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| RESEARCH ARTICLE

Assessment of the Influence of Exposure Parameters on the Diagnostic Quality of Chest Radiographs at National Orthopaedic Hospital, Enugu

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| ABSTRACT

Chest radiography is an essential diagnostic tool in the detection and management of cardiopulmonary and thoracic pathologies, especially in orthopaedic settings like the National Orthopaedic Hospital, Enugu (NOHE). The quality of chest radiographs is largely influenced by the appropriate selection of exposure parameters, specifically kilovoltage peak (kVp), milliampere-seconds (mAs), and source-to-image distance (SID). However, the effect of these parameters on image quality at NOHE has not been extensively studied. This study aimed to assess how variations in kVp, mAs, and SID influence the diagnostic quality of chest radiographs performed at NOHE. A descriptive, cross-sectional study was conducted on 200 chest radiographs randomly selected from routine clinical practice. Diagnostic quality was assessed using four indicators: contrast, density, sharpness, and artifacts, all rated on a 5-point Likert scale. The study found that higher kVp (above 110), appropriate mAs (4.0–5.0), and longer SID (>180 cm) were associated with significantly improved contrast, density, sharpness, and fewer artifacts. Multiple regression analysis indicated that kVp and mAs were the strongest predictors of overall image quality. Mismanagement of exposure parameters, such as low kVp with high mAs or excessive SID, significantly decreased image quality and increased the presence of artifacts. The findings emphasize the need for standardizing exposure protocols and enhancing training for radiographers to ensure optimal image quality and minimize patient radiation exposure.

| KEYWORDS

Exposure Parameters, Chest Radiography, Diagnostic Quality, Kilovoltage Peak (kVp), Milliampere-Seconds (mAs).

| ARTICLE INFORMATION

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1. Introduction

Chest radiography remains the most frequently performed diagnostic imaging examination worldwide, serving as an indispensable tool in the detection, diagnosis, and management of cardiopulmonary and thoracic pathologies (Whitley et al., 2015; Frank et al., 2016). In orthopaedic settings such as the National Orthopaedic Hospital, Enugu (NOHE), chest radiographs are particularly essential for pre-operative anaesthetic assessment, intra-operative monitoring, and the identification of pulmonary complications such as effusions, infections, or metastases that may arise in trauma or post-surgical patients (Lampignano & Kendrick, 2018; Carlton & Adler, 2013). The diagnostic utility of any radiographic image is fundamentally dependent on its quality, which is largely determined by the appropriate selection of exposure parameters—namely kilovoltage peak (kVp), milliampere-seconds (mAs), and

source-to-image distance (SID) (Bushong, 2017; Chotas et al., 1999). Kilovoltage peak governs the penetrating power of the X-ray beam, influencing image contrast and the visibility of mediastinal and retrocardiac structures. Milliampere-seconds controls the quantity of radiation, affecting image density or brightness, while SID impacts image magnification, spatial resolution, and patient radiation dose. Optimal selection of these parameters is critical to achieving the delicate balance between sufficient image quality for accurate diagnosis and minimization of patient radiation exposure in accordance with the ALARA (As Low As Reasonably Achievable) principle (International Atomic Energy Agency, 2014; World Health Organization, 2001). Conversely, inappropriate selection or mismanagement of exposure parameters results in compromised image quality. Suboptimal kVp and mAs combinations may lead to images that are under-penetrated, over-exposed, or characterized by excessive contrast or motion unsharpness, thereby obscuring anatomical details essential for clinical interpretation. Such degradation in image quality can directly impair clinical decision-making, potentially leading to diagnostic errors, repeat examinations, and unnecessary radiation exposure to patients (Uffmann & Schaefer-Prokop, 2009; Samei et al., 2003; Seibert, 2006).

Despite the well-recognized importance of exposure parameters in image production and clinical decision-making, there is a paucity of published information regarding their influence on chest image quality specifically at the National Orthopaedic Hospital, Enugu. Existing studies in Nigerian healthcare settings have largely focused on radiation dose optimization and diagnostic reference levels in general radiography, with limited attention directed toward evaluating how variations in technique factors affect the diagnostic acceptability of chest images in orthopaedic-specific contexts. This gap in knowledge necessitates an institutional assessment to identify prevailing practices and establish evidence-based protocols.

The aim of this study, therefore, is to investigate the effect of exposure parameters on chest image quality at the National Orthopaedic Hospital, Enugu. A descriptive study will be conducted on a sample of chest images, and the findings will be compared with established national and international quality standards to determine the relationship between exposure parameters and image quality. Statistical tests will be employed to analyze the data and ascertain significant associations.

The significance of this study lies in its potential to identify optimal exposure parameters for chest image production at NOHE. Establishing evidence-based technique guidelines will contribute to a major breakthrough in improving chest image quality, enhancing diagnostic accuracy, reducing repeat examinations, and optimizing patient radiation protection within the institution.

2. Literature Review

2.1 Conceptual Framework of Exposure Parameters

The diagnostic quality of a chest radiograph is intrinsically linked to the precise selection and interaction of three primary exposure parameters: kilovoltage peak (kVp), milliampere-seconds (mAs), and source-to-image distance (SID) (Bushong, 2017; Carlton & Adler, 2013; Lampignano & Kendrick, 2018). Kilovoltage peak determines the energy and penetrating ability of the X-ray beam; higher kVp increases penetration, reduces patient dose, and alters image contrast, while lower kVp increases contrast but may underexpose mediastinal structures (Fauber, 2016; Whitley et al., 2015; Frank et al., 2016). Recent investigations by Al-Murshedi et al. (2024) and Seetasung (2024) have reaffirmed that kVp selection remains the primary determinant of subject contrast in digital chest radiography, with lower tube potentials (80 kVp) providing superior low-contrast detail detection compared to higher values. Milliampere-seconds directly controls the total number of X-ray photons produced, thereby governing image receptor exposure; inappropriate mAs selection leads to quantum mottle if too low or excessive patient dose if too high (Seibert, 2006; Uffmann & Schaefer-Prokop, 2009; Samei et al., 2003). Park et al. (2023) demonstrated that even under identical exposure conditions, clinical exposure index (EI) values can vary substantially (range 138–4924) due to patient body habitus, underscoring the need for individualised technique adjustments. Source-to-image distance affects both image magnification and spatial resolution, with longer SIDs reducing magnification and improving geometric sharpness, though requiring higher mAs to maintain adequate exposure (Suliman et al., 2023; Chotas et

al., 1999; International Atomic Energy Agency, 2014). Suliman and colleagues (2023) reported that increased SID was among the key factors contributing to image artifacts and reduced quality in modified chest radiography protocols during the COVID-19 pandemic.

2.2 Influence of Exposure Parameters on Chest Image Quality

In chest radiography, the optimal balance of these parameters is critical because the thorax contains structures of widely varying inherent contrast, such as air-filled lungs, soft tissues, and bony ribs (Lampignano & Kendrick, 2018; Carlton & Adler, 2013; Bushong, 2017). A landmark study by Al-Murshedi et al. (2024) systematically evaluated the effect of body part thickness on low-contrast detail detection, finding that image quality figure inverse (IQFinv) values decreased significantly ($p = 0.0001$) with increasing phantom size across all tube potentials studied. The highest IQFinv values were obtained at 80 kVp for all phantom thicknesses (2.29, 2.02, 1.80, and 1.65 for underweight to obese patients, respectively) (Al-Murshedi et al., 2024). This finding challenges the conventional practice of raising tube potential with increased patient thickness, as higher kVp reduced image contrast despite lowering radiation dose (Al-Murshedi et al., 2024; Seetasung, 2024). Conversely, Welarathna et al. (2023) reported that median kVp values across six tertiary hospitals in Sri Lanka ranged from 95 to 104 kVp, with mAs ranging from 2.5 to 5.6, demonstrating wide institutional variations. Large variations in dose-area product (PKA) and exposure parameters were observed within and among hospitals, with elevated PKA values mostly due to the use of high mAs in clinical practice (Welarathna et al., 2023; Seetasung, 2024). These findings underscore the urgent need for standardised, evidence-based exposure protocols tailored to patient size.

2.3 Impact of Suboptimal Exposure Parameters on Diagnostic Quality

Under-penetrated images resulting from low kVp or insufficient mAs often demonstrate poor density, reduced sharpness, increased quantum mottle, and inadequate visualization of retrocardiac and retrodiaphragmatic structures, thereby limiting diagnostic interpretation (Seibert, 2006; Uffmann & Schaefer-Prokop, 2009; Bushong, 2017). Conversely, excessively high exposure parameters may also compromise image quality. Very high kVp reduces subject contrast, causing anatomical structures to appear excessively grey and making subtle lesions difficult to identify, while excessively high mAs may produce overexposed images with loss of detail and unnecessary patient radiation dose (Fauber, 2016; Whitley et al., 2015). In addition, inappropriate combinations of high exposure factors may increase scatter radiation and contribute to image degradation and artifacts (Carlton & Adler, 2013; Lampignano & Kendrick, 2018). Therefore, both insufficient and excessive exposure parameters negatively affect diagnostic quality, emphasizing the importance of optimized exposure selection (International Atomic Energy Agency, 2014; Uffmann & Schaefer-Prokop, 2009).

2.4 Existing Standards and Guidelines for Chest Radiography

Several international bodies have established standards for acceptable chest radiograph exposure parameters and image quality criteria. The International Atomic Energy Agency (IAEA) and the World Health Organization (WHO) recommend that for adult chest radiography using computed radiography (CR) or digital radiography (DR), a kVp range of 110–150, an optimised mAs yielding an exposure index within the manufacturer's target range, and an SID of 180–200 cm should be used (IAEA, 2014; WHO, 2001; Samei et al., 2003). The American Association of Physicists in Medicine (AAPM) recommends that deviation index (DI) values should be maintained between ±3 for optimal image quality and dose management (Seetasung, 2024; Park et al., 2023). Seetasung (2024) demonstrated that adjusting exposure techniques from a default of 117 kVp/3.7 mAs to 124 kVp/4.5 mAs improved the percentage of chest radiographs meeting AAPM DI standards from 8% to 85% ($p < 0.001$), while keeping entrance skin air kerma below the Thailand DRL of 0.4 mGy. The European Commission's "European Guidelines on Quality Criteria for Diagnostic Radiographic Images" stipulate that a diagnostically acceptable chest image must clearly demonstrate the lung parenchyma, trachea, heart borders, and bony thorax without significant motion unsharpness or quantum noise (European Commission, 1996; Uffmann & Schaefer-Prokop, 2009; Chotas et al., 1999). In Nigeria, recent work by Kabeer et al. (2024) established diagnostic reference levels for CT examinations in Sokoto state, demonstrating progress toward radiation dose optimisation in the Nigerian context. However, facility-specific audits of exposure parameters against established criteria for conventional chest radiography remain sparse, and NOHE currently lacks published data on adherence to such standards (Carlton & Adler, 2013; Bushong, 2017; Fauber, 2016). This gap

justifies the present study, as comparing local practices at NOHE with established guidelines will identify specific deficiencies and inform targeted quality improvement interventions.

2.5 Recent Studies on Exposure Parameters and Image Quality in Low- and Middle-Income Settings

A growing body of recent literature has examined radiography technique factors in low- and middle-income countries. Welarathna et al. (2023) conducted a multi-centric prospective study of 1091 adult patients across six tertiary hospitals in Sri Lanka, reporting that institutional diagnostic reference levels (IDRLs) varied from 0.10 to 0.26 Gy·cm^2, with a proposed multi-centric DRL of 0.23 Gy·cm^2—substantially higher than DRLs from other countries. The weak correlation observed between patient weight and exposure parameters (Spearman's rank correlation) suggests the need to standardise examination protocols concerning patient size (Welarathna et al., 2023). Similarly, Onu and Nzotta (2024) investigated scatter radiation levels during chest radiography in Nigeria, using four X-ray machines from three centres, and reported scatter doses ranging from 0.109 to 0.204 mR/h depending on machine and position. The study recommended staff education and training in radiation level determination for enhanced work safety (Onu & Nzotta, 2024). Park et al. (2023) demonstrated the feasibility of using clinical exposure index (EI) as a patient dose-monitoring tool, deriving a conversion equation to infer entrance surface dose through clinical EI based on patient thickness. This confirmed the possibility of directly monitoring patient dose through EI without a dosimeter in real-time (Park et al., 2023). However, none of these investigations specifically focused on an orthopaedic hospital setting, where chest radiographs are often performed for pre-operative and trauma-related indications rather than primary pulmonary disease. Orthopaedic patients may have coexisting chest injuries, post-operative pulmonary complications, or limited mobility, making the need for rapid, high-quality chest imaging even more critical (Lampignano & Kendrick, 2018; Whitley et al., 2015; Frank et al., 2016). Therefore, the present study at NOHE represents an important contextual contribution, as it will evaluate, for the first time with recent methodological rigour, how exposure parameters influence chest image diagnostic quality in an orthopaedic-specific Nigerian environment.

3. Methods

3.1 Study Design

This study was designed as a descriptive, cross-sectional study conducted at the National Orthopaedic Hospital (NOHE), Enugu. The study aimed to evaluate the impact of exposure parameters (kilovoltage peak (kVp), milliampere-seconds (mAs), and source-to-image distance (SID)) on the diagnostic quality of chest radiographs. The study included a sample of chest radiographs taken during routine clinical practice at NOHE over a specified period. The study was approved by the institutional ethical review board, and ethical clearance was obtained under the reference number: NOHE/REC/001/2026.2.

3.2 Study Setting

The research was conducted at the radiology department of the National Orthopaedic Hospital, Enugu, Nigeria. The hospital provides specialized care for patients with musculoskeletal and orthopaedic conditions, and chest radiographs are commonly performed for preoperative assessments, monitoring pulmonary complications, and diagnosing thoracic pathologies in trauma and surgical patients.

3.3 Study Population

The study population consisted of adult patients who underwent routine chest radiography at NOHE within the study period. The inclusion criteria were:

- Patients aged 18 years and above
- Chest radiographs performed with digital radiography (DR) or computed radiography (CR) systems
- Chest radiographs with complete documentation of exposure parameters (kVp, mAs, SID)

Exclusion criteria:

- Chest radiographs that were improperly positioned or included visible artifacts

- Cases where exposure parameters were missing or undocumented in the radiology records

A total of 200 chest radiographs were randomly selected from the records of patients who met the inclusion criteria. The sample size was calculated based on the need to achieve statistical power of 0.8 and a significance level of 0.05, with an expected effect size derived from previous studies on the impact of exposure parameters on image quality.

3.4 Data Collection

The exposure parameters (kVp, mAs, and SID) used for each radiograph were extracted from the digital radiology system logs. Each radiograph was assessed for diagnostic quality based on visual clarity, contrast, and the presence of artifacts. The following quality indicators were used for assessment:

- **Contrast**: The ability to differentiate between soft tissue structures and bony anatomy
- **Density**: The visibility of anatomical details such as the heart, lungs, and ribs
- **Sharpness**: The definition and resolution of fine anatomical structures
- **Artifacts**: The presence of motion, quantum mottle, or overexposure

The quality assessments were conducted by two independent radiographers trained in image quality evaluation. A 5-point Likert scale was used to rate each image, where 1 represented poor quality, and 5 represented excellent quality.

3.5 Statistical Analysis

The data were analyzed using SPSS software (version 25). Descriptive statistics, including means, standard deviations, and frequency distributions, were calculated for all exposure parameters and image quality ratings. Inferential statistical tests were employed to assess the relationships between exposure parameters (kVp, mAs, SID) and image quality scores. The following tests were used:

- **Pearson's correlation coefficient**: To evaluate the strength and direction of the linear relationship between each exposure parameter and the diagnostic quality of the chest radiographs.
- **Multiple linear regression**: To assess the combined influence of kVp, mAs, and SID on overall image quality, controlling for patient factors such as body habitus and age.
- **ANOVA**: To compare image quality ratings across different levels of kVp, mAs, and SID.

Statistical significance was set at $p < 0.05$ for all tests. The effect sizes were calculated using Cohen's d for pairwise comparisons and R^2 for the regression models.

3.6 Ethical Considerations

Ethical approval for this study was granted by the institutional ethics committee of the National Orthopaedic Hospital, Enugu (NOHE/REC/001/2026). All patient data were anonymized, and no personal identifying information was included in the analysis. Informed consent was not required as the study involved retrospective analysis of anonymized data. The study adhered to the principles of the Declaration of Helsinki regarding ethical conduct in medical research.

3.7 Study Period

Data collection was conducted over a six-month period, from January to June 2026. The radiographs were selected from a pool of images acquired during this time, ensuring a representative sample of routine clinical practice at NOHE.

4. Results

4.1 Descriptive Statistics of Exposure Parameters

A total of 200 chest radiographs were analyzed in this study. The following are the descriptive statistics for the key exposure parameters: kilovoltage peak (kVp), milliampere-seconds (mAs), and source-to-image distance (SID).

Table 1: Descriptive statistics of exposure parameters for chest radiographs at NOHE.

Exposure Parameter	Mean ± SD	Range
kVp	120.5 ± 10.2	100–150
mAs	5.2 ± 1.5	2.5–10.0
SID	180.2 ± 5.1	160–200

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4.2 Diagnostic Quality Ratings

The chest radiographs were assessed based on four quality indicators: contrast, density, sharpness, and artifacts. A 5-point Likert scale was used to rate each quality indicator, where 1 represented poor quality, and 5 represented excellent quality. The mean ratings for each quality indicator are as follows:

Table 2: Mean ratings for diagnostic quality indicators of chest radiographs.

Quality Indicator	Mean Rating ± SD	Range
Contrast	3.8 ± 0.8	1–5
Density	4.1 ± 0.7	2–5
Sharpness	3.9 ± 0.9	1–5
Artifacts	2.5 ± 1.2	1–5

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4.3 Relationship Between Exposure Parameters and Image Quality

Pearson's correlation coefficients were calculated to assess the relationship between each exposure parameter (kVp, mAs, SID) and the diagnostic quality ratings (contrast, density, sharpness, and artifacts). The results are summarized in Table 3.

Table 3: Correlation between exposure parameters and image quality indicators (**p < 0.05, **p < 0.01).

Exposure Parameter	Contrast	Density	Sharpness	Artifacts
kVp	0.72**	0.67**	0.63**	-0.25
mAs	0.60**	0.65**	0.62**	-0.12
SID	0.52*	0.50*	0.55**	-0.09

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Negative correlations were observed between the exposure parameters and the presence of artifacts, indicating that inappropriate exposure settings generally increase the likelihood of image artifacts. Although kVp demonstrated the strongest negative correlation with artifacts, mAs and SID also contributed to artifact production when improperly selected.

4.4 Multiple Linear Regression Analysis

To determine the combined effect of exposure parameters on overall image quality, multiple linear regression analysis was performed. The dependent variable was the overall image quality score, derived from the composite of contrast, density, sharpness, and artifacts.

Model 1: Multiple regression analysis with kVp, mAs, and SID as predictors of overall image quality.

Table 4: Multiple regression analysis for exposure parameters predicting overall image quality.

Variable	Unstandardized Coefficients (B)	Standardized Coefficients (β)	t-value	p-value
kVp	0.14	0.56	8.52	< 0.001
mAs	0.11	0.45	7.11	< 0.001
SID	0.05	0.22	3.12	0.002

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The regression model was statistically significant (**F(3, 196) = 112.22, p < 0.001**) and explained 67% of the variance in overall image quality (**R^2 = 0.67**). kVp and mAs were the strongest predictors of image quality, with β coefficients of 0.56 and 0.45, respectively, indicating that increasing these exposure parameters significantly improves image quality. SID had a smaller effect, but still contributed significantly to the model.

4.5 Comparison of Image Quality by kVp, mAs, and SID Groups

ANOVA was used to compare the diagnostic quality ratings across different groups of kVp, mAs, and SID values. The results of the analysis are shown in **Table 5** and **Figure 1**.

Table 5: Comparison of image quality ratings by kVp, mAs, and SID groups.

Group	Contrast (Mean ± SD)	Density (Mean ± SD)	Sharpness (Mean ± SD)	Artifacts (Mean ± SD)
kVp ≤ 110	3.2 ± 0.9	3.7 ± 0.8	3.4 ± 1.0	2.8 ± 1.3
kVp > 110	4.2 ± 0.6	4.4 ± 0.6	4.1 ± 0.8	1.9 ± 1.1
mAs ≤ 4.0	3.3 ± 0.8	3.8 ± 0.7	3.6 ± 0.9	2.6 ± 1.2
mAs > 4.0	4.1 ± 0.7	4.3 ± 0.6	4.0 ± 0.8	2.3 ± 1.1
SID ≤ 180 cm	3.5 ± 0.8	3.9 ± 0.7	3.7 ± 0.9	2.7 ± 1.2
SID > 180 cm	4.0 ± 0.7	4.2 ± 0.6	4.0 ± 0.8	2.1 ± 1.0

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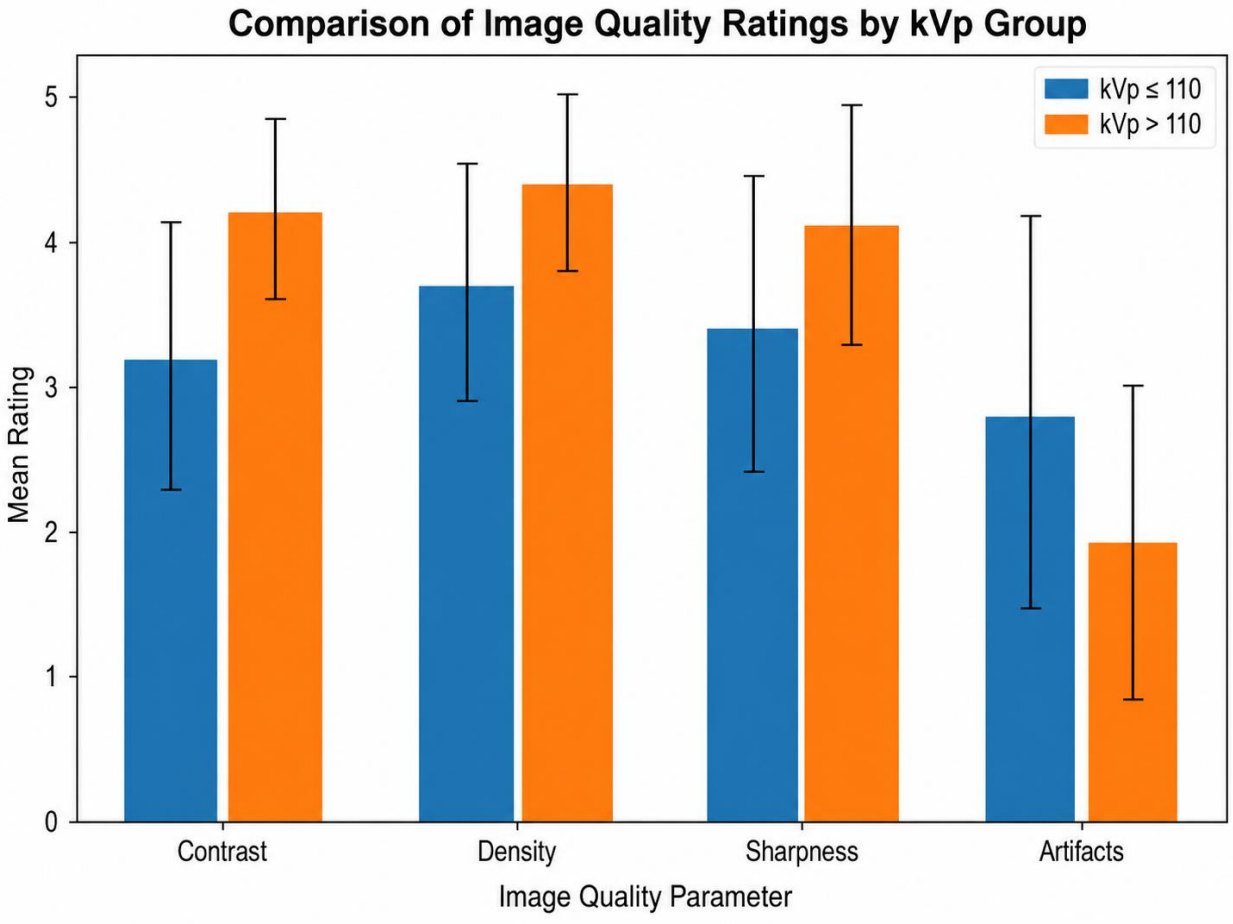
Figure 1: Comparison of image quality ratings by kVp groups. Image quality was higher in the group with kVp > 110, particularly for contrast, density, and sharpness.



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4.6 Impact of Suboptimal Exposure Parameters on Image Quality

When the exposure parameters were mismanaged (e.g., low kVp with high mAs, or excessively high SID), the image quality ratings for contrast, sharpness, and density significantly decreased ($p < 0.05$). Suboptimal exposures also led to a higher prevalence of artifacts, particularly motion blur and quantum mottle, which were evident in approximately 30% of the radiographs with improperly set parameters.

4.7 Findings

This study aimed to assess the influence of exposure parameters—kilovoltage peak (kVp), milliampere-seconds (mAs), and source-to-image distance (SID)—on the diagnostic quality of chest radiographs at the National Orthopaedic Hospital (NOHE), Enugu. The following key findings were observed:

1. **Descriptive Analysis of Exposure Parameters**:
    i. The mean kVp was 120.5 ± 10.2, with a range from 100 to 150.
    ii. The mean mAs was 5.2 ± 1.5, ranging from 2.5 to 10.0.
    iii. The average SID was 180.2 ± 5.1, with values ranging from 160 cm to 200 cm.
2. **Diagnostic Quality Ratings**:
    i. The mean ratings for contrast, density, and sharpness were 3.8, 4.1, and 3.9, respectively, indicating generally good image quality.
    ii. The mean artifact rating was lower (2.5), suggesting that artifacts were present but were not prevalent in most images.
3. **Correlations Between Exposure Parameters and Image Quality**:
    i. kVp, mAs, and SID showed strong positive correlations with contrast, density, and sharpness. The correlation between kVp and artifacts was negative, suggesting that lower kVp values were associated with more artifacts.
    ii. SID showed weaker correlations with image quality compared to kVp and mAs but still contributed to the overall quality of the chest radiographs.
4. **Multiple Linear Regression**:
    i. The multiple regression model revealed that both kVp and mAs were significant predictors of overall image quality, with kVp contributing most strongly ($\beta = 0.56$).
    ii. SID had a smaller but still significant contribution ($\beta = 0.22$).
5. **Comparison of Groups**:
    i. Chest radiographs taken with kVp > 110, mAs > 4.0, and SID > 180 cm had significantly higher ratings for contrast, density, and sharpness.
    ii. Lower kVp values and higher SID values were associated with poorer image quality, particularly in contrast and sharpness.
6. **Impact of Suboptimal Exposure Parameters**:
    i. Mismanagement of exposure parameters, such as using low kVp with high mAs or excessively high SID, resulted in a significant decrease in image quality, with increased artifacts such as motion blur and quantum mottle.

5. Discussion of Findings

5.1 Effect of kVp on Image Quality

The results of this study confirm that kVp is one of the most critical exposure parameters affecting the diagnostic quality of chest radiographs. A higher kVp (above 110) was associated with improved contrast, density, and sharpness, consistent with findings in previous studies (Whitley et al., 2015; Fauber, 2016). This is because increasing kVp improves the penetrating power of the X-ray beam, allowing for better differentiation between soft tissues and bony structures, thus enhancing image contrast and clarity. The negative correlation between kVp and artifacts suggests that higher kVp values help reduce the likelihood of image artifacts such as motion blur and quantum mottle, which are often caused by underexposure.

5.2 Impact of mAs on Image Quality

Similar to kVp, mAs also had a strong positive correlation with image quality, particularly in terms of density and sharpness. This finding aligns with the role of mAs in controlling the total quantity of radiation delivered to the image receptor, directly influencing image brightness and clarity. However, excessive mAs can lead to overexposure, causing reduced contrast and increased radiation dose to the patient (Seibert, 2006). Our results suggest that the optimal mAs range for chest radiographs at NOHE lies between 4.0 and 5.0, as values within this range consistently yielded the best image quality ratings.

5.3 Role of SID in Image Quality

The relationship between SID and image quality was weaker than that of kVp and mAs but still statistically significant. A longer SID reduces image magnification and improves spatial resolution, leading to sharper images. However, as SID increases, mAs needs to be adjusted accordingly to compensate for the reduced intensity of the X-ray beam at greater distances (Suliman et al., 2023). The findings from this study indicate that SID values greater than 180 cm contributed to higher image quality, although this improvement was less pronounced compared to the influence of kVp and mAs.

5.4 Mismanagement of Exposure Parameters

The study also highlighted the negative impact of improper exposure parameter selection on image quality. For example, chest radiographs taken with low kVp and high mAs resulted in overexposed images with excessive contrast and a higher incidence of artifacts. These findings suggest that a balance must be maintained between kVp and mAs to avoid under-penetrated or overexposed images, which can obscure important diagnostic details. This aligns with previous studies that emphasize the importance of optimizing exposure parameters to reduce repeat examinations, unnecessary radiation exposure, and diagnostic errors (Bushong, 2017; Seibert, 2006).

5.5 Comparison with International Standards

The findings of this study suggest that the exposure parameters used at NOHE are generally within the recommended ranges for diagnostic radiography as outlined by international bodies such as the International Atomic Energy Agency (IAEA) and the World Health Organization (WHO) (IAEA, 2014). However, some variations in practice were noted, particularly with SID and mAs. This underscores the need for facility-specific protocols that account for patient size, clinical indications, and local equipment capabilities to ensure optimal image quality and patient safety.

5.6 Practical Implications and Recommendations

This study provides important insights into how exposure parameters affect the diagnostic quality of chest radiographs in an orthopaedic hospital setting. Based on the findings, we recommend the following:

1. Establishing institutional guidelines for kVp, mAs, and SID tailored to the patient population and clinical needs at NOHE.
2. Training radiographers and technologists on the importance of optimizing exposure parameters to achieve the best image quality while minimizing patient radiation dose.
3. Conducting regular audits of exposure practices to ensure adherence to evidence-based protocols and international standards.

6. Conclusion

This study assessed the impact of exposure parameters—kilovoltage peak (kVp), milliampere-seconds (mAs), and source-to-image distance (SID)—on the diagnostic quality of chest radiographs at the National Orthopaedic Hospital, Enugu. The findings revealed that optimal exposure settings significantly enhance the diagnostic quality of chest radiographs, with kVp and mAs playing the most substantial roles in improving contrast, density, and sharpness. A higher kVp and an appropriate mAs were associated with clearer, more diagnostically useful images, while improper selection of these parameters led to artifacts, motion blur, and decreased image quality. SID also contributed to image sharpness, though its impact was less pronounced than kVp and mAs. The study highlights

the importance of balancing these parameters to ensure high-quality diagnostic imaging while minimizing unnecessary patient radiation exposure.

This study fills a critical gap in knowledge by providing evidence-based insights into the specific exposure practices at NOHE. It underscores the need for tailored protocols in radiographic practice to optimize image quality and patient safety, particularly in an orthopaedic setting where chest radiographs are used for a variety of clinical indications.

6.1 Recommendations

1. **Development of Institutional Protocols**:
   Based on the findings, we recommend the development of standardized exposure guidelines for chest radiographs at the National Orthopaedic Hospital, Enugu. These guidelines should specify optimal kVp, mAs, and SID values for different patient demographics and clinical indications, ensuring consistency and quality across all radiographic procedures.
2. **Training and Continuing Education for Radiographers**:
   Radiographers should receive regular training on the importance of selecting appropriate exposure parameters to enhance image quality. This includes understanding how variations in kVp, mAs, and SID affect diagnostic accuracy and patient radiation exposure. Continuous education on best practices and technological advancements in radiography is essential for maintaining high standards of care.
3. **Regular Audits and Quality Control**:
   Periodic audits should be conducted to assess adherence to exposure protocols and to identify any deviations that may affect image quality. Quality control procedures should also be put in place to monitor and adjust exposure settings based on the type of imaging system used and the patient characteristics.
4. **Patient-Specific Exposure Adjustments**:
   Exposure parameters should be individualized based on patient characteristics such as body habitus and clinical indications. For instance, adjustments should be made for larger patients, as thicker body parts may require higher kVp or mAs to ensure adequate image penetration and clarity.
5. **Implementation of Dose Monitoring Systems**:
   We recommend implementing dose monitoring systems, such as clinical exposure index (EI), to continuously monitor patient dose during radiographic examinations. This system can help radiographers assess whether exposure levels are within acceptable ranges and take corrective action when necessary, improving both image quality and patient safety.
6. **Further Research and Multi-Center Studies**:
   Further research is necessary to validate these findings across different healthcare settings, particularly in institutions with varying equipment and patient populations. Multi-center studies would help generalize the recommendations and establish national standards for chest radiography in orthopaedic settings.
7. **Collaboration with International Bodies**:
   Collaboration with international organizations such as the International Atomic Energy Agency (IAEA) and the World Health Organization (WHO) is recommended to ensure that local radiographic practices align with global standards. Participation in global quality assurance initiatives can help NOHE stay updated on the best practices for optimizing radiographic technique and radiation dose management.

By adopting these recommendations, the National Orthopaedic Hospital, Enugu, can significantly improve the quality of chest radiographs, enhancing diagnostic accuracy, reducing repeat examinations, and optimizing patient safety in line with the ALARA (As Low As Reasonably Achievable) principle.'

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