Effectiveness of a Structured Case-Based Chest Radiograph Interpretation Workshop for Undergraduate Medical Students: A Multicenter Pretest-Posttest Educational Study.

ABSTRACT

Background:
Chest radiograph interpretation is an essential clinical skill; however, undergraduate medical students often demonstrate limited competence and confidence in this domain. Structured, case-based teaching may improve learning outcomes.

Objective:
To evaluate the effectiveness of a structured case-based chest radiograph workshop in improving diagnostic skills and confidence among undergraduate medical students.

Methods:
A single-group pretest-posttest educational intervention study was conducted among 68 MBBS students. Participants underwent a structured 30-minute case-based workshop focusing on systematic chest X-ray interpretation and common pathologies. Knowledge was assessed using a 10-item questionnaire before and after the intervention. Confidence was measured using a 5-item Likert scale. Statistical analysis included paired t-test and Wilcoxon signed-rank test.

Results:
The mean knowledge score improved significantly from 3.75 ± 1.57 to 6.43 ± 2.45 ($p < 0.001$), with a mean gain of 2.78 ± 2.48 marks. Confidence scores improved significantly across all domains ($p < 0.001$). The greatest improvement was seen in image-based recognition of pneumothorax and pleural effusion.

Conclusion:
A brief structured case-based chest radiograph workshop significantly improves diagnostic performance and learner confidence. Such focused interventions may be effectively integrated into undergraduate medical education.

INTRODUCTION

Chest radiography is one of the most commonly performed imaging investigations and plays a crucial role in the diagnosis of thoracic diseases, including life-threatening conditions such as pneumothorax and pulmonary edema. Despite its clinical importance, multiple studies have demonstrated that undergraduate medical students and even junior doctors often have limited competence in interpreting chest radiographs (1,2).

Radiology teaching in undergraduate curricula is frequently fragmented, with insufficient emphasis on structured interpretation and image-based learning (3). The Royal College of Radiologists recommends that medical graduates should be able to recognize common abnormalities on chest radiographs using a systematic approach (4).

Case-based learning (CBL) is an active learning strategy that encourages clinical reasoning, pattern recognition, and contextual understanding (5). In radiology, where interpretation relies heavily on visual pattern recognition, case-based approaches may be particularly effective.
This study aimed to evaluate the effectiveness of a structured case-based chest radiograph workshop in improving knowledge and confidence among undergraduate medical students.

METHODS

Study Design and Participants

This educational interventional study employed a single-group pretest-posttest design. A total of 68 undergraduate MBBS students from various institutions attending scheduled teaching sessions were included using universal sampling. The students were in various stages of their academic training

Educational Intervention

Participants attended a 30-minute structured case-based workshop focused on chest radiograph interpretation. The session emphasized a systematic ABCDEF approach and included representative cases of common conditions such as consolidation, pleural effusion, pneumothorax, pulmonary edema, and pulmonary tuberculosis.

Assessment Tools

Knowledge was assessed using a 10-item questionnaire consisting of concept-based and image-based questions. Each correct answer was scored as 1, with a total score out of 10. Confidence was assessed using 4 Likert-scale items (1-5), covering:

- Systematic interpretation
- Emergency recognition
- Identification of common abnormalities
- Differentiation of normal vs abnormal radiographs

Post-session feedback was also collected.

Statistical Analysis

Data were analyzed using SPSS version 25. Continuous variables were expressed as mean ± standard deviation. Pretest and posttest scores were compared using paired t-test and Wilcoxon signed-rank test. A p-value <0.05 was considered statistically significant.

Ethical Considerations

Informed consent was obtained from all participants prior to inclusion. Participant confidentiality and anonymity were maintained throughout the study.

RESULTS

A total of 68 undergraduate medical students were included in the analysis. The mean knowledge score improved from 3.75 ± 1.57 in the pretest to 6.43 ± 2.45 in the posttest, with a mean gain of 2.78 ± 2.48 marks (Table 1, Figure 1). This improvement was statistically

significant using the Wilcoxon signed-rank test ($p = 1.03 \times 10^{-9}$). The paired t-test also demonstrated a significant improvement ($t(67)=9.02$, $p=3.48 \times 10^{-13}$), with a 95% confidence interval for mean gain of 2.18-3.38 marks. The effect size was large (Cohen's dz =1.12).

Self-reported confidence improved significantly across all four domains, including systematic interpretation, recognition of emergency findings, interpretation of common abnormalities, and distinguishing normal from abnormal chest radiographs (Table 2, Figure 2). The composite confidence score improved from 9.56 ± 3.17 to 13.50 ± 2.88 out of 20 ($p<0.001$).

Question-wise analysis

Question-wise analysis showed the greatest improvement in image-based pneumothorax recognition, increasing from 14.7% to 63.2%, and image-based pleural effusion recognition, increasing from 25.0% to 70.6%. Overall, 59 students (86.8%) improved their scores after the workshop (Table 4, Figure 3).

Table 1- Impovement in knowledge scores

	Pretest	Posttest
Mean	3.75 ± 1.57	6.43 ± 2.45

Mean gain	2.68
95% CI	2.08- 3.27
p-value	<0.001
Cohen dz	1.09

Figure 1 Improvement in mean knowledge scores

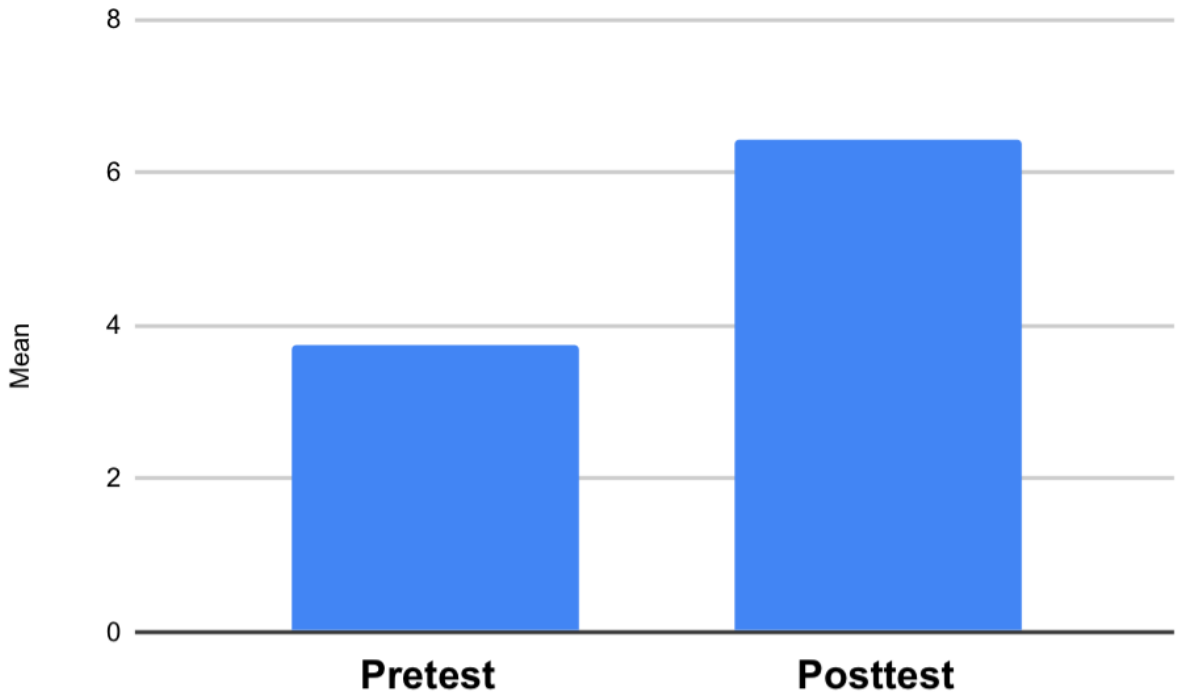


Table 2 Improvement in confidence scores

Confidence scores				
Confidence domain	Pre mean ± SD	Post mean ± SD	Gain	p-value
Systematic interpretation	2.15 ± 0.93	3.40 ± 0.79	1.25	<0.001
Emergency finding recognition	2.28 ± 0.94	3.37 ± 0.79	1.09	<0.001
Localization and interpretation of radiographic abnormalities	2.47 ± 0.94	3.31 ± 0.85	0.84	<0.001
Differentiation of normal vs abnormal radiographs	2.66 ± 0.94	3.43 ± 0.89	0.76	<0.001
Composite confidence score	9.56 ± 3.17	13.5 ± 2.8	3.94	<0.001

Table 3 Domain wise Improvement in confidence scores

Confidence domain	Pre test	Post test
Systematic interpretation	2.15	3.4
Emergency finding recognition	2.28	3.37
Localization and interpretation of radiographic abnormalities	2.47	3.31
Differentiation of normal vs abnormal radiographs	2.66	3.43

Figure 2 Improvement in mean knowledge scores

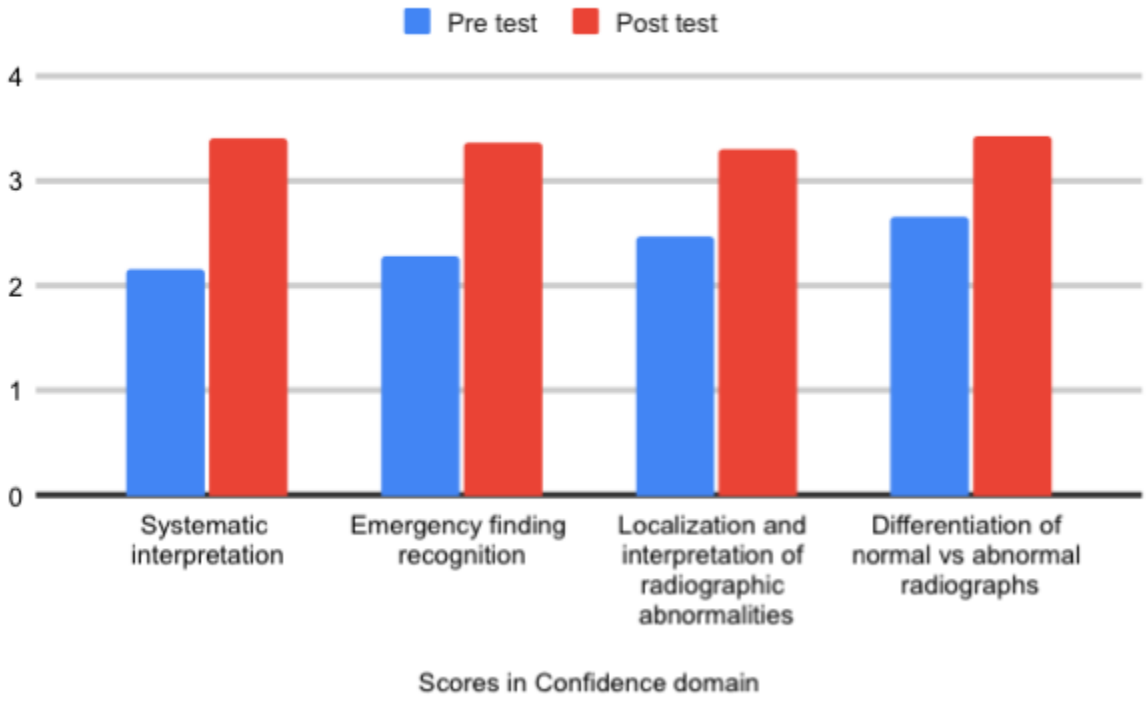


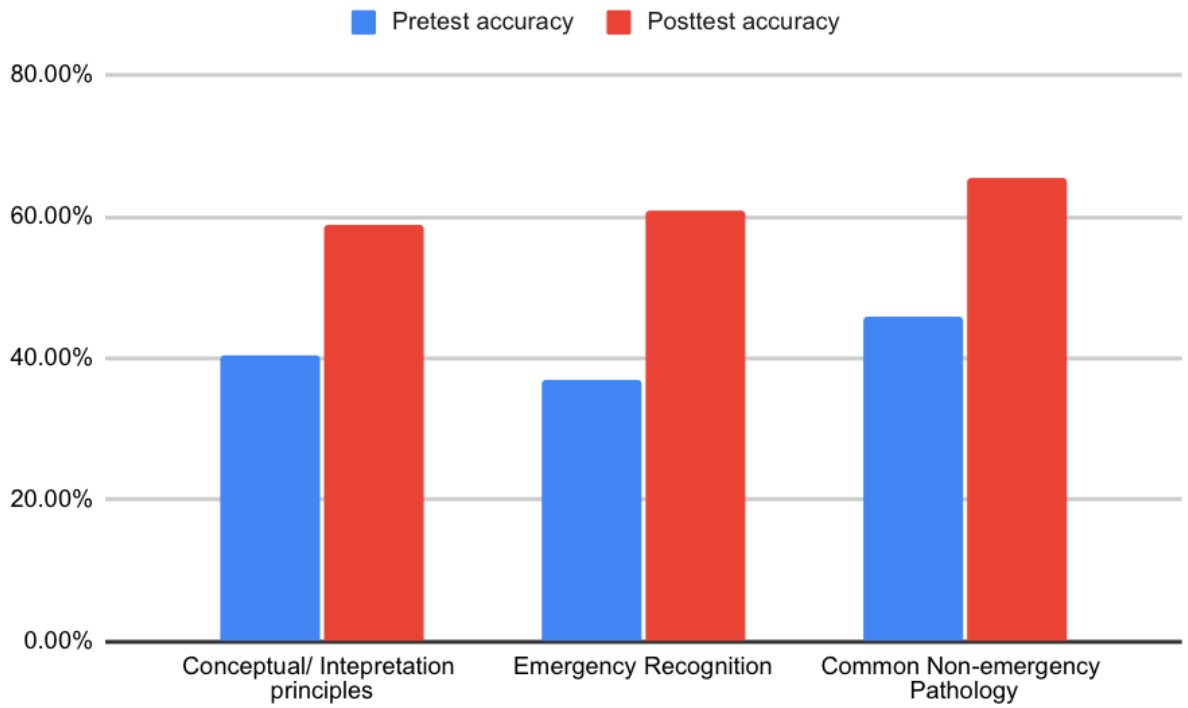
Table 4 Domain wise improvement in chest Xray interpretation skills

Domain	Question included	Pretest accuracy	Posttest	Improvement
Conceptual/ Interetation principles	Q1 (silhouette sign localization), Q5 (poor inspiratory effort)	40.40%	58.80%	18.4
Emergency Recognition	Q2 & Q8 (pneumothorax), Q4 & Q9 (pulmonary edema)	37.10%	61%	23.9

Common Non-emergency Pathology	Q3 & Q7 (pleural effusion), Q6 (pneumonia), Q10 (pulmonary TB)	46.00%	65.40%	19.4

Domain	Pretest accuracy	Posttest accuracy
Conceptual/ Intepretation principles	40.40%	58.80%
Emergency Recognition	37.10%	61%
Common Non-emergency Pathology	46.00%	65.40%

Figure 3 Domain wise improvement in chest Xray interpretation skills



DISCUSSION

This study demonstrates that a brief structured case-based chest radiograph workshop resulted in a statistically and educationally significant improvement in diagnostic performance among undergraduate medical students. The mean knowledge score increased from 3.75 to 6.43, with

a large effect size (Cohen's dz = 1.12), indicating a substantial learning gain attributable to the intervention.

Baseline deficiency and need for structured teaching

The low pretest scores observed in this study are consistent with existing literature demonstrating limited baseline competence in chest radiograph interpretation among medical students and junior doctors (1,9). Eisen et al. reported that even practicing physicians often demonstrate suboptimal accuracy in chest radiograph interpretation (1), while undergraduate cohorts similarly report low confidence and inadequate training exposure (2,9). These findings highlight the need for structured, focused radiology teaching within undergraduate curricula, which is often underemphasized (4).

Effectiveness of case-based learning

The significant improvement observed in this study supports the effectiveness of case-based learning
(CBL) in radiology education. CBL promotes active engagement, contextual reasoning, and pattern recognition-core cognitive processes required for radiologic interpretation (5,6). Unlike traditional didactic teaching, which is often passive, case-based approaches require learners to actively analyze images, generate hypotheses, and apply knowledge in clinically relevant contexts.

These findings are consistent with prior studies demonstrating improved learning outcomes with structured radiology teaching interventions. Sait and Tombs showed that a structured chest X-ray learning module significantly improved learner understanding and performance (2). Similarly, Wentzell et al. demonstrated that interactive radiology teaching improved both diagnostic accuracy and learner confidence (7). A recent systematic review by AlRumayyan et al. concluded that active and case-based teaching methods are superior to passive instruction in improving chest X-ray interpretation skills (6).

Improvement in image-based diagnostic skills

An important finding of this study was the marked improvement in image-based diagnosis, particularly for pneumothorax and pleural effusion.

Pre-intervention recognition of pneumothorax was notably low (14.7%), which improved to 63.2% post-intervention. This is clinically significant, as pneumothorax represents a critical emergency that must be promptly recognized.

This pattern suggests that students particularly benefit from visual pattern recognition training, which is central to radiology expertise (8).

Traditional teaching often emphasizes textual knowledge, whereas radiologic interpretation requires exposure to multiple representative images and reinforcement of visual patterns.

Confidence improvement and educational impact

In addition to objective performance, there was a significant improvement in self-reported confidence across all domains, including systematic interpretation and emergency recognition.

This is important because lack of confidence has been identified as a barrier to effective image interpretation among trainees (9).
The improvement in confidence likely reflects the structured framework (ABCDEF approach) combined with repeated exposure to common radiographic patterns. Increased confidence may translate into improved clinical application, although this was not directly assessed in the present study.

Feasibility and practical implications
A key strength of this intervention is its feasibility. The workshop duration was only 30 minutes, yet resulted in substantial improvement. This suggests that even short, focused radiology teaching sessions can produce meaningful educational benefits, making such interventions practical for integration into busy undergraduate curricula.
Additionally, high levels of student acceptance were observed, with the majority of participants recommending inclusion of similar workshops in formal teaching programs. This aligns with current recommendations advocating greater integration of radiology into undergraduate medical education (4).

LIMITATIONS

This study has several limitations. First, the single-group pretest-posttest design lacks a control group, limiting the ability to attribute improvements solely to the intervention. Second, long-term retention of knowledge was not assessed. Third, confidence outcomes were self-reported and may be subject to response bias. Finally, the study was conducted in a single institution, which may limit generalizability.

CONCLUSION

A structured case-based chest radiograph workshop significantly improves both knowledge and confidence among undergraduate medical students. Even brief, focused radiology teaching interventions can produce meaningful educational benefits. Incorporating such teaching strategies into undergraduate curricula may enhance diagnostic competence and clinical preparedness.

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