Original Article

Efficacy of focused teaching on chest radiographs: Comparison among novice clinicians outside the radiologic field

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Abstract

Objectives: This study aimed to evaluate the effectiveness of focused teaching on the hidden areas in chest radiographs (CXR) for different elective radiology novice clinicians during an elective course.

Materials and Methods: A test including 30 CXRs was administered to various novice clinicians who undertook an elective radiology course at our institution before and after a focused teaching session on the hidden areas of chest radiographs. The effectiveness of focused teaching in the hidden areas was evaluated based on the difference between the pre-test and post-test scores. Improvement scores were compared among different groups of novice clinicians to evaluate their competence.

Results: A total of 22 novice clinicians participated in the study. These included one extern, 5 emergency medicine residents, 10 internist residents, 2 Thai-graduated interns, and 4 foreign-graduated interns. There were no significant differences in the pre-test scores among participants' specialties. However, there was a significant difference in the participants' scores before and after X-ray teaching ($p < 0.001$). Using differences in the pre-test and post-test scores as an indicator of improvement, we discovered the improvement score differed significantly between the participant groups ($p = 0.04$). Nearly all participant groups showed significant positive improvement, except for the foreign-graduated interns, who showed no improvement.

Conclusions: Focusing teaching on the hidden areas in chest radiographs significantly positively impacts nearly all novice clinicians participating in the study, except the foreign-graduated Interns.

Keywords: Chest radiographs, Clinicians, Hidden areas, Medical students.

Introduction

Chest radiography is the most common radiological investigation in hospitals worldwide, employed not only for diagnosis but also for screening in many indications [1-2]. Half of the plain radiographic errors occur on a chest radiograph (CXR) [3], and nearly 80-90% of missed lung cancers are identified using CXRs [2, 4]. This can result in delayed or changed management, altered prognosis, complications, or increased mortality [4]. In real-life clinical settings, in some hospitals, general practitioners (GPs) and other physicians interpret CXRs and manage patients based on their interpretations. Radiologists are consulted only in problematic cases.

The literature demonstrates that GPs have only 77% to 80% sensitivity in detecting symptomatic lung cancer from CXRs [5], and different specialties have varying competencies in CXR interpretation and are generally less competent than radiologists [6-7]. Although there have been efforts to use artificial intelligence (AI) tools to improve performance, their generalizability is still limited, and the use of AI still requires the confirmation of radiologists [8].

Steps in reading radiographs include scanning, recognition, and decision-making. False-negative errors occurred for 30% during scanning, 25% during recognition, and 45% during decision-making [2]. Among CXR diagnostic errors, the most common are detection errors (81%), of which, the non-visualized lung nodule is the majority (40%) [3]. Both a systematic searching pattern and knowledge are crucial to avoid detection errors. Hidden areas are the major areas of non-visualized lesions in CXRs and have been recognized for a long time. The "7 Hidden Areas" include bilateral apices, bilateral hilar, retrocardiac, and subdiaphragmatic regions. These areas are important and must be emphasized in radiology education. Knowledge of the hidden areas and routine practice of a systematic searching pattern are two components that can improve detection errors.

Our prior study demonstrated that formal radiology education is beneficial even in a short period of time [9]. However, targeted teaching for specific learners would be more efficient. The competency of variable learners should be different and should be explored. Knowledge of the learner helps the teacher to educate more easily and effectively.

The objectives of our study were: 1) to investigate the impact of focused teaching on the Hidden Areas subject on the performance of novice clinicians in the test and 2) to compare the significant score improvement on the test among novice clinicians of different specialties (final-year medical students [EXT], interns, emergency medicine residents, and internist residents).

Materials and methods

Population

This study retrospectively analyzed the pre-test and post-test scores of elective students and novice clinicians specialized in emergency medicine and internal medicine, who participated in the Hidden Areas teaching class during their elective period in our department between October 1, 2020 – September 30, 2021. There were 22 participants in this study, comprising 1 EXT, 5 emergency medicine residents, 10 internist residents, 2 Thai-graduated interns, and 4 foreign-graduated interns. Our study separated the interns according to their medical schools into 2 groups: 2 interns who graduated from Thai medical schools and the other 4 Thai interns who graduated from foreign medical schools. The study was approved by our institutional review board, No. HS036/2565. Inform consent was waived owing to the retrospective nature of the study.

Intervention and objective assessment

To assess the detection errors, we developed a 30-CXR test in digital JGP format, with patient identification removed. The set comprised 3 normal CXRs and 27 abnormal CXRs. Among these, 14 lesions were located in hidden areas, all confirmed by computerized tomography. An example of a Hidden Areas image is demonstrated in Figure 1. A 30-image quiz was chosen by a senior author (S.L.) with 30 years of experience. Participants were instructed to identify the lesion in a 30-image quiz within 30 minutes by drawing the lesion on the answer sheets, which had 30-CXR drawings. The other author (S.K.) examined and scored all the participants' answer sheets, blinded to participants' identifications as well as the state of the pre-test or post-test, to limit inter-rater variability. The scoring system is illustrated in Table 1. An example of the answer sheet and scores is shown in Figure 2.

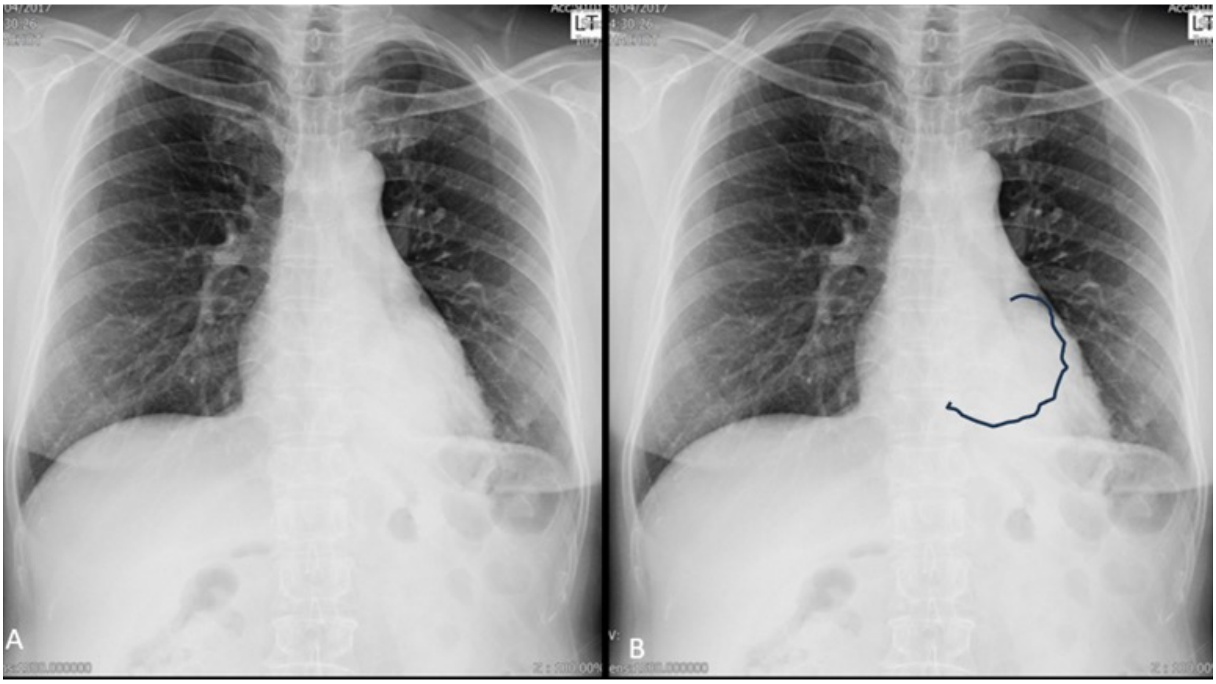

Figure 1. *(A) An example of a Hidden Areas lesion in the test set (B) The answer to the lesion indicated by a line outlining the lateral border of the left retrocardiac opacity.*

Table 1. *Scoring system.*

	complete	Partially complete	incorrect
area	10	5	0
size	10	5	0

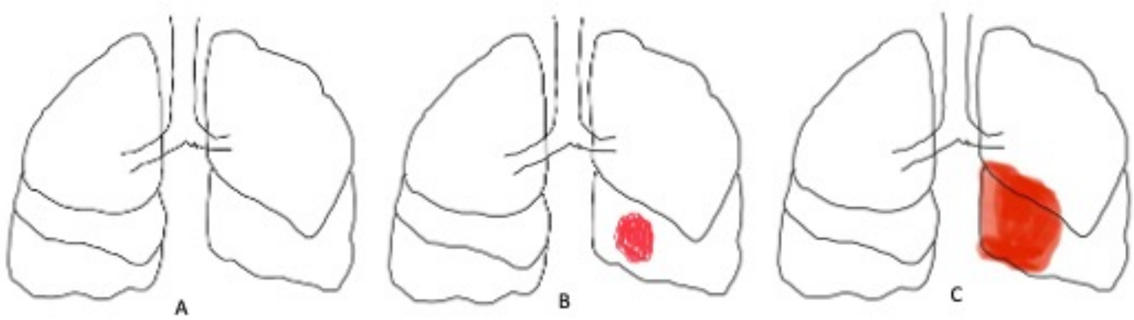

Figure 2. *(A) An example of the answer sheet; (B) The area in the answer is correct but the size is partially correct (score = 15). (C) The answer is completely correct (score = 20).*

The Hidden Areas teaching class was an integral part of our radiology elective course. It began with a pre-test consisting of 30 CXRs, followed by a brief lecture in Thai language on hidden areas supplemented with examples of hidden area lesions in CXRs by a single teacher (S.L.). The duration of the teaching was 15 to 20 minutes. After the lecture, the same test set was administered to the participants. Upon completing the test, a teaching radiologist (S.L.) provided the answers and discussed them in detail with the participants.

Statistical analysis

The data were analyzed using SPSS version 22. Residuals were examined and tested for the assumption of normality. A Wilcoxon signed ranks test was used to compare the mean rank of the pre- and post-test scores of each group, determining whether the improvement was statistically significant. A comparison of improvement scores between participants' groups was performed using the Kruskall-Wallis test. The Man-Whitney U test was used to compare the improvement scores between sexes. Lastly, the effect of participants' age on the improvement score was analyzed using linear regression analysis. A p-value of less than 0.05 was considered statistically significant.

Results

Demographic data, pre-test scores, posttest scores, and improvement scores are shown in Table 2. There were 11 males and 11 females in the study, with ages ranging from 24-32 years and a mean age of 28.64 years. The age distribution was as follows: five participants were 28 years old; three each were 24, 26, and 27 years old; two each were 25, 29, and 30 years old; one participant was 31 years old, and one was 32 years old. Demographic data for all groups did not show statistical differences.

There were no significant differences in the pre-test scores among participants specialties (Kruskall-Wallis test; Chi-square = 6.22, df = 4, p = 0.183). A significant difference was observed in the scores for participants before X-ray teaching (pre-test score, mean +/- SD = 133.64 +/- 28.50) and after X-ray teaching (post-test score, mean +/- SD = 162.50 +/- 41.74) (Wilcoxon signed ranks test; z = -3.29, n =22, p < 0.001). Using differences in the pre-test and post-test scores as indicators of improvements, we found that the improvement score (mean +/- SD = 28.86 +/- 32.91) differed significantly across the specialties (Kruskall-Wallis test; Chi-square = 10.04, df = 4, p = 0.04). All participants, except for the foreign-graduated interns, showed improvement in post-test scores. The foreign-graduated interns, however, showed a decline, as illustrated in Table 2. EXT showed more improvement than all other groups. However, there was no significant difference in improvement scores between the sexes of participants (Mann-Whitney U test; Z = -0.363, n = 22, p = 0.735). Additionally, using linear regression analysis to investigate the effect of the participant's age on the improvement score, the participant's age posed no significant impact (mean +/- SD = 27.36 +/- 2.26) on the improvement score (linear regression; F (1,20) = 0.058, p = 0.797).

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Table 2. *Demographic data, pre-test scores, post-test scores, and improvement scores.*

	Age (year) (mean ± SD)	Sex	Pre-test scores (mean ± SD)	Post-test scores (mean ± SD)	Improvement Scores (mean ± SD)
Extern	24	M: 1, F: 0	95	170	75a
Thai-graduated Interns	25.5 ± 0.71	M: 0, F: 2	132.5 ± 17.68	185 ± 56.57	52.5 ± 38.89a
Emergency Medicine Residents	28.2 ± 1.79	M: 1, F: 4	151 ± 14.32	175 ± 19.69	24 ± 8.94a
Internist Residents	28.1 ± 1.37	M: 7, F: 3	140.5 ± 21.66	178 ± 22.63	37.5 ± 32.43a
Foreign-graduated Interns	26.25 ± 3.86	M: 2, F: 2	105 ± 40.62	95 ± 39.79	-10 ± 20.89b

**SD = standard deviation, a & b = Kruskall-Wallis test results*

Discussion

Different types of GPs possess different learning abilities [7]. The current study shows that focused teaching on hidden areas has a significantly positive impact on almost all novice clinicians, except for the foreign-graduated interns. The foreign-graduated Interns comprised doctors who graduated from foreign medical schools in various countries. To practice in Thailand, they must pass all three steps of the Thai National License Examination steps and complete a one-year clinical clerkship in Thai hospitals. All four foreign-graduated interns in our study are Thai nationals undergoing clinical clerkship in our hospital and have not yet passed the final NL exam. Only one foreign-graduated intern showed a positive improvement; the others demonstrated negative results. The participants' background performance may explain the result. Our previous study demonstrated that participants with a high-performance background can acquire knowledge in a short learning period better than those with a low-performance background [9]. This group may have a low-performance background, and a short learning period may be insufficient for them to acquire optimal knowledge. In addition, Pavlov et al. demonstrated that a task that is too difficult results in significantly reduced engagement among participants [10]. Prior knowledge and the teaching approach, including time and methods, are crucial factors [11]. This group requires more time, additional tools, and possibly different learning methods [12]. Tailoring the difficulty level of the learning materials to match each student is effective [13]. The usefulness of various learning resources is perceived differently by participants at different levels. Wu et al. demonstrated that an independent self-learning method can improve radiology knowledge in elective students and lead to positive student perceptions of the elective experience [14]. The learning environment is also an important factor that should be considered [15]. A standardized radiology curriculum should be implemented in all institutions and countries [16]. Further focused research is required in this group.

Among the groups showing positive improvement, EXT and Thai-graduated interns, who were fresh GPs, exhibited more improvement than emergency medicine and internist residents. A possible explanation could be that participants with extensive knowledge may find it challenging to acquire new information and may be less open to new ideas [17]. These residents have already chosen their career paths; radiology is not their primary focus. Consequently, they might pay less attention to radiology than GPs who have not yet made a definitive decision and are eager to explore various specialties.

Interestingly, the pre-test scores of all groups showed no statistical difference. There are a few reasons to explain this phenomenon. Firstly, lesion detection in the hidden areas is inherently challenging, focusing on teaching this subject. When a test is overly difficult, it may fail to effectively differentiate between participants effectively and could lead to frustration, decreasing motivation [18]. Secondly, all of these participants had undergone a formal radiology education for over a year, and the retention of radiology knowledge may be relatively short. Our prior study also observed short retention of radiology knowledge in 5th-year and 6th-year medical students [9].

The major limitation of this study was the small number of participants. Larger-scale studies should be conducted to validate our findings. We tested only detection skills, so the 1-minute time limit for each image was deemed appropriate. It can simulate real clinical practice, where physicians do not spend much time on CXR interpretation. The patient's history was not provided, which is an important part of CXR interpretation [7]. However, a prior study revealed that reading with or without history does not affect the detection [19]. Future studies incorporating all three skill sets, including detection, interpretation, and decision-making, would better mimic real-life settings. As part of the nature of the test, the participants were aware that there must be more pathological cases than in their routine practice, as well as a memory effect. The lack of a control group is also a significant limitation. Students who took the pre-test and post-test without teaching may experience score improvement. We did not collect data on participants' experience in CXR interpretation, which was an important factor. The test set was in the JPG format, which was not as high quality in resolution as our routine radiology practice. Lastly, our study was performed in a single institution and cannot be generalized.

Conclusion

Detection errors in reading CXRs are significant and should be emphasized in radiology education. The formal radiology curriculum should prioritize teaching the hidden areas of radiograph interpretation. Focused teaching in these areas significantly positively impacts nearly all novice clinicians in this study, except for the foreign-graduated intern group. Given that learners have varying learning abilities, targeted teaching tailored to individual needs is likely to be more effective.

Conflict of Interest

All authors declare that there is no conflict of interest.

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