OPTIMIZATIONOFRADIOLOGICAL PROTECTION FOR COMPANIONS IN PEDIATRIC CHEST X-RAYS

Comment [DSA1]: Make the title more search friendly and easy to understand..Optimization of radiation protection for companions in pediatric chest radiography.

ABSTRACT

Aims: The objective of this study is to optimize the positioning of the companion during pediatric chest radiographic exams by analyzing the scattered radiation dose measured with an ionization chamber.

Place and Duration of Study: The experimental study was conducted between February 2024 and April 2024, in the radiodiagnosis laboratory belonging to the Medical Physics and Radiology Technology courses at the Franciscan University (UFN) in the city of Santa Maria, Rio Grande do Sul.

Methodology:A fixed conventional X-ray device and a phantom (simulating object) filled with 15 cm of water to represent a pediatric chest were used. The parameters of voltage (kV) and the product of current and time (mA.s) were kept constant. Measurements of the incident air KERMA ($K_{a,i}$) were performed by positioning the dosimetric system at four points around the phantom (0º, 90º, 180º, and 270º), simulating the exposure conditions of the companion.

Results: The results showed that the lowest radiation dose received by the companion at the gonadal level occurred at 90º around the table (cathode side), while the lowest dose at the lens level was at 270º (anode side). The highest dose at the gonadal level was observed at 180º, and the highest dose at the lens level was at 90º.

Conclusion: It was concluded that the companion should position themselves on the anode side (270º), as the lens does not have lead protection, while protection is available for the rest of the body. This recommendation aims to optimize radiological safety for the companion.

Keywords: X-rays; Incident Radiation; Scattered Radiation; Radiological Protection.

1. INTRODUCTION

Chest radiographic exams are essential for diagnosing respiratory conditions such as pneumonia, bronchitis, and tuberculosis. However, exposure to ionizing radiation is a concern, especially in children due to their higher biological sensitivity and risk of cellular damage, as well as the exposure of companions during pediatric exams [1].

Comment [DSA2]: And pleural diseases like pleural effusion and pneumothortax

Proper immobilization of children often involves other people (88.9%), a practice that, while reducing child stress, contradicts the ALARA principle (As Low As Reasonably Achievable), which aims to minimize radiation exposure [2]. Proper immobilization during the procedure should ensure quality images and reduce the need for repeat exams [3].

According to the World Health Organization (WHO), approximately 50% of pediatric radiological exams are chest X-rays, with a central concern about the scattered radiation generated by the interaction of X-rays with the patient's tissues.

Comment [DSA3]: Gramatically correction... patients` tissues.

During clinical practice, radiology professionals should apply exposure techniques that optimize the radiation dose without compromising diagnostic quality, following the ALARA principle. This includes careful selection of exposure parameters, the use of modern equipment with dose reduction technologies, and considering imaging alternatives that do not involve radiation when appropriate [3].

Positioning for a pediatric chest exam, according to Bontrager&Lampignano [4], involves determining the film size and maintaining the cassette transversely. The child should be in a dorsal decubitus position with arms extended and scapulas out of the lung fields, supported by sandbags. Parents can assist with positioning unless the mother is pregnant. Correct positioning includes keeping the shoulders below the upper margin of the detector, with the central ray perpendicular to the film centered on the midsagittal plane (MSP), as shown in detail in Figure 1.

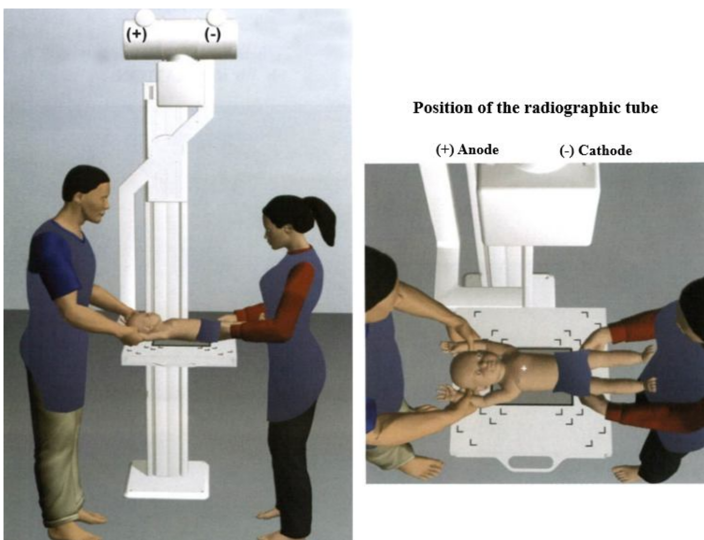

Fig. 1. Positioning for Pediatric Chest AP
Adapted from [5]

Radiology professionals have the responsibility to inform both parents and other companions about the risks associated with radiation exposure and to ensure that all safety measures are followed during the exam [6]. To mitigate the risks, it is recommended to use lead aprons and to ensure proper positioning of the companions, minimizing their exposure [1]. Therefore, the objective of this study is to optimize the positioning for the companion during pediatric chest radiographic exams.

2. MATERIAL AND METHODS

The study was conducted in the radiodiagnosis laboratory of the UniversidadeFranciscana (UFN) in Santa Maria - RS, as part of the research for the Radiodiagnosis and Radiological Procedures III course. An Intecal radiographic equipment, model MAAF, and a RADCAL dosimetry system, model 9015, with a DE 180 cm³ survey probe were used to evaluate

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scattered radiation. To simulate a pediatric chest radiographic exam, a phantom object consisting of a plastic box measuring 39 x 26 x 22 cm³, filled with water up to a thickness of 15 cm, was used. The dosimetric measurements were performed with a voltage of 70kV, current of 200mA, and a current-time product of 5 mA.s, with a radiation field of 25 x 25 cm. The dosimetric chamber was positioned at 100 cm perpendicular to the primary beam projection. Figure 2 illustrates 8 measurement positions: 4 at the gonad region (90 cm) (Figure 2[a-d]) and 4 at the lens region (150 cm) (Figure 2[e-h]). Three readings were recorded for each companion position. In each stage, configurations of three readings for each companion position at the table ends were recorded.

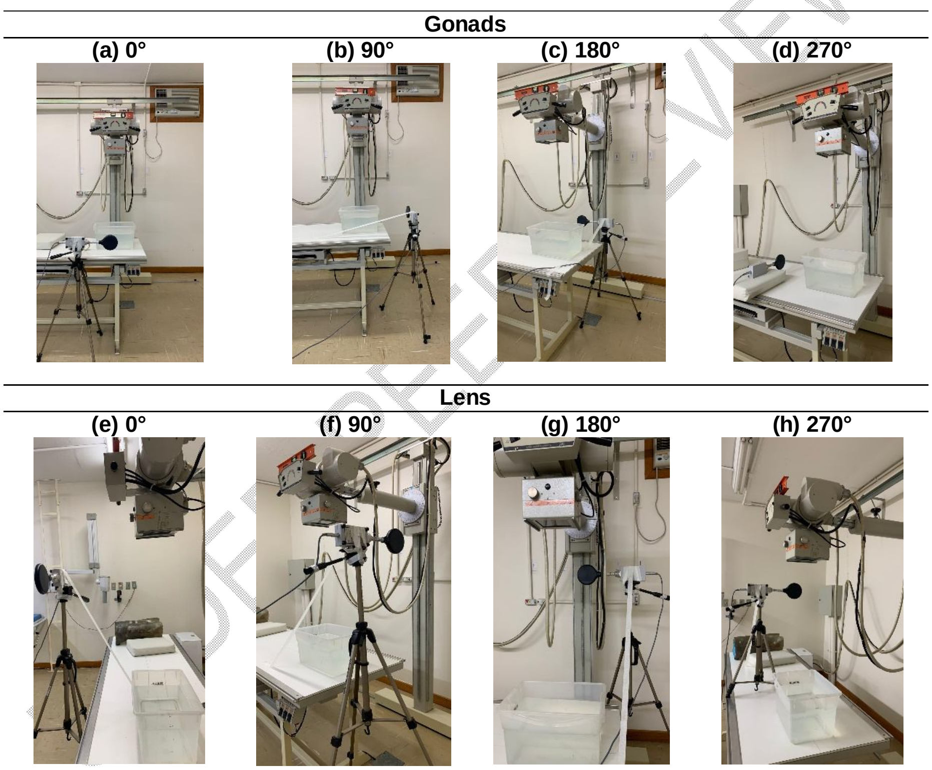

Fig. 2. Demonstration of positions and heights for K_{AIR} measurement

3. RESULTS AND DISCUSSION

The values obtained for K_{AIR} for each of the measurements made from the geometry in Figure 2 and their average values are presented in Table 1, identified according to the angle of disposition.

Table 1. List of measured K_{AIR} readings at the gonads and lens heights, along with the average value and their positions

	Gonads			
	0º	**90º**	**180º**	**270º**
Measured values (mGy)	1.052	0.564	1.326	1.003
	1.052	0.534	1.043	0.972
	1.065	0.571	1.007	1.003
	1.065	0.569	1.093	1.015
Average	1.059	0.560	1.117	0.998
	Lens			
	0º	**90º**	**180º**	**270º**
Measured values (mGy)	1.103	1.097	1.106	0.471
	1.085	1.116	1.088	0.474
	1.066	1.110	1.057	0.471
	1.081	1.110	1.082	0.478
Average	1.084	1.108	1.083	0.474

Table 1, therefore, presents the measured K_{AIR} values at different angles of disposition for the positions at the height of the gonads and the lens of the eye, allowing for the analysis of the information regarding the distribution of the radiation dose as a function of body orientation.

Considering the height of the gonads, the K_{AIR} values vary according to the angle of disposition, with the lowest values measured at 90° (0.560 mGy) and the highest at 180° (1.117 mGy). This variation can be attributed to the different exposure of the gonads depending on the body's position relative to the radiation source. The 90° position consistently presents the lowest K_{AIR} values, indicating lower exposure in this orientation. Conversely, the 180° position shows the highest average values, suggesting that this position offers the highest radiation exposure. This implies that the orientation of the companion during the procedures can significantly influence the dose received by the gonads, a crucial factor in optimizing radiological protection.

In the case of the lens of the eye, the K_{AIR} values also vary, but less markedly compared to the gonads. The average values obtained were higher at 90° (1.108 mGy) and 180° (1.083 mGy), while the lowest average was observed at 270° (0.474 mGy). The relative consistency in measurements for the angles of 0°, 90°, and 180° (with averages of 1.084 mGy, 1.108 mGy, and 1.083 mGy, respectively) suggests that the lens of the eye is exposed relatively uniformly in these positions. However, the significant reduction in dose at 270° highlights the importance of body orientation, with this position potentially providing better protection for the lens of the eye.

These results emphasize the importance of body position in the distribution of the radiation dose for both the gonads and the lens of the eye. The variations in K_{AIR} values indicate that optimizing the patient's position during radiological procedures can significantly reduce radiation exposure. Radiological protection strategies should, therefore, consider these variations to minimize exposure risks for both reproductive organs and sensitive areas such as the eyes.

Considering the results obtained from the measurements, there is an agreement with the anode heel effect. The anode heel effect results in a reduction of X-ray intensity on the anode side of the useful beam, caused by absorption in the thicker part of the target, and consequently, the radiation intensity on the cathode side in the irradiated area is higher [7].

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Figure 3 was constructed from the data in Table 1, showing the curves of scattered radiation dose in relation to the position of the companion around the radiographic equipment for both measured heights.

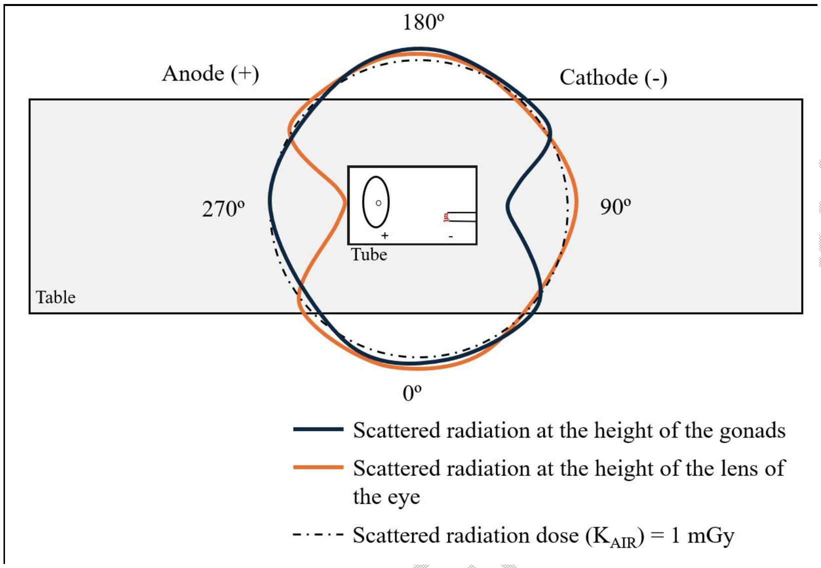

Fig. 3. K_{AIR} curve for gonad and lens heights

From a more dynamic perspective, Figure 3 shows that, to minimize exposure to the gonads during pediatric chest radiographic exams, the ideal positioning of the companion is at 90°, which presented the lowest average radiation dose. In this position, the companion is lateral to the patient, significantly reducing direct exposure to the gonads. In contrast, the highest exposure was recorded at the 180° position, where the companion is facing the X-ray beam, resulting in a higher radiation dose. However, to minimize exposure to the lens of the eye, the ideal position is 270°, providing more effective protection. The highest radiation dose to the lens was recorded at the 90° position, where the companion is lateral to the X-ray beam, resulting in greater exposure.

4. CONCLUSION

Pediatric chest exams conducted with investigative criteria are crucial for diagnosing various medical conditions, but it is essential to balance the diagnostic benefits with the risks associated with ionizing radiation exposure. Appropriate radiological protection measures must be implemented to minimize exposure to primary radiation for the child and scattered radiation for the companions.

The results of this experimental research identified the ideal points for the companion's positioning, highlighting the locations with the lowest radiation doses. Considering that the dose received varies with height and that lead body protection is available, the most suitable position for the companion is one that minimizes exposure to the lens, which is not protected by lead. Therefore, to achieve this goal, the companion should position themselves at 270° in relation to the radiographic equipment, that is, on the anode side.

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