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CONCORDANCE BETWEEN JUNIOR RESIDENTS AND CONSULTANT RADIOLOGISTS IN REPORTING PNEUMOPERITONEUM ON PLAIN RADIOGRAPHS

Original Research

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ABSTRACT

Background: Pneumoperitoneum, the presence of free intraperitoneal air, is a critical radiological finding often indicative of gastrointestinal perforation and requires immediate intervention. Early detection using plain radiographs is essential, especially in resource-limited settings where advanced imaging may not be readily available. However, interpretation accuracy may vary with clinical experience, particularly during on-call hours when junior residents are primarily responsible for initial assessments. Establishing the reliability of resident interpretations is vital to improving diagnostic workflows and patient outcomes.

Objective: To assess the level of diagnostic concordance between junior radiology residents and consultant radiologists in identifying pneumoperitoneum on plain radiographs and to analyze variations across demographic and clinical subgroups.

Methods: A cross-sectional study was conducted over six months (December 9, 2021, to June 8, 2022) at the Department of Diagnostic Radiology, Aga Khan University Hospital, Karachi. A total of 100 radiographs were prospectively analyzed. First- and second-year FCPS-II radiology residents independently assessed anonymized plain radiographs for signs of pneumoperitoneum, categorizing each as negative or requiring urgent attention. These preliminary evaluations were then compared with final consultant reports. Inter-observer agreement was quantified using Cohen's Kappa statistic, with stratification based on age, gender, patient location, radiographic technique, and residency year.

Results: The mean age of the patients was 38.09 ± 17.48 years, with 61.0% male and 39.0% female participants. Junior residents identified pneumoperitoneum in 26 cases, while consultant radiologists confirmed 74 cases. Diagnostic concordance was observed in 82 out of 100 cases. The Kappa coefficient was 0.520 (95% CI: 0.327–0.714, $p < 0.001$), indicating moderate agreement. Substantial agreement was found among patients aged <60 years ($\kappa = 0.684$), females ($\kappa = 0.692$), and ICU/outpatient settings ($\kappa = 0.750$, $\kappa = 0.765$). Decubitus radiographs demonstrated perfect agreement ($\kappa = 1.000$), while supine views showed lower agreement ($\kappa = 0.298$).

Conclusion: This study demonstrates moderate yet statistically significant diagnostic agreement between junior residents and consultants in identifying pneumoperitoneum. Variations in concordance across subgroups highlight the need for enhanced supervision, feedback mechanisms, and targeted radiographic interpretation training to improve diagnostic reliability among junior radiologists.

Keywords: Cohen's Kappa; Diagnostic Imaging; Observer Variation; Pneumoperitoneum; Plain Radiograph; Radiology Residents; X-Ray.

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INTRODUCTION

Pneumoperitoneum, defined as the presence of free gas within the peritoneal cavity, is a critical radiological finding often indicative of gastrointestinal perforation, which constitutes a surgical emergency in both adult and pediatric populations (1). Timely recognition and intervention are vital, as up to 95% of cases require urgent surgical or medical management to prevent life-threatening complications such as secondary peritonitis, sepsis, and multiorgan failure (2,3). Prompt and accurate diagnosis not only improves clinical outcomes but significantly reduces morbidity and mortality rates associated with delayed intervention. Despite advances in medical imaging, plain radiography continues to serve as the frontline diagnostic modality in emergency settings due to its availability, rapid turnaround time, cost-effectiveness, and minimal radiation exposure (4,5). Although less sensitive than computed tomography (CT) in detecting small volumes of free intraperitoneal air, radiographs can still identify pneumoperitoneum in 55% to 85% of cases, particularly when using optimized views such as erect chest X-rays or lateral decubitus positioning (6). CT imaging, with its superior sensitivity and specificity, remains the gold standard for detecting minimal pneumoperitoneum (7). However, radiographs retain a pivotal role in initial triage, often guiding further diagnostic pathways and influencing early clinical decision-making, especially in resource-limited settings (8).

The interpretation of radiographs, especially in emergency scenarios, is commonly performed by junior radiology residents, who are tasked with identifying urgent findings requiring immediate communication. These preliminary reads are subsequently reviewed by senior residents or attending radiologists. This tiered approach not only enhances diagnostic training but also ensures that potentially life-threatening findings are not overlooked during off-hours or high-volume shifts (9,10). Institutional practices support junior residents by encouraging consultation with senior colleagues when facing diagnostic uncertainty, fostering a culture of collaborative learning and patient safety. Prior studies examining diagnostic discrepancies have highlighted considerable variability in image interpretation, with higher error rates observed among non-radiologists due to limited imaging experience, high-pressure environments, and lack of specialized training (11,12). Conversely, within radiology departments, discrepancy rates between residents and attending radiologists remain relatively low. Reported discordance in plain radiograph interpretation typically ranges between 0.1% and 2.6%, with one large-scale study identifying a 1.4% discrepancy rate between preliminary resident reads and final consultant interpretations (13,14). A study reported a 1.5% disagreement rate for plain radiographs, which has contributed to the establishment of performance benchmarks in academic radiology programs (15).

In Pakistan, the increasing clinical workload and demand for timely radiological reporting, compounded by limited human resources, have necessitated the growing involvement of radiology residents in frontline diagnostic responsibilities. Despite the crucial role residents play in preliminary image evaluation, there remains limited evidence regarding their diagnostic concordance with consultants in detecting pneumoperitoneum on plain radiographs. This gap in literature raises questions about the diagnostic reliability of resident reads in real-world clinical settings, particularly in identifying critical findings that require swift management. The present study, therefore, aims to assess the level of agreement between junior radiology residents and consultant radiologists in identifying pneumoperitoneum on plain radiographs, with the objective of evaluating the diagnostic accuracy of residents and exploring the implications for clinical workflow, training, and patient safety.

METHODS

This cross-sectional study was conducted over a six-month period in the Diagnostic Radiology Department of Aga Khan University Hospital (AKUH), Karachi, following approval from the institutional Ethical Review Committee (ERC Reference #: 2022-5874-21991). The study aimed to assess inter-observer agreement between junior radiology residents and consultant radiologists in detecting pneumoperitoneum on plain radiographs. A consecutive sampling technique was employed to ensure a representative collection of cases. The sample size was calculated using the WHO sample size calculator, referencing a previously published study that reported 95.7% diagnostic agreement with zero variance between resident and consultant interpretations (16). Assuming a 95% confidence interval and a 4% margin of error, a sample size of 100 radiographs was determined. Radiographs included in the study were those that demonstrated pneumoperitoneum and were obtained from patients presenting to the emergency department, outpatient clinics, or inpatient units. Junior radiology residents participating in the study were male and female FCPS-II trainees in their first or second year, while the consultant

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radiologists ranged in age from 28 to 60 years. Exclusion criteria comprised follow-up imaging of previously diagnosed pneumoperitoneum, post-operative abdominal radiographs, and images with technical inadequacies such as poor collimation, incorrect labeling, or annotation errors.

Eligible radiographs were prospectively identified and included only after written informed consent was obtained from patients or their authorized surrogates. Junior residents independently reviewed the anonymized radiographs using the hospital's Picture Archiving and Communication System (PACS), with no access to clinical history or prior reports to maintain objectivity and reduce diagnostic bias. The radiographs were assessed for the presence or absence of pneumoperitoneum and classified as either negative or showing urgent findings. Subsequently, the final diagnostic reports issued by consultant radiologists were retrieved from PACS to compare interpretations. All image assessments were conducted using the Rogan viewer integrated with PACS, and findings were documented systematically in a pre-structured proforma to maintain consistency and ensure data confidentiality. The diagnostic concordance between residents and consultants was evaluated using the Cohen's Kappa statistic, a widely accepted measure for assessing inter-rater reliability. Descriptive statistics were employed to summarize the demographic and clinical data. Quantitative variables such as age and residency year were reported as means with standard deviations, while qualitative variables—including gender, comorbidities, patient location, referral source, and level of residency training—were presented as frequencies and percentages. To account for potential effect modifiers, stratification was performed based on demographic and clinical variables. Post-stratification Kappa analysis was then applied to assess whether agreement varied across subgroups. A p-value of less than 0.05 was considered statistically significant for all analyses, which were conducted using SPSS version 23.

RESULTS

The study sample consisted of 100 individuals, with a mean age of 38.09 ± 17.48 years. The age distribution revealed that 18.0% of patients were below 19 years, 68.0% fell within the 19–60 year range, and 14.0% were aged 61–65 years. A majority of the participants were male (61.0%), while females comprised 39.0% of the sample. With respect to patient location at the time of imaging, 40.0% of radiographs were taken in the Emergency Department, 25.0% in ICU/CCU, 16.0% in the Outpatient Department, and 19.0% in general inpatient wards. Regarding imaging modalities, 10.0% underwent chest X-rays in the erect position, 8.0% had abdominal X-rays in the erect position, 59.0% had abdominal X-rays in the supine position, and 13.0% had abdominal X-rays in the decubitus position. Among the junior residents interpreting the radiographs, 67.0% were first-year FCPS-II trainees, while 33.0% were in their second year. The average training duration was 1.33 ± 0.47 years. Of the total 100 cases assessed, agreement between junior residents and consultant radiologists on the presence or absence of pneumoperitoneum was observed in 82.0% of cases, with 18.0% showing disagreement. Among these, 16 cases were classified as true positives, 8 as false positives, 10 as false negatives, and 66 as true negatives. The overall diagnostic accuracy of junior residents compared to consultants was quantified using Cohen's Kappa statistic, yielding a value of 0.520 ($p < 0.001$), indicating moderate agreement. The standard error was 0.099, and the 95% confidence interval ranged from 0.327 to 0.714. The number of expected agreements by chance alone was 62.5%.

Stratified analysis showed substantial diagnostic agreement in patients under 60 years, with Kappa values of 0.684 ($p = 0.002$) in the <19 age group and 0.622 ($p = 0.001$) in the 19–60 group. Agreement dropped notably in the 61–65 year category ($\kappa = 0.273$, $p = 0.308$). Females demonstrated stronger concordance ($\kappa = 0.692$, $p = 0.001$) compared to males ($\kappa = 0.382$, $p = 0.003$). By patient location, the highest agreement was observed in ICU/CCU settings ($\kappa = 0.750$, $p = 0.001$) and Outpatient Departments ($\kappa = 0.765$, $p = 0.002$), while the lowest and statistically non-significant agreement was noted in general inpatient wards ($\kappa = 0.197$, $p = 0.372$). In terms of radiographic technique, perfect agreement was achieved in abdominal X-rays in the decubitus position ($\kappa = 1.000$, $p < 0.001$), followed by chest X-rays in the erect position ($\kappa = 0.571$, $p = 0.010$). Lower agreement was seen in abdominal X-rays in the supine ($\kappa = 0.298$, $p = 0.022$) and erect positions ($\kappa = 0.333$, $p = 0.346$). Both first- and second-year residents exhibited moderate agreement with consultants, with Kappa values of 0.523 ($p < 0.001$) and 0.478 ($p = 0.006$), respectively, indicating relatively consistent performance across training levels. To further evaluate the diagnostic accuracy of junior residents, additional metrics were derived from the confusion matrix. The sensitivity, representing the ability of residents to correctly identify cases of pneumoperitoneum, was calculated at 61.5%, while the specificity, indicating their accuracy in ruling out the condition when absent, was 89.2%. The positive predictive value (PPV), reflecting the likelihood that a resident-reported positive was truly pneumoperitoneum, was 66.7%. The negative predictive value (NPV), showing the reliability of a negative resident report, stood at 86.8%. The overall diagnostic accuracy of junior residents, defined as the proportion of total correct classifications, was 82.0%. These findings demonstrate relatively high specificity and NPV, suggesting that junior

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residents were more consistent in ruling out pneumoperitoneum than confirming its presence, which aligns with the moderate inter-observer agreement previously reported.

Table: 1 Inter-observer agreement analysis using Kappa statistics to determine the concordance between junior residents and consultant radiologist in reporting pneumoperitoneum on plain radiographs

Initially reported by resident pneumoperitoneum	**Finally reported by consultant pneumoperitoneum**		
	Present	Absent	Total
Present	16(True positive)	8(False positive)	24
Absent	10(False negative)	66(True negative)	76
Total	26	74	100
Kappa statistics	0.520		
Kappa Standard error	0.099		
95% Cl	0.327- 0.714		
P-value	<0.001		

Table: 2- Stratification for age, gender, location, type of x-ray, and years of residency with regard to inter-observer agreement analysis using Kappa statistics

Variable		**Total N=100**	**Initially reported by resident pneumo-peritoneum**	**Finally reported by consultant pneumoperitoneum**		**Kappa(k) Statistics**	**P-value**
				Yes	**No**		
Age (year)	< 19	18(18.00)	Yes	3(TP)	0(FP)	0.684	0.002
			No	2(FN)	13(TN)		
	19-60	68(68.00)	Yes	13(TP)	5(FP)	0.622	0.001
			No	5(FN)	45(TN)		
	61-65	14(14.00)	Present	0(TP)	3(FP)	0.273	0.308
			Absent	3(FN)	8(TN)		
Gender	Male	61(61.00)	Yes	7(TP)	6(FP)	0.382	0.003
			No	7(FN)	41(TN)		
	Female	39(39.00)	Yes	9(TP)	2(FP)	0.692	0.001
			No	3(FN)	25(TN)		
Patient location	Emergency	40(40.00)	Yes	8(TP)	2(FP)	0.486	0.001
			No	7(FN)	23(TN)		
	ICU/CCU	25(25.00)	Yes	4(TP)	1(FP)	0.750	0.001
			No	1(FN)	19(TN)		
	Outpatient	16(16.00)	Present	2(TP)	1(FP)	0.765	0.002
			Absent	0(FN)	13(TN)		
	Inpatient	19(19.00)	Present	2(TP)	4(FP)	0.197	0.372
			Absent	2(FN)	11(TN)		
Type of x-ray requested	Chest X-ray erect	10(10.00)	Yes	3(TP)	1(FP)	0.571	0.010
			No	2(FN)	14(TN)		
	Abdominal X-ray erect	8(8.00)	Yes	1(TP)	1(FP)	0.333	0.346
			No	1(FN)	5(TN)		

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Variable		Total N=100	Initially reported by resident pneumo-peritoneum	Finally reported by consultant pneumoperitoneum Yes	No	Kappa(k) Statistics	P-value
	Abdominal X-ray supine	59(59.00)	Present	5(TP)	6(FP)	0.298	0.022
			Absent	7(FN)	41(TN)		
	Abdominal X-ray decubitus	13(13.00)	Present	7(TP)	0(FP)	1.000	<0.001
			Absent	0(FN)	6(TN)		
Year of residency	1st year	67(67.00)	Yes	8(TP)	5(FP)	0.523	<0.001
			No	5(FN)	49(TN)		
	2nd year	33(33.00)	Yes	8(TP)	3(FP)	0.478	0.006
			No	5(FN)	17(TN)		

Table 3: Diagnostic Accuracy Metrics

Diagnostic Metric	Value
Sensitivity	0.615
Specificity	0.892
Positive Predictive Value (PPV)	0.667
Negative Predictive Value (NPV)	0.868
Overall Accuracy	0.820

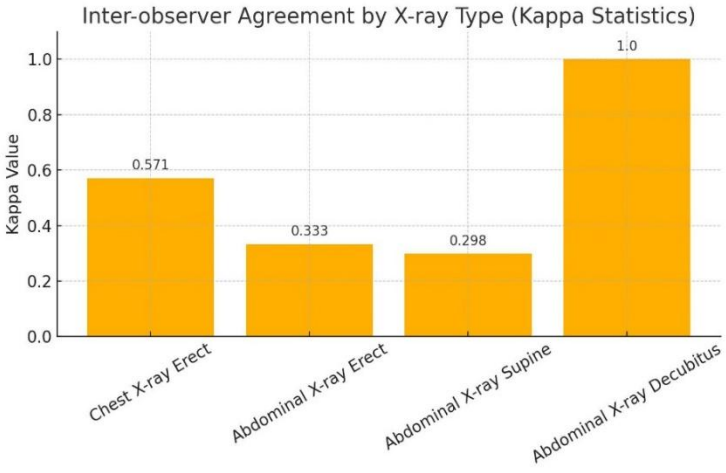

Figure 2 Inter-observer Agreement by X-ray Type (Kappa Statistics)

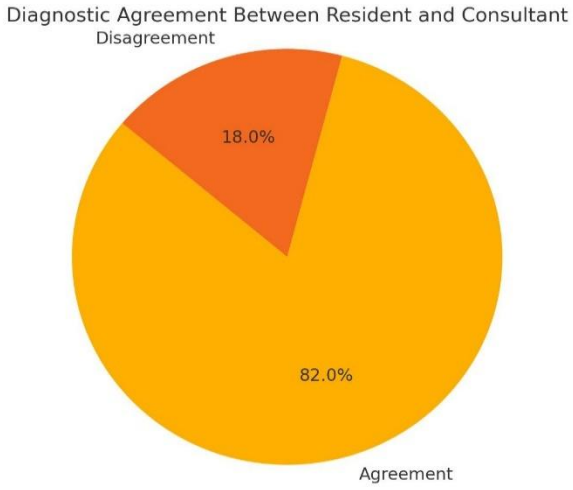

Figure 1 Diagnostic Agreement Between Resident and Consultant

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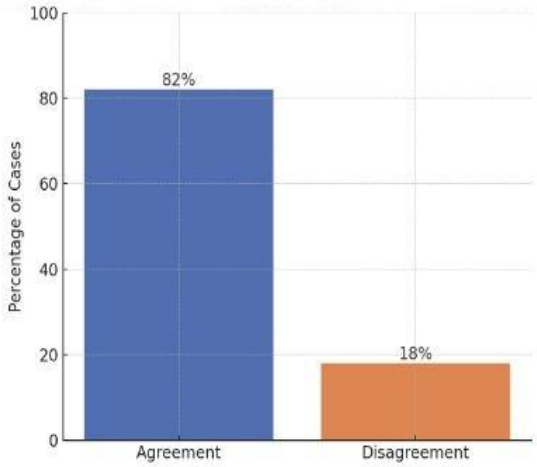

Agreement between Initial and final diagnoses of Pneumoperitoneum

DISCUSSION

Pneumothorax represents a serious clinical condition that requires prompt diagnosis and management due to its potential to cause rapid deterioration, especially in trauma or intensive care settings. The findings of this study contribute to existing literature by evaluating the diagnostic concordance between junior radiology residents and consultant radiologists in identifying pneumothorax on plain chest radiographs. The moderate inter-observer agreement demonstrated by a Kappa value of 0.520 ($p < 0.001$), with a 95% confidence interval ranging from 0.327 to 0.714, supports the premise that while junior residents can reliably interpret radiographs in many cases, diagnostic variability remains, particularly in high-pressure or technically limited settings. These results align with previous studies that reported moderate to high diagnostic accuracy among radiology trainees, especially with increasing clinical experience. Earlier investigations showed diagnostic accuracy ranging from 62.5% among junior residents to over 80% for senior counterparts, underscoring the role of training and exposure in interpretive proficiency (15). Moreover, the reported discrepancy rates in this study were slightly higher than the 0.1% to 2.6% range documented in institutional audits of radiographic interpretation (16,17). While many of these discrepancies may be clinically insignificant, a subset—including those involving pneumothorax—can significantly alter patient management and outcomes, thus reinforcing the need for structured oversight during preliminary image evaluations.

The study further reiterates the diagnostic challenges associated with portable chest radiography, particularly in critically ill or immobilized patients. Suboptimal positioning, low inspiratory effort, and interference from medical equipment can obscure radiological signs of pneumothorax, necessitating heightened vigilance during interpretation (18,19). Given these limitations, radiographic accuracy is closely tied not only to reader experience but also to image quality and clinical context, factors that often vary significantly during off-hours or in emergency situations. While the findings highlight the reliability of junior residents in many cases, they also reveal areas needing improvement. The moderate sensitivity (61.5%) and positive predictive value (66.7%) suggest that a considerable proportion of pneumothorax cases may either be missed or overcalled, reflecting limitations in both pattern recognition and clinical integration at early training stages. These findings call for enhanced supervision, dedicated training modules focused on subtle radiological signs, and the incorporation of simulated emergency cases to improve diagnostic readiness (20,21). Moreover, integrating real-time feedback from attending radiologists could serve as a valuable tool in minimizing interpretation errors and reinforcing diagnostic pathways.

A notable strength of this study is its real-world relevance, reflecting everyday clinical workflows in academic centers where junior residents are routinely tasked with interpreting urgent imaging. The study also utilized a well-defined and structured approach to assess diagnostic agreement using Kappa statistics, ensuring a quantifiable and objective measure of inter-reader reliability. Additionally, stratified analysis across various patient demographics and imaging techniques provided insights into factors influencing diagnostic accuracy. However, several limitations must be acknowledged. As a single-center study, the results may not be generalizable to institutions with differing clinical environments or training models. The modest sample size, though statistically powered, may not fully

capture the variability across broader populations. Another important limitation was the absence of a gold standard modality such as computed tomography (CT) to confirm cases of pneumothorax, restricting the ability to measure absolute diagnostic accuracy. Furthermore, while resident interpretations were compared with those of consultants, the potential for bias existed due to the lack of complete blinding in assessments. The study also did not stratify diagnostic performance based on the year of residency, potentially overlooking differences in interpretive competence related to experience level. Future research should consider multicenter designs with larger sample sizes and standardized CT confirmation to enhance the validity and applicability of findings. Inclusion of structured feedback loops, evaluation of training interventions, and real-time audit systems may also help to bridge the diagnostic gap between trainees and consultants. Overall, the findings affirm the important role junior residents play in emergency radiology services while emphasizing the continued need for structured mentorship and performance monitoring to ensure diagnostic accuracy and patient safety.

CONCLUSION

In conclusion, this study affirms a meaningful level of diagnostic concordance between junior radiology residents and consultant radiologists in identifying pneumoperitoneum on plain radiographs. These findings underscore the growing competence of residents in recognizing critical radiological signs, particularly during on-call hours, and emphasize the importance of their role in early decision-making. The study reinforces the value of structured training, continuous mentorship, and systematic performance evaluation in strengthening diagnostic accuracy. By supporting resident development within a supervised framework, healthcare institutions can enhance both clinical confidence and patient safety in time-sensitive scenarios.

AUTHOR CONTRIBUTION

Author	Contribution
Abida Ahmed*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Aneeqa Qureshi	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Rafay Memon	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Samita Asad	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Saadia Ali	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Farhan Ahmed	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published

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