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Evaluation of Pediatric Radiation Dose for The Follow Up Chest Radiography Post Cardiac Surgery at Al Makassed Hospital with Risk Factors Assessment of Thyroid Gland

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Abstract: ***This study aimed to evaluate the radiation dose received by pediatric patients undergoing follow-up chest radiography after cardiac surgery, with a focus on assessing thyroid gland risk factors. A retrospective analysis was conducted on pediatric patients, categorizing the number of radiographic occurrences into three frequency ranges: 1-10, 11-20, and >21. Key variables analyzed included frequency, total radiation dose in mGy, and estimation risk, with descriptive statistics such as mean, standard deviation, minimum, and maximum calculated for each range. Results showed that the >21 frequency range had the highest mean frequency and total mGy, indicating significantly greater radiation exposure and average occurrences compared to lower ranges. Estimation risk also increased with frequency, suggesting a higher potential for risk assessment error. These findings underscore the need to optimize radiation dose protocols for follow-up chest radiography in pediatric patients post cardiac surgery. Recommendations include implementing dose monitoring and tracking systems, exploring alternative imaging modalities, and enhancing education among healthcare professionals. However, the study's retrospective nature highlights the necessity of prospective research to validate these findings.***

Keywords: Pediatric, Radiation Dose, Chest Radiography, Follow-Up, Cardiac Surgery, Risk Factors, Thyroid Gland.

1. Introduction

Cardiac surgery is a common and often life-saving treatment for congenital and acquired heart diseases in pediatric patients. Postoperative follow-up typically involves regular chest radiography to monitor surgical outcomes, detect potential complications, and guide ongoing clinical management. While essential for ensuring optimal care, the frequent use of radiographic imaging introduces the need to carefully evaluate the associated risks, particularly due to the ionizing radiation exposure involved [1].

Pediatric patients are inherently more vulnerable to radiation-induced risks than adults due to their developing organs, higher cellular proliferation rates, and longer life expectancy. Among these organs, the thyroid gland is particularly sensitive to radiation exposure, with potential long-term implications for thyroid function and development. This heightened sensitivity underscores the critical need to minimize unnecessary radiation exposure, especially during the formative stages of growth [2].

Despite the recognized importance of radiation safety in pediatric imaging, there remains a paucity of research specifically addressing the radiation doses associated with follow-up chest radiography in the context of pediatric cardiac surgery. Existing studies predominantly focus on general pediatric radiology or cardiac imaging, leaving a gap in understanding the unique radiation exposure patterns and risks in this specialized patient population. This lack of targeted research limits the development of optimized imaging protocols tailored to these patients' specific needs [3].

Additionally, the variability in radiation dose levels and the factors influencing thyroid gland exposure in pediatric patients undergoing follow-up chest radiography are poorly understood. Addressing these knowledge gaps is essential for advancing imaging practices that strike a balance between diagnostic accuracy and radiation safety [4], [5], [14], [6]–[13]. A comprehensive evaluation of these factors could provide the foundation for more effective dose-monitoring systems and protective measures, ultimately improving the care and safety of pediatric patients.

The problem lies in the limited understanding of radiation dose levels and the associated risk factors impacting the thyroid gland in pediatric patients undergoing follow-up chest radiography post-cardiac surgery. This study aims to evaluate the radiation doses received by this vulnerable population and identify risk factors contributing to thyroid gland exposure. The findings aim to inform evidence-based recommendations for optimizing imaging protocols and minimizing radiation-related risks to enhance the long-term health outcomes of pediatric cardiac surgery patients.

2. Materials and Methods

This study utilized a prospective methodology to investigate radiation dose exposure in pediatric patients undergoing follow-up chest radiography after cardiac surgery. Ethical approval was obtained from Palestine Ahliya University and Al-Makassed Hospital, ensuring adherence to the Declaration of Helsinki principles. A total of 76 pediatric patients, who underwent cardiac surgery and subsequent follow-up chest radiography between January 1, 2023, and May 10, 2023, were included. Data collection encompassed demographic information (age, patient ID, patient number) and imaging data (dates, dose, and frequency). The inclusion criteria encompassed pediatric patients aged 1 month to

18 years who had open-heart surgery for congenital or acquired heart diseases and received follow-up chest radiography within 3 to 12 months postoperatively. Patients with pre-existing thyroid conditions, prior chest or neck radiation therapy, or incomplete imaging data were excluded.

Chest radiographs were acquired using a mobile X-ray system (MobileArt Evolution MX8 Version, Shimadzu) and analyzed via a PACS system (Evisena) for medical data management. The images were evaluated by a radiologist and cardiologist with over 15 years of experience to ensure accuracy and reliability in identifying postoperative outcomes and potential complications. The system enabled detailed recording of image doses and frequencies to facilitate precise analysis. Imaging protocols adhered to pediatric radiation safety guidelines to minimize unnecessary exposure while maintaining diagnostic quality.

Data analysis involved descriptive statistics to summarize demographic and imaging variables, performed using Microsoft Excel and SPSS software. The analysis included mean, standard deviation, and frequency distribution to evaluate the variability in radiation dose and its association with patient demographics and imaging frequency. Additionally, the results of chest-pediatric image evaluations were correlated with radiation dose levels to identify potential risk factors contributing to thyroid gland exposure.

3. Results and Discussion

Frequency: The frequency variable shows a wide range of values, ranging from 1 to 66. The mean frequency of 17.25 suggests that, on average, the events or occurrences represented by the data point in the table 1 happen approximately 17.25 times. However, the relatively high standard deviation of 17.636 indicates a significant amount of variability or dispersion in the data points around the mean. This suggests that the frequency values are spread out, and there may be instances of both high and low frequency occurrences.

Table 1. shows the frequencies, total mGy, and estimation dose

	Frequency	Total mGy	Estimation Risk
Mean	17.25	1.173000	5.8650
Std. Deviation	17.636	1.1992533	5.99627
Minimum	1	0.0680	0.34
Maximum	66	4.4880	22.44

Total mGy: The total mGy variable represents values ranging from 0.0680 to 4.4880. The mean value of 1.173000 indicates the average total mGy recorded. The standard deviation of 1.1992533 suggests a moderate level of variability or dispersion in the data points around the mean. This variable might be related to measurements of radiation exposure or dosage, with different instances yielding varying levels of mGy.

Estimation Risk: The estimation risk variable ranges from 0.34 to 22.44. The mean estimation risk of 5.8650 suggests the average level of risk associated with estimation processes or calculations. The standard deviation of 5.99627 indicates a considerable degree of variability or dispersion in the estimation risk values around the mean. This variability implies that there may be instances with both low and high estimation risks, possibly due to different factors or approaches used in the estimation process.

Table 2. Frequencies classification through the sample

Frequency 1-10	N	Valid	31
		%	47.69
	Mean		4.77
	Std. Deviation		2.232
	Minimum		1
	Maximum		9
Frequency 11-20	N	Valid	19
		%	29.23
	Mean		15.49
	Std. Deviation		2.824
	Minimum		11
	Maximum		20
Frequency >21	N	Valid	15
		%	23.07
	Mean		45.27
	Std. Deviation		14.528
	Minimum		21
	Maximum		66

Frequency 1-10 shown in table 2 The frequency range of 1-10 has a total of 31 valid observations, which represents 47.69% of the total. The mean frequency for this range is 4.77, indicating that, on average, the events or occurrences represented by these data points happen around 4.77 times. The standard deviation of 2.232 suggests a moderate level of variability or dispersion in the data points around the mean. The minimum frequency recorded in this range is 1, and the maximum frequency is 9.

Frequency 11-20: The frequency range of 11-20 has 19 valid observations, accounting for 29.23% of the total. The mean frequency for this range is 15.49, indicating a higher average occurrence compared to the previous range. The standard deviation of 2.824 suggests a moderate level of variability in the data points around the mean. The minimum frequency recorded in this range is 11, and the maximum frequency is 20.

Frequency >21: The frequency range above 21 has 15 valid observations, representing 23.07% of the total. The mean frequency for this range is 45.27, indicating a significantly higher average occurrence compared to the previous ranges. The standard deviation of 14.528 suggests a relatively high degree of variability or dispersion in the data points around the mean. The minimum frequency recorded in this range is 21, and the maximum frequency is 66.

These statistics provide insights into the distribution and characteristics of the frequency data across different ranges. The analysis shows varying mean values, standard deviations, and minimum/maximum frequencies for each range, indicating differences in the occurrence patterns or behaviors of the events being measured.

Table 3. Doses distribution according to frequency groups

Frequency 1-10	N	31
	Mean	0.324645
	Std. Deviation	0.1517580
	Minimum	0.0680
	Maximum	0.6120
Frequency 11-20	N	19
	Mean	1.053105
	Std. Deviation	0.1920384
	Minimum	0.7480
	Maximum	1.3600
Frequency >21	N	15
	Mean	3.078133
	Std. Deviation	0.9879131
	Minimum	1.4280
	Maximum	4.4880

Frequency 1-10 in table 3 shown The frequency range of 1-10 has 31 valid observations. The mean frequency for this range is 0.324645, indicating that, on average, the events or occurrences represented by these data points happen around 0.32 times. The standard deviation of 0.1517580 suggests a relatively low level of variability or dispersion in the data points around the mean. The minimum frequency recorded in this range is 0.0680, and the maximum frequency is 0.6120. Frequency 11-20: The frequency range of 11-20 has 19 valid observations.The mean frequency for this range is 1.053105, indicating a higher average occurrence compared to the previous range.The standard deviation of 0.1920384 suggests a moderate level of variability in the data points around the mean. The minimum frequency recorded in this range is 0.7480, and the maximum frequency is 1.3600.

Frequency >21: The frequency range above 21 has 15 valid observations. The mean frequency for this range is 3.078133, indicating a significantly higher average occurrence compared to the previous ranges. The standard deviation of 0.9879131 suggests a relatively high degree of variability or dispersion in the data points around the mean. The minimum frequency recorded in this range is 1.4280, and the maximum frequency is 4.4880.

Table 4. Estimation dose according to frequency

Frequency 1-10	N	31
	Mean	1.6232
	Std. Deviation	0.75879
	Minimum	0.34
	Maximum	3.06
Frequency 11-20	N	19
	Mean	5.2655
	Std. Deviation	0.96019
	Minimum	3.74
	Maximum	6.80
Frequency >21	N	15
	Mean	15.3907
	Std. Deviation	4.93957
	Minimum	7.14
	Maximum	22.44

Frequency 1-10 in table 4The frequency range of 1-10 has 31 valid observations. The mean frequency for this range is 1.6232, indicating that, on average, the events or occurrences represented by these data points happen around 1.62 times. The standard deviation of 0.75879 suggests a moderate level of variability or dispersion in the data points around the mean. The minimum frequency recorded in this range is 0.34, and the maximum frequency is 3.06.

Frequency 11-20: The frequency range of 11-20 has 19 valid observations. The mean frequency for this range is 5.2655, indicating a higher average occurrence compared to the previous range. The standard deviation of 0.96019 suggests a moderate level of variability in the data points around the mean. The minimum frequency recorded in this range is 3.74, and the maximum frequency is 6.80.

Frequency >21: The frequency range above 21 has 15 valid observations. The mean frequency for this range is 15.3907, indicating a significantly higher average occurrence compared to the previous ranges. The standard deviation of 4.93957 suggests a relatively high degree of variability or dispersion in the data points around the mean. The minimum frequency recorded in this range is 7.14, and the maximum frequency is 22.44.

4. Conclusion

The research focused on evaluating the radiation dose received by pediatric patients undergoing follow-up chest radiography after cardiac surgery, with an additional assessment of the risk factors associated with the thyroid gland. The study collected data on three main variables: frequency, total mGy, and estimation risk.The analysis of the frequency data across different ranges (1-10, 11-20, and >21) revealed varying mean values, standard deviations, and minimum/maximum frequencies. The frequency range of 1-10 had the lowest average occurrence, while the frequency range >21 had the highest average occurrence. Regarding the radiation dose measured in total mGy, the mean values increased across the frequency ranges, indicating a higher radiation exposure in the frequency range >21 compared to the other ranges. The assessment of estimation risk showed an increasing trend as the frequency range increased, with the highest mean estimation risk observed in the >21 frequency range. The standard deviations for estimation risk also increased, suggesting more variability in risk assessment as the frequency increased. These findings suggest that pediatric patients undergoing follow-up chest radiography after cardiac surgery, particularly in the frequency range >21, may be exposed to higher radiation doses and have a higher risk of estimation error. Therefore, it is important to carefully consider the radiation dose and associated risks, especially regarding the thyroid gland, when performing these radiographic examinations in pediatric cardiac patients.

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