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Comparative Study of Radiation Exposure in Pediatric Chest X-rays using Digital Radiography vs. Traditional Film

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Abstract
Radiation exposure in paediatric patients is a significant concern, particularly in imaging studies like chest X-rays. This study compares radiation exposure between digital radiography (DR) and traditional film radiography (FR) in paediatric chest X-rays. This comparative study was conducted over one year at a tertiary care center. A total of 150 paediatric patients requiring chest X-rays were randomly assigned to either the DR group (n = 75) or the FR group (n = 75). Radiation doses were measured using dosimeters the image quality was assessed by a blinded radiologist. Patient demographic data, including age and sex, were recorded. The average radiation dose in the DR group was significantly lower compared to the FR group. Specifically, the DR group received an average dose of 0.05 mSv, while the FR group received 0.15 mSv ($p<0.01$). Image quality was rated as acceptable for diagnostic purposes in 98% of DR images and 95% of FR images. No significant differences were observed in diagnostic outcomes between the two groups. Digital radiography significantly reduces radiation exposure in paediatric chest X-rays compared to traditional film radiography without compromising diagnostic image quality. DR should be preferred in pediatric imaging to minimize radiation risks.

INTRODUCTION

Radiation exposure in paediatric imaging is a critical concern due to the increased sensitivity of children to ionizing radiation and the potential long-term health risks, including cancer[1,2]. The advent of digital radiography (DR) has revolutionized medical imaging by providing numerous advantages over traditional film radiography (FR), such as reduced radiation dose, enhanced image qualityimproved workflow efficiency[3,4]. However, despite these benefits, FR remains widely used in many healthcare settings, including paediatric imaging.

The utilization of DR in paediatric radiology has been associated with significant reductions in radiation exposure without compromising diagnostic accuracy[5]. Studies have demonstrated that DR can deliver high-quality images with lower radiation doses compared to FR, making it a preferred option for imaging vulnerable populations like children[6,7]. Furthermore, the rapid image acquisition and immediate availability of digital images streamline clinical work flows, allowing for quicker diagnoses and reduced patient wait times[8].

Paediatric patients are particularly vulnerable to the adverse effects of ionizing radiation due to their rapidly dividing cells and longer expected lifespan, which increases the probability of radiation-induced malignancies developing over time[9,10]. Consequently, minimizing radiation exposure in this population is paramount. The ALARA (As Low As Reasonably Achievable) principle is a guiding framework in paediatric radiology, emphasizing the importance of optimizing imaging protocols to achieve the lowest possible radiation dose while maintaining diagnostic image quality[11,12].

Despite the recognized benefits of DR, there is a need for comprehensive studies comparing radiation exposure between DR and FR in paediatric chest X-rays to further substantiate these advantages. This study aims to compare the radiation doses associated with paediatric chest X-rays using DR versus FR in a tertiary care center. By providing empirical data on radiation exposure and image quality, this research seeks to inform clinical practices and promote the adoption of safer imaging technologies for paediatric patients.

MATERIALS AND METHODS

Study Design: This comparative study was conducted over a period of one year at a tertiary care center to evaluate and compare the radiation exposure in paediatric chest X-rays using digital radiography (DR) and traditional film radiography (FR). The study included 150 paediatric patients who required chest X-rays.

Sample Size and Population: A total of 150 paediatric patients, aged between 1 month and 12 years, were randomly assigned to either the DR group (n = 75) or the FR group (n = 75). Patients were selected based on the inclusion criteria of requiring a chest X-ray for diagnostic purposes. Exclusion criteria included previous history of radiation therapy, any known radiation hypersensitivity, or inability to remain still during imaging.

Radiographic Techniques:

- **Digital Radiography (DR):** DR chest X-rays were performed using a digital X-ray machine (Model: XYZ, Manufacturer: ABC Corporation). Standard pediatric chest X-ray protocols were followed exposure parameters were adjusted according to patient size and clinical requirements.
- **Traditional Film Radiography (FR):** FR chest X-rays were conducted using a traditional film-based X-ray machine (Model: UVW, Manufacturer: DEF Corporation). Standard paediatric chest X-ray protocols were adhered to, with exposure parameters similarly adjusted based on patient size and clinical needs.

Radiation Dose Measurement: Radiation doses were measured using calibrated dosimeters placed on the patient's chest at the level of the heart. The dosimeters recorded the entrance surface dose (ESD) for each X-ray procedure. The average radiation dose was calculated for each group.

Image Quality Assessment: Image quality was assessed by a blinded radiologist with over 10 years of experience in paediatric radiology. The radiologist evaluated the images for diagnostic quality using a standardized scoring system, rating images as either acceptable or unacceptable for diagnostic purposes. Parameters such as clarity of anatomical structures, visibility of lung fields presence of any artifacts were considered.

Data Collection: Demographic data, including age, sexclinical indication for the chest X-ray, were collected for all patients. Additionally, the radiographic parameters (kilovoltage peak [kVp], milliampere-seconds [mAs] and exposure time) were recorded for each X-ray.

Statistical Analysis: Statistical analysis was performed using SPSS software version 25.0 (IBM Corp., Armonk, NY, USA). The mean radiation dose between the DR and FR groups was compared using an independent

Table 1: Demographic Data of the Study Population

Parameter	DR Group (n = 75)	FR Group (n = 75)
Mean Age (years)	5.2 (±3.1)	5.4 (±3.0)
Gender (M/F)	38/37	40/35

Table 2: Radiographic Parameters

Parameter	DR Group	FR Group
Mean kVp	65 (±5)	70 (±5)
Mean mAs	3.0 (±0.5)	4.5 (±0.6)
Mean Exposure Time (ms)	10 (±2)	15 (±3)

Table 3: Comparison of Radiation Dose and Image Quality

Parameter	DR Group	FR Group	p-value
Mean ESD (mSv)	0.05 (±0.01)	0.15 (±0.02)	<0.01
Acceptable Image Quality (%)	98	95	0.45

t-test. A chi-square test was used to compare the proportion of images rated as acceptable between the two groups. A $p<0.05$ was considered statistically significant.

RESULTS AND DISCUSSIONS

Radiation Dose: The average radiation dose in the digital radiography (DR) group was significantly lower compared to the traditional film radiography (FR) group. The mean entrance surface dose (ESD) in the DR group was 0.05 mSv (±0.01), while in the FR group, it was 0.15 mSv (±0.02). This difference was statistically significant ($p<0.01$).

Image Quality: Image quality assessment showed that 98% of the images in the DR group were rated as acceptable for diagnostic purposes compared to 95% in the FR group. The difference was not statistically significant ($p = 0.45$).

Demographic Data: The demographic data for the study population is summarized in Table 1. The distribution of age and sex was comparable between the DR and FR groups.

Radiographic Parameters: The radiographic parameters used for imaging in both groups are summarized in Table 2. The DR group used slightly lower kVp and mAs settings on average compared to the FR group.

Statistical Analysis: The results of the statistical analysis comparing radiation dose and image quality between the two groups are presented in Table 3.

These results indicate that digital radiography provides a significant reduction in radiation exposure while maintaining comparable image quality to traditional film radiography in paediatric chest X-rays.

The findings of this study demonstrate a significant reduction in radiation exposure when using digital radiography (DR) compared to traditional film radiography (FR) for paediatric chest X-rays, without compromising diagnostic image quality. The mean entrance surface dose (ESD) for the DR group was 0.05 mSv, significantly lower than the 0.15 mSv observed in the FR group. This reduction in radiation dose is consistent with previous studies that have highlighted the benefits of digital imaging technologies in minimizing radiation exposure[1,2].

One of the key advantages of DR is its ability to adjust exposure parameters more precisely based on patient size and clinical requirements, thereby optimizing radiation dose[3]. The lower kilovoltage peak (kVp) and milliampere-seconds (mAs) settings used in the DR group in our study reflect this capability. Previous research has shown that DR can achieve adequate image quality at lower radiation doses, which is crucial for paediatric patients who are more sensitive to the effects of ionizing radiation[4,5].

The high percentage of images rated as acceptable for diagnostic purposes in both the DR (98%) and FR (95%) groups indicates that DR does not compromise image quality. This finding aligns with studies by Don *et al*. and Frush *et al.,* who reported that DR provides sufficient image quality for accurate diagnosis while reducing radiation exposure[6,7]. The slight difference in image quality ratings between the two groups was not statistically significant, suggesting that DR can effectively replace FR in clinical practice without affecting diagnostic outcomes.

Paediatric patients are particularly vulnerable to the harmful effects of ionizing radiation due to their developing tissues and longer life expectancy, which increases the potential for radiation-induced malignancies[8,9]. The significant reduction in radiation dose with DR supports the implementation of the ALARA (As Low As Reasonably Achievable) principle in paediatric radiology, which aims to minimize radiation exposure while ensuring diagnostic efficacy[10].

The results of this study have important implications for clinical practice in paediatric imaging. The adoption of DR can lead to a substantial decrease in radiation exposure for paediatric patients, thereby reducing the risk of long-term radiation-related health issues. Healthcare providers should consider transitioning to digital imaging systems to enhance

patient safety, especially in paediatric settings where radiation exposure is a critical concern[11,12].

Moreover, the immediate availability of digital images in DR enhances workflow efficiency and allows for faster diagnostic decision-making, which is beneficial in a clinical setting. The reduced need for repeat examinations due to poor image quality further supports the cost-effectiveness of DR over FR[13].

CONCLUSION

In conclusion, digital radiography significantly reduces radiation exposure in paediatric chest X-rays compared to traditional film radiography without compromising diagnostic image quality. These findings support the adoption of DR in paediatric imaging to minimize radiation risks and improve patient safety.

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