

Confronting our Mistakes: A Comprehensive Evaluation of Radiographic Errors in Digital Chest Radiography Among Adult Population in a Public Sector Hospital

Rabia Liaqat¹, Ayesha Isani Majeed², Muhammad Nauman Malik³, Aqeel Shafi⁴, Syeda Zakia Shah⁵,
Bushra Liaqat⁶

^{1,4,6}Postgraduate Resident, ²Associate Professor, ³Medical officer, ⁵Assistant Professor, ⁶RMP
(Pakistan Institute of Medical Sciences, Islamabad)

Author's Contribution

^{1,4,6}Substantial contributions to the conception or design of the work; or the acquisition, analysis and ²Final approval of the version to be published, Drafting the work or revising it critically for important intellectual content

^{3,5}Active Participation in active methodology

Funding Source: None

Conflict of Interest: None

Received: Jan 22, 2021

Accepted: April 29, 2021

Address of Correspondent

Dr Rabia Liaqat

Senior Registrar

Nishtar Medical University Multan

Rabialiaqat@live.com

ABSTRACT

Objective: To find out the various types of radiographic errors in digital chest radiography and their effect on image quality leading to image rejection.

Methodology: This cross-sectional study was carried out in Radiology department of Pakistan Institute of Medical Sciences for a period of one month, September 2019. The study included 1560 digital Chest X-Rays, reaching the Picture Archive and Communication System (PACS), fulfilling the inclusion criteria. All these X-rays were analyzed by two radiology residents for the presence of radiographic errors in them. The various radiographic errors were then classified as Positioning error, poor collimation, Artefacts, improper exposure, motion blur and mislabeling. The frequency of each radiographic error was measured along with their implication on image quality resulting in three major image categories: ACCEPT, JUST ACCEPTABLE and REJECT. The SPSS was adopted for inferential statistical analysis.

Results: The study included 1013 (64.9%) male patients and 547 (35.1%) female patients. The mean age came out to be 36 +/- 15 years. Out of 1560 X-rays, 964 (61.8 %) had radiographic errors in them while 596 (38.2%) were completely devoid of radiographic errors. Positioning error (44.5 percent) was the most frequently encountered error followed by poor collimation (29.8%), artefacts (14.9%), Improper exposure (8%), motion blur (2.2%) and mislabeling (0.5%). The rejection rate came out to be 16.5 %. The major cause of image rejection was anatomy cutoff, especially the cut-off of cardio phrenic (CP) angle.

Conclusion: Positioning errors represent the commonest cause of image rejection in chest radiography. The main identified pitfall was lack of radiographer's education and training in performing an examination and indicates a need to improve their performance.

Key words: Digital Radiography, Chest X ray, Radiographic error, Image reject

Cite this article as: Liaqat R, Majeed AI, Malik MN, Shafi A, Shah SZ, Liaqat B. Confronting our Mistakes: A Comprehensive Evaluation of Radiographic Errors in Digital Chest Radiography Among Adult Population in a Public Sector Hospital *Ann Pak Inst Med Sci.* 2021; 17(2): 129-133. doi.10.48036/apims. v17i2.440

Introduction

Radiography is one of the basic tools and standard of care in clinical medicine addressing several pathological conditions, hence playing a vital role in disease management.¹ A poor-quality radiographic image not only misleads the health care professionals in concluding a correct diagnosis but also results in image retake leading to excessive patient radiation exposure and reducing the cost effectiveness of this imaging modality.²

The traditional film-based radiography has been largely replaced by digital radiography since ages.² With the advent of digital radiography, a significant improvement in image quality has been sought, thus reducing the percentage of image reject/retake from 10–15% to 3–5 %.^{2,3} The term 'REJECT' refers to radiographs of patients that are unacceptable and need to be repeated.⁴ A recent study has highlighted a significant difference between the reject/retake rate of a radiologist and that of a radiographer with the former being more in favor of

keeping the images instead of rejecting them.⁴ Image quality is best addressed by interdisciplinary approach where the radiographer and the radiologist exchange experience-based knowledge in a clinical context underpinned by research-based knowledge.⁴ Image retake analysis is a useful answer to quality assurance in digital radiography and is helpful in designing certain guidelines to minimize the image rejection rate.^{2,5} The conventional film-based radiography mandated a proper reject analysis system within imaging departments to answer the performance and quality of the imaging systems.² Worldwide imaging departments have designed proper Quality Assurance (QA) and Quality control (QC) programs to control the image quality within direct digital radiography as well.^{5,6} Many factors lead to radiographic errors and subsequent increased rate of image retake. Chest radiography is a frequently requested radiological examination not only for disease assessment in sick patients but also serving as a baseline investigation for all Medical fitness programs. It is the most commonly performed imaging examination in Radiology with half captured in-department and half captured using portable x-ray equipment. The various types of radiographic errors in chest radiography include positioning errors, artefacts, Improper exposure, incorrect collimation, patient motion. Improper exposure results from error or faulty settings of two main radiographic factors: the peak kilovoltage (Kvp) and the mAs. Not all radiographic errors result in image rejection rather few exclusive causes of rejection in chest x rays include cut-off of CP angle, rotational errors, artefacts due to radiopaque objects.^{4,6} A significantly greater image reject rate is found for in-department versus Outpatient chest examinations.⁷ The most commonly observed radiographic error in general radiography, as well as chest radiography, is that of positioning, followed by artefacts, incorrect collimation, Improper exposure and patient motion.^{2,4,5,7} The advent of digital radiography has minimized the errors due to incorrect exposure however the errors due to positioning remain at an increase.^{3,10} The two most important demographic variables, age and sex, both show a significant correlation with the presence of radiographic error, with the female gender and the elderly population being more prone to acquiring them in their imaging examinations.² Although patient factors such as obesity, hypoventilation during imaging lead to image unsharpness, effective quality assurance programs are predominantly aimed at minimizing errors attributable to preventable technical factors.⁶ Another classification system for radiographic errors is: those caused by

radiographers, those caused by patient and the equipment related errors.⁸ The greatest cause of radiographic errors are the radiographers.⁸ A radiographer is the key person in performing a radiological examination and has a number of roles. Apart from lack of proper educational and training systems, certain workplace interruptions affect the performance of radiographers leading to radiographic errors.⁹ Quality assurance radiographers and radiologists believe that 'repeats' are predominantly related to positioning skills and repeat analysis is the main tool to plan training needs to up-skill the radiographers.^{3,10} This study exclusively takes into account a radiologist's perception of radiographic errors occurring in chest radiography and a final analysis of reject/retake rate. Surprisingly no reject/retake analysis yet to have been conducted for digital radiography in our department. The results of the study would be immensely helpful in designing the various guidelines to minimize the radiation related health hazards secondary to image retake.

Methodology

This cross-sectional study was carried out in Radiology Department of Pakistan Institute of Medical Sciences for a period of 1 month, in September 2019. An approval from the Ethical committee of the institute was sought. The study involved analysis of all daily acquired frontal projections of chest X rays, reaching the Picture archival and communication system (PACS), fulfilling the inclusion criteria. The study included digital Chest X rays of adult population of both genders (>13 years) who were referred from the outpatient department or required the examination for the purpose of medical fitness. The study excluded pediatric age group, unconscious patients, portable chest X-rays, lateral projection of chest radiographs and those X-rays which were acquired from the CR systems. Through consecutive sampling technique a total number of almost 1560 images were included in the study and were analyzed by two senior radiology residents for the presence of radiographic errors. The various radiographic errors were then classified as: Positioning errors, incorrect collimation, artefacts, improper exposure, motion blur and error of laterality or mislabeling. The positioning error was a broad category which resulted in various other effects e.g. rotation, CP angle cut-off, centering error, partial scapular inclusion within lung field. The SPSS was adopted for inferential statistical analysis. At the end of the study the frequency of each radiographic error was measured. The implication

of radiographic errors on image quality was also determined by categorizing the images into three: ACCEPT, JUST ACCEPTABLE and REJECT. The first category 'ACCEPT' was of those images which were completely devoid of radiographic errors. The 'REJECT' category included those images having major radiographic errors which resulted in image rejection and warranted a retake. The intermediate category of 'JUST ACCEPTABLE' included those images where the presence of minor radiographic errors was not showing any significant loss of diagnostic information and didn't require a retake.

Results

A total number of 1560 chest X rays were analyzed for the presence of radiographic errors in them. The study included 1013 (64.9%) male patients and 547 (35.1%) female patients. The mean age came out to be 36 +/- 15 years. Out of 1560 X-rays, 964 (61.8 percent) had radiographic errors in them while 596 (38.2%) were completely devoid of any radiographic errors. A graphical representation of various types of radiographic errors has been shown in figure 1.

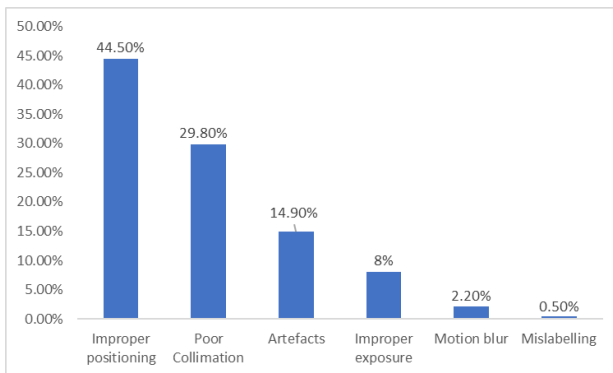


Figure 1. Frequency of radiographic errors in Digital Chest Radiography

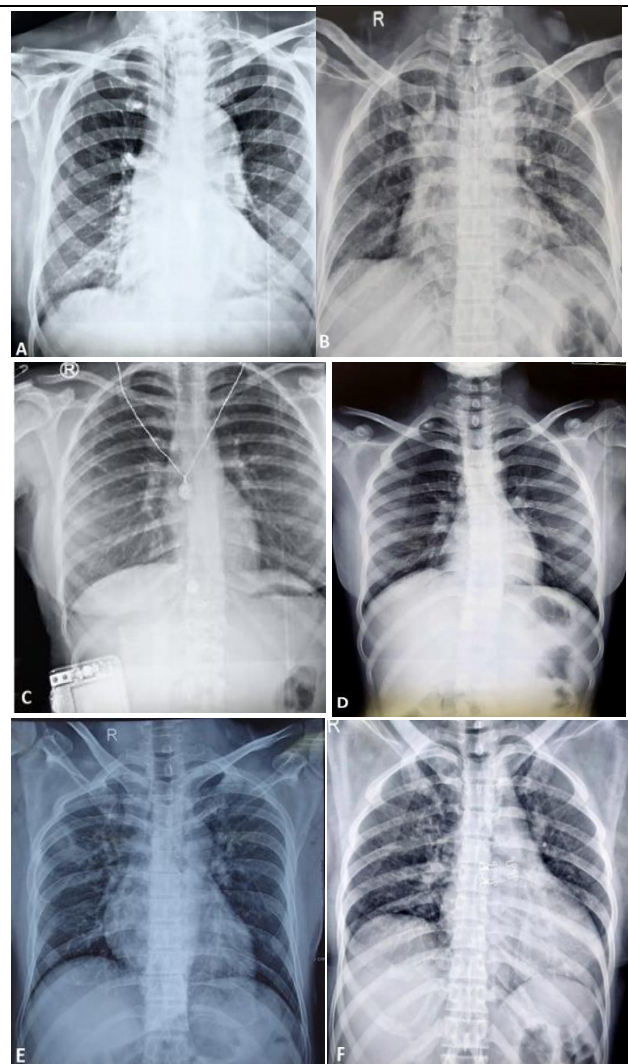
The chi-square test was applied with a significant proportion ($\chi^2 = 86.8$, P value of 0.0001) of chest X rays showing radiographic errors in them. Most of the images had multiple errors in them. Figure A-F show various Chest X -rays having radiographic errors in them.

Improper positioning (44.5%) was the most frequently encountered error followed by poor collimation (29.8%). Improper positioning further had a number of effects on image as shown in table I. This preliminary error assessment was followed by calculating the image reject rate. The images devoid of radiographic error were classified as KEEP. The REJECT category

predominantly included images of improper positioning with anatomy cut off (5.7%) and marked rotational component (4.8%), followed by marked improper exposure (3.8%) and motion blur images (2.2%) resulting in an overall image reject rate of 16.5%. The intermediate category of 'COULD KEEP' included the majority of the images (45.3%).

Table I-Various implications of Incorrect positioning

Results of Positioning error	Percentage
Rotational error	33.9%
Centering error	19.8%
Scapular inclusion	18.8%
CP angle cut-off	12.8%
Others	14.6%



Figures A-F: Various types of Radiographic errors: A) Anatomy Cut off, B) Rotational Error, C) Artefacts, D) Incorrect collimation, E) Scapular inclusion within lung field, F) Improper exposure

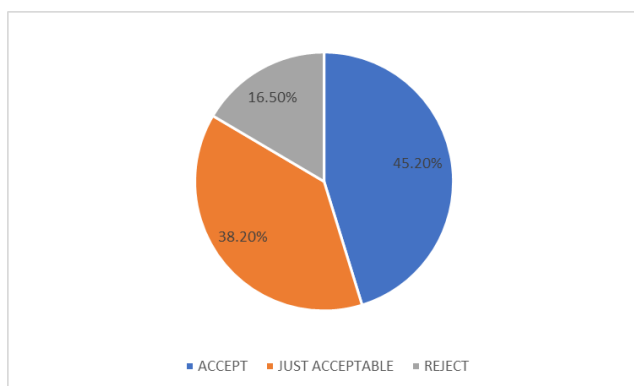


Figure II. Final image assessment

Discussion

The acquisition of high-quality diagnosable radiographic images require proper positioning of the patient and selection of optimal exposure factors.^{5,9,10,11} The assessment of presence of radiographic error is necessary to ensure optimal image quality yielding diagnostic information but is also required to adhere to the principle of ALARA (As Low As Reasonably Achievable).¹²⁻¹⁵ With the advent of digital radiography a significant reduction in exposure errors has been successfully achieved but the errors due to lack of optimum positioning remain on the rise in both CR and DR systems.^{4,6} Literature review strongly supports Image reject rate as the cardinal component of quality assurance(QA) program in medical imaging departments.^{4,11,12,16}

Improper positioning was the most frequently occurring error in our study representing 44.5 % of all radiographic errors. Worldwide literature also compliments our results with lack of optimum positioning being the commonest error in both general radiography and digital chest radiography as well^{12,13}. E.kjelle et al in 2020 carried out a study regarding the perception of radiologists as well as radiographers in image acceptance and noted that positioning error was the commonest error as determined by both the groups leading to poor image quality and resulting in image rejection.⁴ The rejection rate due to poor positioning according to this study was 55 % by the radiologists and 45 % by the radiographers.⁴ Omar S alhamnadi et al in 2019 and Hoffman B et al in 2015 observed similar results and reported positioning error being the commonest in their studies as well comprising of 9.3 % and 27.9 % of all radiographic errors in chest radiography respectively. The second most frequently found radiographic error is variable in different studies i-

e Omar S alhamdi reported artefacts being the second while in our study poor collimation was the second commonest occurring error which was largely attributable to non-adherence of the radiographers to the strict rules of collimation settings according to patients' body habitus. Most of the images showed under-collimation including upper half of abdomen within most of the images. Although an under-collimated image does not require an image retake however, due to larger exposed area an increased dose of radiation is delivered to the patient. The third commonly observed error in our study was artefacts with visualization of radio-opaque object being the commonest artefact. The main cause of this error was lack of proper patient preparation prior to the examination e.g. jewelry removal, undressing the clothes and wearing a proper gown. The presence of artefacts in an image not only masks the pathology but at times simulate it as well.

The chief consequence of radiographic error is image rejection resulting in image retake. The reject rate overall in literature is between 11-15 % for chest radiography.^{13,17} Omar S alahmadi et al in 2019 reported a rejection rate of 14.6 % in digital chest radiography with quite similar results to the previous literatures.^{12, 16} Our study came out to have a comparable rejection rate of 16.5 %. Another study by Sadiq et al. reported a rejection rate of 29.34% with chest X rays having the highest rejection rate. In our study, the major errors which contributed to the REJECT category were Anatomy cutoff (5.7%), especially the cut-off of CP angle, images having marked rotation (4.8%), motion blur images (2.2%), major radio-opaquefarti (2%) and those images with strikingly altered exposure factors (1.8%). But in our department the actual image retake rate was less, 7.9%, predominantly for those images having anatomy/CP angle cut off and motion blur. The main aim of current and previous studies is to minimize the rate of image rejection with subsequent reduction in image retake by addressing the various preventable technical errors. The main identified pitfall was the radiographer's education and training in performing an examination.⁴ An overall reject rate of 16.5% indicates a need for continuous practice in the Radiology Department to improve the performance of the radiographers by educating and training them in digital skills. As a radiographer is a key person in identifying the errors in radiographic images, he/she can play a vital role in minimizing the image reject rate. However, the combined expertise of both radiologists and then radiographers can undoubtedly serve as a far better

strategy towards image quality improvement in concordance with the principle of ALARA.

Conclusion

The radiographic errors remain challenging in digital chest radiography affecting the quality of the image. Positioning errors represent the commonest cause of image rejection in chest radiography. Monitoring the rejection rate is of utmost importance in maintaining quality assurance programs within imaging departments.

References

1. Aviram G. Chest radiography for tuberculosis screening: a valuable tool. *Isr Med Assoc J*. 2015;17(1):50-51
2. Lin C S, Chan P C, Huang K.-H, Lu C.-F, Chen Y.-F, Chen Lin et al. Guidelines for reducing image retakes of general digital radiography. *Adv Mech Eng*. 2016; 8(4) : 1-6 <https://doi.org/10.1177/1687814016644127>
3. D. Waaler, B. Hofmann, Image rejects/retakes—radiographic challenges, *Radiat Prot Dosimetry* 2010; 139(1-3): 375–379 <https://doi.org/10.1093/rpd/ncq032>
4. Kjelle E, Schanche A K, Hafskjold L. To keep or reject, that is the question - A survey on radiologists and radiographers' assessments of plain radiography images: *Radiography* 2020 <https://doi.org/10.1016/j.radi.2020.06.020>
5. Nol J, Isouard G & Mirecki, J. Digital Repeat Analysis; Setup and Operation. *J Digit Imaging*. 2006;19(2):159-166 <https://doi.org/10.1007/s10278-005-8733-1>
6. Waite S, Scott JM, Legasto A, Kolla S, Gale B, Krupinski EA: Systemic error in radiology: *American Journal of Roentgenology* 2017 ; 209:3, 629-639 <https://doi.org/10.2214/AJR.16.17719>
7. Foos D.H, Sehnert W.J, Reiner B, Siegel E.L, Segal A, Waldman D.L et al. Digital Radiography Reject Analysis: Data Collection Methodology, Results, and Recommendations from an In-depth Investigation at Two Hospitals. *J Digit Imaging*, 2009; 22(1), 89–98 . <https://doi.org/10.1007/s10278-008-9112-5>
8. Sukumar S, Yadav S, Sahana S, David LR, Kumari M. X-ray image reject analysis in OPD X-ray department—a pilot study. *Int J Med Pharm Sci* 2012; 3 (2); 33-37
9. L. Moller, K. W. Christiansen, A. S. Mortensen, “Interruptions affect the quality of radiographic practice”, *Journal of Radiology Nursing*, 2019; 39(1); 48-52 <https://doi.org/10.1016/j.jradnu.2019.10.003>
10. Peer R Peer, M Walcher, W Pohl W. Jaschke Comparative reject analysis in conventional film-screen and digital storage phosphor radiography : *Eur Radiol*, 1999; 9 (8): 1693-1696
11. AA Almalki, RA Manaf, MH Juni, KS Hayati, NM Noor, AAM Gabbad A Systematic review on repetition rate of routine digital radiography. *Int J Curr Res* 2017;9(2): 46325-46330
12. Sadiq AA, Miftaudeen MN, Mohammed A, Akpaniwo GM, Girei A, Garba Nwobi IC. Reject-repeat analysis of plain radiographs as a quality indicator at University of Maiduguri teaching hospital (UMTH). *EJPMR* 2017; 4(2):188–91.
13. Alahmadi A.S, Alrehaili A A, Gameraddin M B. Evaluation of reject analysis of chest radiographs in diagnostic radiology. *American JOURNAL OF DIAGNOSTIC IMAGING*, 2019: 5(1) ;4–8 <https://doi.org/10.5455/ajdi.20180830110208>
14. Hofmann B, Rosanowsky TB, Jensen C, Wah KH. Image rejects in general direct digital radiography. *Acta Radiologica Open*. 2015; 4(10):1–6. <https://doi.org/10.1177/2058460115604339>
15. Waaler D, Hammer S, Langdalen CC, Haug LT. How radiographers visually perceive X-ray images with the task of accepting or rejecting them—a pilot study. *Radiography Open*. 2017; 3(1): 2–3. <https://doi.org/10.7577/radopen.1997>
16. Owusu-Banahene J, Darko EO, Hasford F, Addison EK, Asirifi JO. Film reject analysis and image quality in Diagnostic Radiology Department of a Teaching hospital in Ghana. *J Radiat Res Appl Sci* 2014; 7(4):589–94 <https://doi.org/10.1016/j.jrras.2014.09.012>
17. Zewdu M, Kadir E, Berhane M. Analysis and economic implication of X-Ray film reject in diagnostic radiology department of Jimma University Specialized Hospital, Southwest Ethiopia. *Ethiopian J Health Sci*. 2017; 27(4):421–6. <https://doi.org/10.4314/ejhs.v27i4.13>
18. Benza C, Damases-Kasi C, Daniels ER, Amkongo M, Nabasenja C. The causes of reject images in a radiology department at a state hospital in Windhoek, Namibia. *South Afr Radiographer* 2018;56(1):37-38.
19. Andersen ER, Jorde J, Taoussi N, Yaqoob SH, Konst B, Seierstad T. Reject analysis in direct digital radiography. *Acta Radiol* 2012; 53(2):174–8. <https://doi.org/10.1258/ar.2011.110350>