

To repeat or not to repeat: Radiologists demonstrated more decisiveness than their fellow radiographers in reducing the repeat rate during mobile chest radiography

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ABSTRACT

Introduction: Radiologists and radiographers play a complementary role in providing an optimal image quality with decrease radiation dose and proper diagnosis during chest radiographs. We aim Investigate years of experience among radiologists and radiographers on perception of image quality and its impact on repeat rate when evaluating portable pediatric chest radiographs.

Methods: IRB approved retrospective study consisted of randomly selected images (n = 131) of pediatric portable chest radiographs. Images were blindly assessed by four radiologists and four radiographers. Readers were asked to assess qualitative and quantitative image quality by rating: image quality, decision to repeat and image technique. All data was compared employing Pearson's Correlation, Visual grading characteristic (VGC) and Cohens' kappa analyses.

Results: Image quality: Radiologists (88.4%) rated images as excellent significantly more than radiographers (11.6%), and radiographers (90.1%) as poor significantly more than radiologists (9.9%) (p < 0.05). Repeat: Radiologists (57%) decided not to repeat images significantly more than radiographers (43%) (p < 0.05). Image technique: Radiologists rated images as acceptable (65%) and excellent (97.7%) significantly more than radiographers (35% and 2.3% respectively) (p < 0.05), whereas radiographers (84%) assessed image technique as poor significantly more than radiologists (16%) (p < 0.05). VGC: radiographers had slightly better qualitative evaluation of image quality than radiologists. An association between image quality (p < 0.002) and repeat decision (p < 0.044) with years of experience was established when comparing years of experience with image assessment rubric, while no association was noted with image technique (p < 0.9).

Conclusion: Radiologists demonstrated more decisiveness than their fellow radiographers in reducing the repeat rate of portable pediatric chest radiographs. Interestingly, years of experience only seem to affect image technique and image quality assessment among radiologists.

Implications for practice: Continuous education of radiographers and close collaboration with radiologists is crucial to achieve optimal image quality and low radiation doses.

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Introduction

Recent focus on reducing radiation dose to the pediatric population has been intensely investigated around computed tomography (CT) scans.¹ However, pediatric chest radiographs have had their research value diminish in recent years with the chief focus of research being towards CT scanning.¹ Chest radiographs are the most commonly performed imaging to pediatric patients as they are requested on a regular basis in the intensive care unit (ICU), to

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record the position of the endotracheal tube (ETT) as well as establish lung parenchymal status.^{2–4} The main focus in chest radiography is to balance low radiation dose with optimal image quality that will not affect radiological diagnosis.⁵

Patient safety during pediatric radiography is achieved according to a series of guidelines that are set by various organizations around the world with emphasis on radiation dose delivered and acceptable image quality.^{6–9} Radiographers are responsible to expose pediatric patients to x-rays under certain selected parameters (kVp, mAs) that affect image quality and delivered radiation dose.¹⁰ On the other hand, radiologists' main role is pathology detection and diagnosis. There have been attempts to compare radiologists to radiographers in terms of perceived image quality and repeat rate in radiographs.¹¹ In addition, a recent study investigated adult chest radiograph interpretation by radiographers proving it to be on par with radiologists,¹² however, participants were trained prior to the study on the same image quality criteria which could have been a source of bias. To our knowledge, there are no known studies that compared senior and junior radiographers' and radiologists' assessment of image quality and rejection rate in pediatric chest radiographs. Therefore, the aim of this study is to investigate if there is a correlation between years of experience and repeat examinations between radiographers and radiologists.

Methods

This retrospective study was approved by the institutional review board at our institution and patients' informed consent was waived. Images ($n = 131$) of pediatric mobile chest radiographs were randomly selected and retrieved from the picture archiving and communication system (PACS). The images were assessed by radiologists ($n = 4$) and radiographers ($n = 4$). The participants had varying years of expertise ranging from 1 to 22 years.

Radiographers were trained prior to image assessment. The training reviewed imaging critique and pathology detection which was accredited by the American Society of Radiologic Technologists as well as image review sessions with the pediatric radiologist.

Qualitative image assessment included a multi-reader analysis that consisted of 4 radiologists certified by the American Board of Radiology and 4 radiographers. Readers were asked to assess (1) image quality, (2) image technique, and (3) decision of whether to repeat the study. Image quality is related to contrast and the ability to identify anatomy.¹³ Image technique for chest radiographs includes aspects related to positioning¹⁴ (i.e. breathing technique and rotation).

The same set of images ($n = 131$) was presented to all readers. Images were blinded; only the images were presented to participants with no clinical history or previous images. Images were assessed on GSDP calibrated 3-megapixel monitor. Readers were permitted to manipulate the window and the level of each reader indicated the level of image quality. They were given a quality survey-based on modified chest radiograph quality criteria, 1: poor, impaired image quality limited by excessive image noise; 2: acceptable, reduced image quality with poor vascular and lung parenchymal definition or excessive image noise, limitations in low contrast resolution remain evident; 3: excellent, excellent attenuation of the lung parenchyma and vasculature limited perceived image noise (Fig. 1).

Similarly, readers indicated the level of image technique and provided a subjective decision confidence level from 1 to 3, where 1 indicated: poor; 2: acceptable; 3: excellent image technique (Fig. 2). For the need to repeat, readers decided whether to repeat (2) or not (1) (Fig. 3).

Initially, we compared the assessment of the three factors (image quality, image technique, and repeat rate) between radiographers and radiologists. Then, we assessed the same factors while taking into consideration years of experience. Participants were divided into two subgroups; those with one to five years of experience were identified as juniors, while those with more than five years of experience were identified as seniors.

Analyses were conducted using SPSS 24 for Windows (SPSS Inc, Chicago, IL). Independent student t-test was employed to compare the different assessment of image quality, image technique, and repeat rates between radiologists and radiographers. In addition, Pearson Chi-square was employed to assess the presence of an association between the three rated aspects, radiologists, radiographers, and years of experience. The results were considered statistically significant if $p \leq 0.05$. Categorical variables are presented as frequencies and/or percentages, and continuous variables are presented as means \pm standard deviations.

Results

Correlation between radiologists and radiographers

One hundred and thirty-one pediatric chest radiographs were randomly selected for the visual perception of this study. The radiographs were analyzed by radiologists and radiographers with a mean year of experience of 1.75 ± 0.83 and 2.4 ± 0.80 respectively.

Image quality

Statistical analysis demonstrated a significant difference in terms of assessment of image quality between radiologists and radiographers ($p < 0.001$). The assessment of image quality as acceptable was highest among radiologists ($n = 327$) and radiographers ($n = 304$) with no significant difference between them ($p > 0.05$) (Table 1). However, radiologists ($n = 176$) tended to rate image quality as excellent significantly more than radiographers ($n = 23$), and radiographers ($n = 197$) rated image quality as poor significantly more than radiologists ($n = 21$) ($p < 0.05$).

Image technique

Statistical analysis demonstrated a significant difference in terms of assessment of image technique between radiologists and radiographers ($p < 0.001$). Image technique was assessed as acceptable and excellent significantly more in radiologists ($n = 334$ and 126 respectively) than radiographers ($n = 180$ and 3 , respectively) ($p < 0.05$). Whereas, radiographers ($n = 336$) assessed image technique as poor significantly more than radiologists ($n = 64$) ($p < 0.05$).

Repeat

Statistical analysis demonstrated a significant difference in the decision to repeat images between them ($p < 0.001$), where radiologists ($n = 510$) decided not to repeat images significantly more than radiographers ($n = 384$).

Correlation between radiologists and radiographers with years of experience

Radiologists

Statistical analysis demonstrated a significant difference between the assessment of image quality ($p = 0.001$) and image technique ($p = 0.001$). Interestingly, no significant difference between the repeat rate and years of experience was noted ($p = 0.104$) (Table 2).

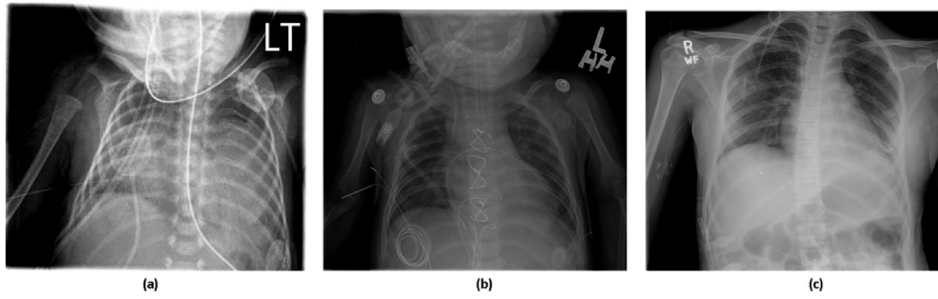


Figure 1. Pediatric chest radiographs demonstrating readers' assessment of image quality as (a) poor, (b) acceptable and (c) excellent.

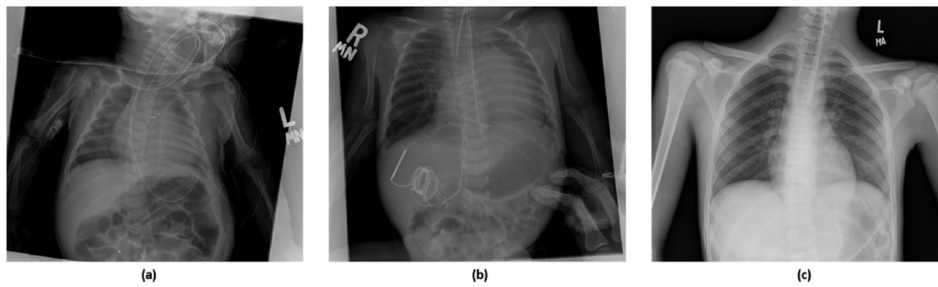


Figure 2. Pediatric chest radiographs demonstrating readers' assessment of image technique as (a) poor, (b) acceptable and (c) excellent.

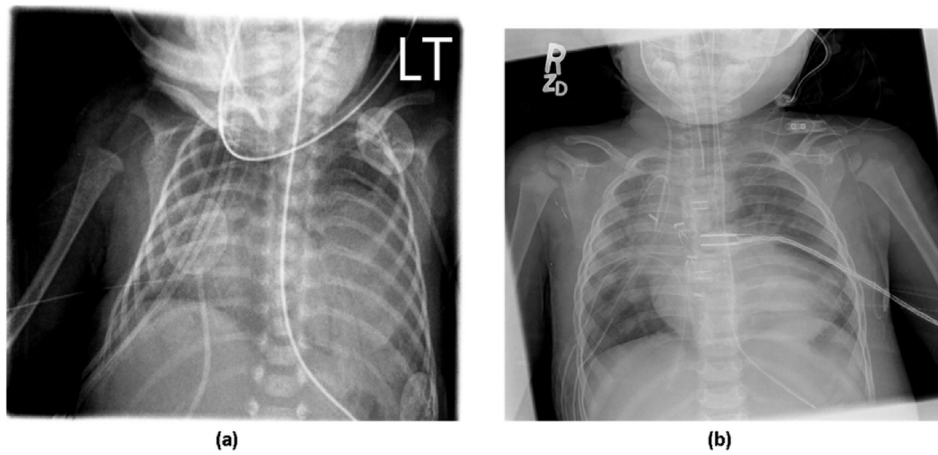


Figure 3. Pediatric chest radiographs demonstrating readers decision (a) to repeat and (b) do not repeat.

Table 1

Distribution of the assessment of image quality, decision to repeat and image technique according to radiologists and radiographers.

		Radiologist		Radiographer		P Value
		n	%	n	%	
Image Quality	Poor	21	9.7%	197	90.3%	0.001
	Acceptable	327	51.8%	304	48.2%	
	Excellent	176	88.4%	23	11.6%	
Image technique	Poor	64	15.9%	336	84.1%	0.001
	Acceptable	334	65.0%	180	35%	
	Excellent	126	97.7%	3	2.3%	
Repeat	No	510	56.8%	384	43.2%	0.001
	Yes	14	9.4%	135	90.6%	

Table 2
Distribution of the assessment of image quality, image technique and decision to repeat according to years of experience among radiologists and radiographers.

Years of Experience	Radiologists						P Value
	Poor		Acceptable		Excellent		
	n	%	n	%	n	%	
Image Quality							
1–5 years	7	2.70%	140	53.40%	115	43.90%	0.001
>5 years	14	5.30%	187	71.40%	61	23.30%	
Image technique							
1–5 years	29	11.10%	147	56.10%	86	32.80%	0.001
>5 years	35	13.40%	187	71.40%	40	15.30%	
Repeat							0.104
	No		Yes				
	n	%	n	%			
1–5 years	252	96.20%	10	3.80%			
>5 years	258	98.50%	4	1.50%			
Years of Experience	Radiographers						P Value
	Poor		Acceptable		Excellent		
	n	%	n	%	n	%	
Image Quality							
1–5 years	49	38.90%	76	60.30%	1	0.80%	0.074
>5 years	148	37.1%	228	57.2%	22	5.50%	
Image technique							
1–5 years	82	65.10%	44	34.90%	0	0.00%	0.616
>5 years	259	65.07%	136	34.17%	3	0.75%	
Repeat							
	No		Yes				
	n	%	n	%			
1–5 years	100	79.40%	26	20.60%			0.114
>5 years	289	72.61%	109	27.38%			

Radiographers

No statistical significance was noted when comparing the assessment of image quality ($p = 0.074$), image technique ($p = 0.616$), and repeat rate ($p = 0.114$) between different years of experience in radiographers (Table 2).

Visual grading characteristic

The VGC analysis is a non-parametric rank-invariant method for analysis of visual grading data and image quality of multiple readers according to a gold standard. In our study, the gold standard is an expert in image quality assessment with 22 years' experience. When an agreement is shown between readers and the gold standard the area under the curve (AUC) is <50%. In our area under the curve for radiographers (AUC = 0.606–0.665, 95% CI: 0.497–0.775) was less than that of radiologists (AUC = 0.468–0.629, 95% CI: 0.357–0.737) with only one outlier radiologist who had a lesser area under the curve (AUC = 0.629). Overall, radiographers were in greater agreement with the gold standard selected for image quality than radiologists (Fig. 4).

Discussion

In our study, we compared the differences in perception of image technique and image quality, and the decision to repeat imaging between radiologists and radiographers in mobile pediatric chest radiography. Additionally, we analyzed the variance in assessment principles between radiologists and radiographers with different levels of expertise. This is of great importance since children have two times the risk of developing radiation-related

diseases compared to adults and that all of these variables influence radiation doses directly and indirectly.¹⁵ Additionally, we analyzed the variance in assessment principles between radiologists and radiographers with different levels of expertise. Our results inferred that radiographers are more technically oriented while radiologists are driven by their ability to diagnose. Interestingly, years of experience only appeared to have a significant effect on image technique and image quality assessment of radiologists.

When assessing image technique and image quality, our study demonstrated a significant difference between radiologists and radiographers. This is consistent with other studies that compared both groups' assessments of qualitative and quantitative image quality.^{11,16} Whaley et al. speculated the reason for this to be the difference in perceptions between both parties.¹⁶ In our study, radiographers appeared to be more critical in terms of image quality as they were nine times as likely to score images as poor compared to radiologists. Similarly, for image technique, radiographers were five times as likely to score images as poor compared to radiologists. The primary role of the radiographer is to obtain an image that is of diagnostic quality, whilst the role of the radiologist is to provide a diagnosis. Due to the varying nature of perception in image quality requirements, the radiologist will not repeat as many x-rays as the radiographer because once the clinical question is answered the examination ceases. This difference in perception between image quality and diagnosis separates the approach to image quality and repeat rates between radiographers and radiologists. Radiographers' educational background enables them to appreciate how challenging it is to attain proper image technique and image quality¹¹; therefore, explaining the high rate of poor assessment among them. Radiologists were 42 and 1.8 times more likely to assess image technique as excellent and acceptable respectively compared to radiographers. This can be due to the fact that radiologists relate acceptance of image quality to pathology detection. Even poor images in terms of image technique and image quality can provide information that can be valuable to the diagnosis and could not be poorly scored.

It seems clear that both radiographers and radiologists rarely decide to repeat images. However, radiographers tend to reject images on a technical basis even when the information provided is enough for radiologists to carry out a proper diagnostic evaluation. This explains the decreased inclination of radiologists to reject images with respect to radiographers.¹¹ One study stated that technical assessment resulted in premature rejection of images by radiographers.¹¹ Therefore, when analyzing the results for image quality and repeat rate, it can be concluded that the decision to repeat imaging is affected by the assessment of image quality for both radiographers and radiologists, but repeat rates by radiographers are more focused to image quality compared to radiologists who require acceptable image quality to answer the clinical question set by the referring physician.

The most interesting finding in our study appeared upon comparing the two groups with respect to years of experience. Findings demonstrated that experience did not seem to have a meaningful effect on the scoring of images for radiographers. For radiologists, years of experience did have a significant effect on their scoring of image quality and image technique, but not on their decision to repeat. Senior radiologists scored image quality and image technique as acceptable 32% and 27% respectively more than junior radiologists. This result implies that increased experience of radiologists enabled them to be more understanding of radiographers' perception of image technique and image quality. However,

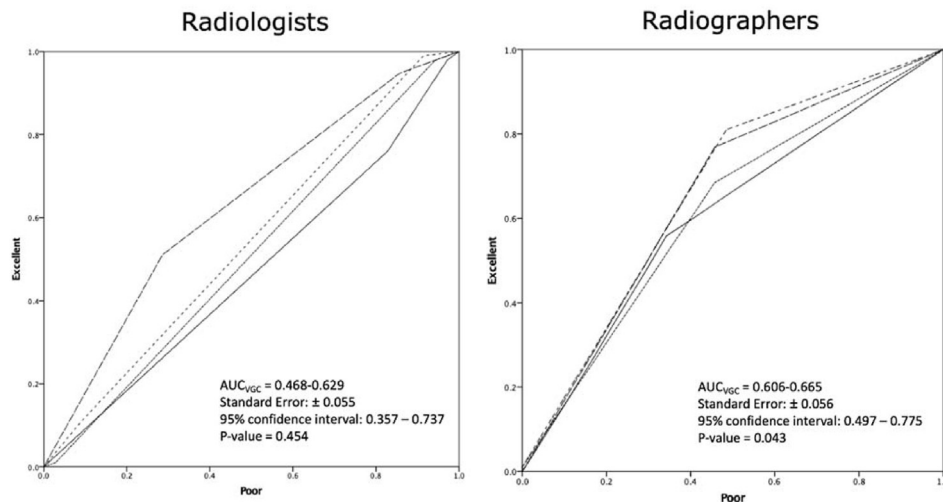


Figure 4. VGC curve for (a) radiologists and (b) radiographer's assessment of image quality.

radiographers did not reciprocate and learn from their fellow radiologists as they gained experience due to the lack of continuous learning in the radiology department, and this showed in their results for the decision to repeat were purely based experience. The results highlight a dilemma in communication between both groups.

When a patient seeks diagnosis via radiography, the primary personnel responsible to attain the adequate data for diagnosis are radiographers. Therefore, radiographers have a key role in maintaining image quality, reducing repeat rate, and assuring the safety of patients. After an image is acquired, it is sent to radiologists for proper analysis and diagnosis. Accordingly, radiologists cannot play as much of a direct role in attaining the needed image quality, reducing repeat rate and radiation dose. However, they still have a vital role, which is to communicate with radiographers their perceptions of good image quality to attain a proper diagnosis. Unifying perceptions on image quality between both parties seems essential to optimize patient care. Proper communication between radiographers and radiologists is expected to result in reducing the number of repeated images, improving image quality while demonstrating better compliance to the as low as reasonably achievable (ALARA) principle.

Our study like all others seems to have some shortcomings. Firstly, we did not measure the clinical impact and diagnostic efficacy when comparing image quality with pathology detection. Second, there was no reference standard used when categorizing optimal image quality as it varies between user, experience, and education. Third, we did not perform a quantitative image quality analysis. Further studies are required to highlight the effect of pathology detection compared to image quality with radiographers and radiologists. Finally, limitations were also noted in the sample. The sample size and subcategories might be inadequate and too small. In addition, the number of radiologists and radiographers within each experience category was not equal. These limitations in our sample might bias the obtained results and hinder their power. Sample limitations should be avoided in the recruitment phase of future studies.

Conclusion

The mismatch between radiologists and radiographers, where the former demonstrated more decisiveness than their fellow radiographers in reducing the repeat rate of mobile pediatric chest radiographs. Interestingly, years of experience only seem to affect

image technique and image quality assessment among radiologists. Radiographers would benefit in terms of potentially reducing repeat rates if they had more education around the acceptability of image based on an understanding of visible pathology or the impact it may have on image quality. This can only be attained by close collaboration between radiographers and radiologists.

Compliance with ethical standards

Ethical approval

The study was approved by the Institutional Review Board and all procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee.

Informed consent

Informed consent was waived as this was a retrospective study

Conflict of interest statement

All authors declare no conflict of interest.

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