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Competency of Residents and Interns in Pneumothorax Diagnosis on Chest Radiography: an Observer Performance Study

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Abstract

Aim: This study aimed to investigate the competency of residents and interns in diagnosing pneumothorax on chest radiography (CXR) as well as to identify potential areas requiring training on this subject.

Materials and Methods: A case set including a total of 40 chest radiographies that were in the digital imaging and communications in medicine (DICOM) format were loaded to the DICOM-compatible software tool-Viewer for Digital Evaluation of X-ray images (ViewDEX). Fifty-three observers, including 25 residents and 28 interns, interpreted the images by answering all the questions determined for each case.

Results: The overall accuracy rate to diagnose pneumothorax on CXR was 79% in the study cohort, with 79.5% and 78.6% for residents and interns, respectively. No significant difference was observed between residents and interns when compared in terms of accuracy rates (regardless of the residents' specialties; p=0.600). When the residents' specialties were considered, the diagnostic accuracy rate was found to be significantly different between the groups (p<0.05).

Conclusion: The results of our study in terms of the overall accuracy rates of residents and interns in pneumothorax diagnosis on CXR are comparable to the previous studies in literature. However, comparison to another national study was not feasible due to the lack of published studies on this topic in Turkey. We believe that our study may serve as a starting point by raising the awareness on the subject and promote further studies in our country.

Keywords: Pneumothorax, chest radiography, diagnosis, competency, residents, interns

Introduction

Pneumothorax refers to a collection of air within the pleural space. It is mostly seen after any blunt or penetrating trauma; however, spontaneous or iatrogenic cases of pneumothorax may commonly be encountered in clinical practice (1). Although its clinical manifestations are widely variable from asymptomatic to progressive cases causing death, pneumothorax is an urgent situation that should be treated immediately upon diagnosis. The first-line imaging modality to identify pneumothorax is chest radiography (CXR) (2). Expeditious diagnosis following accurate interpretation of CXR is expected from emergency physicians and/or clinicians of several departments in this clinical setting. Physicians may not always have the opportunity

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to consult a radiologist; therefore, decisions are made based on their initial interpretations relying upon personal experience and basic skills. The aim of the present study was to investigate the competence of residents and interns in diagnosing pneumothorax on CXR as well as to identify potential areas requiring training on this topic.

Materials and Methods

This retrospective study was conducted at the Radiology, Emergency Medicine, and Thoracic Surgery Departments of our institutions. The study was approved by the institutional ethics committee of Ufuk University School of Medicine (approval number: 30112015-9). Informed consent was obtained from all participants included in the study.

Selection of CXRs

The selection procedure was managed by a national board-certified radiologist who had 5 years of experience in CXR interpretation. Forty adult patients (aged ≥18 years) who underwent a posteroanterior (PA) CXR examination with a suspected diagnosis of primary spontaneous pneumothorax were included. Digital PA CXRs of 35 patients with spontaneous pneumothorax and five patients with normal findings were randomly recruited from the Picture Archiving and Communication System (Centricity PACS, GE Healthcare, General Electric, Milwaukee, USA). All pneumothoraxes were apparent on PA CXRs. All CXRs were taken in the upright position with full digital flat panel equipment (General Electric Medical solutions, GE Milwaukee, USA). The diagnoses were confirmed with clinical findings or computed tomography of the chest for all pneumothorax cases and with clinical findings and PA CXR in all cases without pneumothorax. Medical records of the patients were reviewed and patient demographics, symptoms, clinical findings, and final diagnoses were noted.

Interpretation of CXRs

A case set including a total of 40 CXRs (35 with spontaneous pneumothorax and five with normal findings) that were in the digital imaging and communications in medicine (DICOM) format was loaded to the DICOM-compatible software tool-Viewer for Digital Evaluation of X-ray images (ViewDEX), which is suitable for observer performance studies (Figure 1) (3). This tool allowed each observer to evaluate the image and proceed by answering all of the questions determined for each case. A measuring tool and image handling functions, including zoom, window settings, and pan, were also available in the tool. Each observer was briefly informed and trained about the tool before starting the interpretation process. The cases were presented at random. There was no time limitation for interpretation. It was explained that not all the radiographs were necessarily abnormal. No clinical information was provided other than the age and sex of each patient. After completion of interpretation, a log file containing the answers and the time spent on each case was created for each observer.

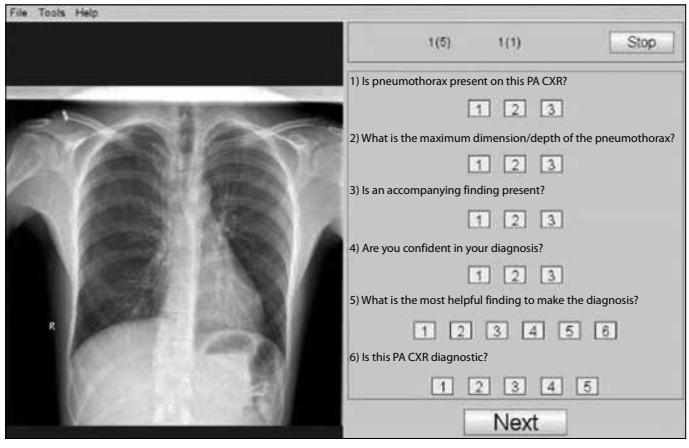

Figure 1. Screenshot of the DICOM-compatible software tool-ViewDEX. A PA CXR (left) and the answer folder (right) are presented. The observer evaluates the image and makes a decision for each question in the answer folder. By clicking on "next," the observer proceeds to the next image

Each case was interpreted preliminarily by a consensus panel of two experts in CXR interpretation: one national board-certified radiologist and one thoracic surgeon. They were not included in the initial CXR selection procedure and were blinded to the demographic and clinical information of the patients. A question folder, comprising the following six questions, was created on ViewDEX for each case: (1) Is pneumothorax present on this PA CXR? (2) What is the maximum dimension/depth of the pneumothorax? (3) Is an accompanying finding present? (4) Are you confident in your diagnosis? (5) What is the most helpful finding to make the diagnosis? (6) Is this PA CXR diagnostic? Subsequently, the choices for the questions and the correct answers for each case were defined by the same consensus panel (Table 1).

After completion of interpretation, each observer was requested to complete a survey composed of two questions: (1) Did you enjoy the interpretation session? (2) Did you find the ViewDEX tool easy to use? The choice was either "Yes" or "No."

Selection of observers

Fifty-three observers from the same university hospital, including 25 residents and 28 interns (final-year medical students), participated in the study. The age, sex, specialty of the participants, and level of training in the specialty were recorded. Of 25 residents, 8, 7, 3, 2, and 5 were specialists in emergency medicine, anesthesiology, radiology, pulmonary medicine, and surgery residents, respectively. All interns were close to completion of all of their rotations, including internal medicine, surgery, emergency medicine, pediatrics, and obstetrics and gynecology. Emergency medicine, anesthesiology, internal medicine, and surgery residents were chosen because they interpret CXRs in their daily practice, prior to surgery or in the intensive care unit. In addition, these residents are most likely to encounter pneumothorax cases and have the responsibility to make an accurate diagnosis following interpretation of CXRs. Radiology residents for the most part had practiced general radiology.

Statistical analysis

The analysis of the results was performed using the IBM Statistical Package for Social Sciences statistics (IBM SPSS Statistics; Armonk, New York, USA) version 21.0 software for Windows. Descriptive statistics were reported and Chi-square test was used for group comparisons. The statistical significance level was set at a p value of <0.05.

Results

The participants included 28 interns and 25 residents; 24 (46%) participants were women. Of the 25 residents, 8, 7, 3, 2, and 5 were specialists in emergency medicine, anesthesiology, radiology, pulmonary medicine, and surgery residents, respectively.

The overall accuracy rate in diagnosing pneumothorax on CXR was 79% in the study cohort, whereas it was 79.5% and 78.6% for the residents and interns, respectively. No significant difference was found between residents and interns when compared in terms of accuracy rates (regardless of the residents' specialties; p=0.600). When the residents' specialties were considered, the diagnostic accuracy rate was found to be significantly different between the groups (p<0.05; Table 2).

Table 1. Choices for questions

Questions	Choices
1) Is pneumothorax present on this PA CXR?	a) No
	b) On right side
	c) On left side
2) What is the maximum dimension/depth of the pneumothorax?	a) No pneumothorax
	b) <2 cm
	c) >2 cm
3) Is an accompanying finding present?	a) No
	b) Haemothorax (same side)
	c) Rib fracture (same side)
4) Are you confident in your diagnosis?	a) Not sure
	b) Undecided
	c) Sure
5) What is the most helpful finding to make the diagnosis?	a) No pneumothorax
	b) Displacement of the pleural line
	c) Absence of distal lung markings
	d) Collapse of the lung
	e) Mediastinal shift
	f) Subcutaneous emphysema
6) Is this PA CXR diagnostic?	a) Surely not diagnostic
	b) Not diagnostic
	c) Undecided
	d) Diagnostic
	e) Surely diagnostic

PA CXR: posteroanterior chest radiography

The rate of correct diagnosis (rate of correct answers obtained for question 1) ranged between 25% and 100%, whereas the error rate ranged between 0% and 75% for each CXR.

The rate of correct answers for question 2 (the size of pneumothorax) was 71.3% and 69.9% for residents and interns, respectively. No significant difference was found between the resident and intern groups (p=0.681). When the residents' specialties were considered, the rates of correct answers for question 2 were 73.3%, 59.5%, 80%, 71.2%, and 90% for emergency medicine, anesthesiology, radiology, pulmonary medicine, and surgery residents, respectively, and 70.5% for interns. The difference was found to be significantly different between the groups (p<0.05).

The rates of correct answers for question 3 (the accompanying findings) were 65.6%, 62%, 65%, 58.5%, 56%, and 63% for emergency medicine, anesthesiology, radiology, pulmonary medicine, surgery residents, and interns, respectively. No significant difference was found between the groups (p=0.785).

The answers for question 4 were analyzed to evaluate the confidence level. In terms of confidence level, no significant difference was found between residents and interns (p=0.133). The confidence level was found to be significantly different between the correctly diagnosed and missed cases for both the residents and interns (p<0.001).

For answers to question 5, choices b and c were considered together. The displacement of the pleural line and absence of distal lung markings were considered the most helpful findings in diagnosing pneumothorax by 70.8% and 70% of the residents and interns, respectively. For answers to question 6, both choices d and e were considered "diagnostic." Accordingly, 75.2% and 74.1% of the residents and the interns defined the CXRs as diagnostic, respectively.

With respect to the responses to the survey that was conducted to evaluate the participants' opinions about the CXR interpretation session using the ViewDEX tool, it was found that all of the observers enjoyed their sessions and defined the tool as easy to use.

Discussion

CXR is the first choice imaging modality for identifying pneumothorax because it represents a simply accessible, rapid, inexpensive, and noninvasive imaging technique (4). In patients with suspected pneumothorax, CXR provides valuable information beyond confirmation by determining the extent of pneumothorax and potential causes. Additionally, it may assist in treatment options. Regarding the importance of accurate and fast diagnosis needed for proper management, the competency of physicians in pneumothorax diagnosis on CXR is crucial. To the best of our knowledge, the present study is the first to investigate the competency of residents and interns in pneumothorax diagnosis on CXR, which was conducted in Turkey.

Table 2. Accuracy rates of interns and residents regarding specialties

	Interns	Emergency medicine residents	Anesthesiology residents	Radiology residents	Pulmonary medicine residents	Surgery residents	p
Accuracy rate	78.6%	82%	72%	79.2%	95%	92%	0.001

Among all radiographic examinations, CXR is the most widely and represents one of the most complex imaging modalities to interpret. Unsatisfactory CXR interpretation skills of medical students, residents in training, and practicing physicians have been demonstrated in prior studies (5-9).

The current study investigated the competence of residents and interns in diagnosing pneumothorax on CXR. The overall accuracy rate was 79% in the study cohort, with 79.5% and 78.6% for the residents and interns, respectively. Regarding accuracy rates, no significant difference was found between the interns and residents, regardless of the residents' specialties. In contrast, when the residents' specialties were considered, the difference was found to be significant. Accordingly, the pulmonary medicine and surgery residents had the highest accuracy rates. Radiology and emergency medicine residents had lower rates, whereas anesthesiology residents and interns had the lowest rates.

One study investigated the ability of final-year medical students to interpret conventional CXRs with several abnormal findings, including multiple pulmonary metastases, left ventricular failure, total lung collapse, pneumothorax, rib notching (aortic coarctation), bullous emphysema, right middle lobe consolidation, pneumoperitoneum, and apical tuberculosis (10). Pneumothorax was missed by 40.4% of the participating students. The authors indicated that an error rate of 20%-30% would probably be acceptable, although the ideal correct diagnosis rate was 100%. In our study, interns had an error rate of 21.4%, and it may be considered acceptable. In another study, pneumothorax was misdiagnosed by 91% of the 145 participants, including interns, residents, and pulmonary/critical care and cardiology personnel (11). A more recent study by Christiansen et al. (12) found an overall accuracy of 51% in chest X-ray interpretation by junior doctors. The number of correct diagnoses regarding two chest X-rays with pneumothorax included in their study were reported as 73% and 59%, respectively. Thus, the overall accuracy rates depicted in our study are comparable to previous studies. Nevertheless, it may be assumed that the residents' overall performance in diagnosing pneumothorax on CXR was low, although expected to be obviously superior when compared to interns. Furthermore, because pneumothorax is an emergency that requires rapid and accurate diagnosis, higher performance of residents in terms of diagnosis may be anticipated.

We have to emphasize that our institution represents a relatively small-scale faculty of medicine; thus, residents' relatively low experience with patients with pneumothorax might have influenced their diagnostic performance. However, comparison to another national study was not feasible due to the lack of published studies on this topic in Turkey. Thus, the results of our study provide an opportunity to raise awareness and define the potential fields of our curriculum to be strengthened, if any. We believe that targeted education can decrease resident error rates and that improved patient care can be achieved. The implementation of quality control measures in postgraduate residency programs should also be valuable for providing an insight and ascertaining the fields requiring improvement in training activities, including basic radiology skills, particularly, interpretation of CXR. Additionally, another point of consideration is that basic radiology skills of residents originate from undergraduate training that widely varies among institutions. Further studies investigating the CXR interpretation skills of medical students and residents in other national institutions should be conducted and improvement of standardization in national medical education and residency training programs should be targeted.

Recent surveys and publications emphasized the importance of undergraduate radiology teaching (13, 14). CXR interpretation is considered an essential clinical skill for medical school graduates. Additionally, independent and rapid assessment of CXR by residents prior to formal radiology reading is often required. However, one study clearly demonstrated that both undergraduate and postgraduate trainees do not agree that the existing radiology teaching matches their learning needs (15). In the current study, the DICOM-compatible software tool-ViewDEX was used for the image evaluation process. Both residents and interns agreed that they enjoyed their interpretation session and defined the tool as easy to use. One potential future direction of the current study could be the development of a CXR competency exam using this tool. In this way, we could easily and confidently assess the deficiencies of training in our institution to meet the learning needs in the field of basic radiology. Examinations may provide more insight to the interns and residents on basic radiology skills, raise their awareness, and motivate them. Moreover, this tool may provide new teaching opportunities. For instance, data sets consisting of examples of "can't miss" diagnoses on several topics may be created to serve as new components to teach radiology during the preclinical and clinical phases of the curriculum.

The rate of correct diagnosis (rate of correct answers obtained for question 1) ranged between 25% and 100%, whereas the rate of misdiagnosis ranged between 0% and 75% for each CXR. Four of the 40 cases involved in the study were accurately diagnosed by 100% of the observers (all of them were examples of large pneumothorax). Higher missing rates were obtained mostly in cases of small pneumothorax: one of them being the most misdiagnosed case with a rate of 75%. Although accuracy of CXR in the estimation of pneumothorax size is beyond the scope of the current study, the higher missing rates in small pneumothorax cases in our study imply that the pneumothorax size may influence the detection of pneumothorax on CXR, particularly by inexperienced observers.

In a study that investigated the ability of final-year medical students to interpret conventional CXRs with several abnormal findings, the overall level of certainty about diagnoses was found to be low: 25% of pneumothorax diagnoses (10). In our study, although the difference was not significant, the overall level of confidence was high: 76.6% and 71.8% for residents and interns, respectively. The level of confidence for correctly diagnosed cases was higher than that of missed cases for both residents and interns.

The diagnosis of pneumothorax on CXR is usually straightforward with the radiographic hallmarks, including displacement of the pleural line and absence of distal lung markings between the edge of the pleura and the chest (16). In our study, these two characteristic findings were considered the most helpful findings for diagnosing pneumothorax by 70% and 70.8% of the interns and residents, respectively.

Future research in this area should focus on whether training of observers helps to improve competency in diagnosing pneumothorax on CXR. This could be investigated by determining their diagnostic accuracy rates at the start of the study (baseline data), subsequently training one group in the diagnosis of pneumothorax on CXR and keeping a control group without training. After a period of time, the observers could be re-evaluated to determine whether training enhanced their diagnostic accuracy rates.

Study limitations

The main limitation of the present study was the observation bias. The difference between real clinical scenario and the prepared scenario might have influenced the estimation of the observers' ability. Other potential limitations were small number of observers, particularly residents representing different training programs and that the year of training among residents was not considered.

Conclusion

The results of our study in terms of the overall accuracy rates of residents and interns in pneumothorax diagnosis on CXR are comparable to the previous studies in literature. However, comparison to another national study was not feasible due to the lack of published studies on this topic in Turkey. We believe that our study may serve as a starting point by raising the awareness on the subject and promote further studies in Turkey. By this way, the potential fields to be supplied should be defined and more useful conclusions should be drawn.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Ufuk University School of Medicine (30112015-9).

Informed Consent: Informed consent was obtained from all individual participants included in the study.

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