	4,79	0,07
PROFILE	97,06	16,91	0,24

Source: Author, 2024.

For the 17 patients with suspected tuberculosis, the mean (Table 5), among the incidences, for blood pressure, the value increased by 1.71 kV, whereas the mAs value increased by 11.12 (approximately 205%)

Table 5 - Mean for patients with suspected tuberculosis.

Average			
INCIDENCE	kV	mAs	DEP – mGy
PA	94,35	5,41	0,08
PROFILE	96,06	16,53	0,24

Source: Author, 2024.

For the 19 patients with suspected chronic obstructive pulmonary disease (COPD), the mean found (Table 6) showed an increase in blood pressure of 0.10 kV, and the mAs increased by 13.21 (an increase of approximately 236%).

Table 6 - Mean for patients with suspected Chronic Obstructive Pulmonary Disease.

Average			
INCIDENCE	kV	mAs	DEP – mGy
PA	92,11	5,58	0,08
PROFILE	92,21	18,79	0,26

Source: Author, 2024.

For the 15 patients with suspected pleural effusion, the mean (Table 7) showed that the voltage (kV) increased by 1.2 kV. The mAs, in turn, had an addition of 11.88 (an increase of approximately 226%).

Table 7 - Mean for patients with suspected pleural effusion.

Average			
INCIDENCE	kV	mAs	DEP – mGy
PA	93,67	5,25	0,07
PROFILE	94,87	17,13	0,25

Source: Author, 2024.

Finally, for the 18 patients with suspected respiratory tract infection (RTI), the mean (Table 8) shows that the voltage (kV) was kept the same for both incidences, unlike the voltage, the mAs value increased by 11.64 (an increase of approximately 158%).

Table 8 - Mean for patients with suspected respiratory tract infection.

Average			
INCIDENCE	kV	mAs	DEP – mGy
PA	93,39	7,33	0,13
PROFILE	93,39	18,97	0,32

Source: Author, 2024.

In addition, to evaluate the total dose, the average of all incidences was made for the 100 patients (Table 9), showing an increase in voltage (kV) of 0.91 kV, while the mAs had an increase of 12.04 (increase of approximately 211%).

Table 9 - Total mean by incidences and their values of DEP 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.

DISCUSSION

Every activity involving radiological protection in the diagnostic area is aimed at minimizing radiation exposure of patients and workers, one of the fundamental principles of radiological protection is to minimize time, since the dose received by an individual is directly related to the duration of exposure, since if the time during which an individual is exposed to radiation is doubled, the dose will be doubled (Bushong, 2010).

Currently, all over the world, it has been adopted that any dose, no matter how small, is associated with the probability of damage (stochastic effects), leading to the adoption of three basic principles, the justification that says that any activity involving radiation must bring a greater benefit than harm; optimization, which defines that the dose should be as low as reasonably feasible (ALARA - As Low As Reasonably Achievable); and the principle of individual dose limitation which determines that individual doses of workers and individuals in the public should not exceed annual dose limits (CNEN, 2014). Optimization is the basis for carrying out this project.

The results found show that the entry dose into the skin delivered to patients during their chest X-rays is in accordance with the maximum reference value established by RDC 611/22 IN No. 90, both when we talk about the different groups associated with different pathologies and the general average of all 100 patients. For further comparison, the PA value is 77.5% lower than the reference value, while the value of the dose for lateral is 82.14% lower.

However, although the dose is in compliance, it is important to pay attention to the changes made in the exposure parameters, in the case of the total mean of the patients, while the current-time product (mAs) had a percentage increase of approximately 211% between the incidences, which also led to an increase in the dose, since the amount of X-rays is directly proportional to the current-time product (Bushong, 2010), while the voltage (kV) responsible for the penetrability of the X-ray beam, as previously explained, had a percentage increase between the incidences of approximately 1%.

This leads in turn to the loss of details in the radiographic image, due to the changes caused in the density of the tissues by the pathologies, so the changes in the parameters are only causing the increase in the dose, not contributing to the correct diagnosis.

The pathophysiology of each of the diseases has specific characteristics that may lead to the need for parameter adjustment.

Pneumonia originates in the airways and spreads to the alveoli, thus producing an immune response in the lungs that causes the alveolar sacs to fill with exudate (Fleming, 2008). Radiographically, the inflammation caused leads to an increase in the radiodensity of the tissue, thus requiring an increase in the penetrability of the beam and an adjustment in the current product-time (mAs) in order not to have the loss of contrast, but what was evidenced is that the change to the voltage (kV) was approximately 0.7% while the mAs had a percentage increase of approximately 286%.

Chronic obstructive pulmonary disease (COPD) is characterized by persistent airway obstruction that often causes difficulty emptying the lungs; it can be caused by emphysema or chronic bronchitis (smoking is the main cause of COPD) (Bontrager, 2015). Due to the destruction of elastin in the alveoli, the lung tends to lose its elasticity, which causes the air to become stagnant, leading to an increase in residual air volume. Radiographically, this hyperinflation leads to an increase in the presence of air in the structure and an excessive dilation of the lung, which makes a decrease in the penetration of the beam, for better visualization, the results found an increase in voltage (kV) from one incidence to another, of 0.1%, as well as the mAs should be maintained or even reduce its value, however, this population has undergone a percentage increase of approximately 196%.

Atelectasis refers to the collapse of a peripheral, segmental or lobar lung region, or to the collapse of one or both lungs, resulting in the inability to perform gas exchange, and in more severe cases the displacement of the trachea of the heart may occur (Hernández, 2008). This difficulty in air intake leads to an increase in lung density, so an increase in voltage (kV) would end up helping in a better visualization of the pathology, however the result shows that this increase reached only 2%, while the mAs had a significant increase of approximately 253%.

Pleural effusion can be inflammatory or non-inflammatory, it occurs due to the accumulation of serous fluid in the pleura, this accumulation leads to compression of the lungs, causing respiratory distress in the patient (Kumar et al, 2016). Both types of pleural effusion can be demonstrated through the presence of fluid levels on chest X-rays with horizontal rays, small amounts are more visible in the lateral decubitus position with the affected side down or in an upright position (Bontrager, 2015). Just as atelectasis, due to the reduction in the ability of the lung to dilate, there is an increase in radiodensity, added to the presence of fluid in the pleural space, it is necessary to increase the voltage (kV) for better visualization, for this pathology the percentage increase in kV was approximately 1.2%, while the mAs had a percentage increase of approximately 226%.

Respiratory tract infections (RIs) can be simple, caused by bacterial or viral agents. Depending on its severity, it may not be necessary to change the parameters, perhaps only a discreet adjustment of the mAs. Thus, it was observed that among the incidences, the tension did not change at all, even with the increase in body structure, and the mAs had a percentage increase of 158%

Tuberculosis, in turn, is caused by the inhalation of mycobacteria, it is transmitted mainly by air droplets, but it can also be transmitted by the inhalation of these dry mycobacteria (Fleming, 2008). For this pathology Lordotic AP views are often requested, as they are better for visualization of calcifications and cavitations in the apices and upper lobes (Bontrager, 2015). Thus, depending on the extent of these calcifications or fibroses, an increase in tension is necessary due to its greater density. The results showed a percentage increase for voltage (kV) of approximately 1.8%, while mAs had a percentage increase of approximately 205%.

CONCLUSION

From the results presented, it is concluded that the entry dose into the skin is in accordance with the maximum reference values established by RDC 611/22 IN No. 90. However, it is notorious that the selection of parameters, taking into account the suspected pathologies that affected the patients, was not carried out in a way that the physiological changes caused by them were considered, thus resulting in a loss of details for a better diagnosis.

In addition, the increase of such a large percentage of the current product time (mAs) led to a significant increase between the incidences, which could be avoided with a control between the voltage (kV) and the mAs, because for each 15% increase in kV, it is possible to reduce the mAs by half without compromising the image quality. also reducing the dose delivered. Thus, the need to implement a permanent education program (PEP) for adequate training of professionals is shown.

REFERENCES

1. Bontrager, K. L., & Lampignano, J. P. (2015). Tratado de posicionamento radiográfico e anatomia associada (8th ed.). Elsevier.

2. Bushong, S. C. (2010). Ciência radiológica para tecnólogos (9th ed.). Elsevier.

3. Comissão Nacional de Energia Nuclear (CNEN). (2014). Princípios básicos de segurança e proteção radiológica (3rd ed. rev.). CNEN. Available at: https://www.gov.br/cnen/pt-br/acesso-rapido/centro-de-informacoes-nucleares/material-didatico-1/principios-basicos-de-seguranca-e-protecao-radiologica-terceira-edicao-revisada.pdf. Accessed on: December 8, 2024.

4. Fauber, T. L. (2017). Radiographic imaging and exposure (5th ed.). Elsevier.

5. Fleming, J. (2008). Fundamentals of radiographic pathology. Three Phase CEUs & SCS Continuing Education.

6. Gumieri, D. D. F. (2018). ABC... na avaliação sistemática da radiografia de tórax. Revista Curie & Roentgen – Conselho Nacional de Técnicos em Radiologia (CONTER), Brasília, DF, 1–9. Available at: https://conter.gov.br/uploads/trabalhos/p41.pdf. Accessed on: September 8, 2024.

7. Hernández, C. O., et al. (2008). Atelectasia. Bronquiectasias. Available at: https://www.aeped.es/sites/default/files/documentos/14.pdf. Accessed on: December 9, 2024.

8. Kumar, V., Abbas, A. K., & Aster, J. C. (2016). Robbins & Cotran: bases patológicas das doenças (9th ed., adapted translation). Elsevier Editora Ltda.

9. López, G. A. (2021). Análise comparativa de doses de entrada e produtos dose/área em órgãos da cabeça e pescoço. Omnis Scientia, Triunfo, PE. [e-book].

10. Frank, E. D., Long, B. W., & Smith, B. J. (2016). Merrill's atlas of radiographic positioning and procedures (13th ed., Vol. 1). Elsevier.

11. Resolução da Diretoria Colegiada - RDC nº 611, de 9 de março de 2022. Available at: https://pesquisa.in.gov.br/imprensa/jsp/visualiza/index.jsp?data=16/03/2022&jornal=515&pagina=107. Accessed on: November 30, 2024.

12. Singh, H., & Neutze, J. A. (Eds.). (2011). Radiology fundamentals: Introduction to imaging & technology (4th ed.). Springer.

13. UNSCEAR. (2022). Sources and effects of ionizing radiation (Vol. 1, Sources, Report to General Assembly, with Scientific Annexes). UNSCEAR. Available at: https://www.unscear.org/unscear/uploads/documents/publications/UNSCEAR_2020_21_Annex-A.pdf. Accessed on: November 30, 2024.