Interpretation of Pneumothorax on Emergency Department Chest Radiographs by Emergency Physicians and Residents

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Cite this article as: Azapoglu Kayman B, Ozaydin V, Tozum H, Ay D. Interpretation of Pneumothorax on Emergency Department Chest Radiographs by Emergency Physicians and Residents. Eurasian J Emerg Med. 2018; 17: 14-7.

Abstract

Aim: Pneumothorax is defined as the entry of air into the pleural space, which may cause mortal complications when delayed in diagnosis and treatment. The diagnosis is made on an erect posteroanterior chest X-ray that shows an edge caused by visceral pleura and absence of lung markings beyond this edge. These chest radiographs are initially interpreted by an emergency physician and decisions are made on the basis of this initial interpretation.

Materials and Methods: The chest radiographs of 100 patients were collected from the PACS archive. Fifty of these radiographs were reported as normal and 50 of them were pneumothorax. Emergency clinicians participating in the study included four emergency medicine physicians, three final year-residents (senior), four intermediate year residents (middle-senior), and four first-year residents (junior). Each physician interpreted 100 radiographs. The effects of interobserver variability and degree of pneumothorax on diagnosing pneumothorax on chest X-ray were investigated. The chest radiographs were re-interpreted 2 weeks later to identify intraobserver variability.

Results: The accuracy of the emergency department physicians and residents on diagnosing complete pneumothorax was 100%, intermediate pneumothorax was 95.1%, and small pneumothorax was 49.7%. The rate of correct diagnosis among final-year, intermediate-year, and first-year residents was 83.3%, 75.5%, and 62.5% of the radiographs, respectively.

Conclusion: The increase in the volume of pneumothorax rendered easy diagnosis chest radiograph. The residency year is associated with correct diagnose of pneumothorax especially in small pneumothorax cases.

Keywords: Pneumothorax, chest radiograph, emergency physicians, emergency residents, interpreting radiograph

Introduction

The presence of air between the visceral and parietal pleura leaves is clinically defined as pneumothorax and can lead to complications that can result in mortality if the diagnostic-therapy process is not managed appropriately (1).

Chest radiographs are the first choice among imaging methods to diagnose pneumothorax correctly and rapidly. Diagnosis is made by identifying the visceral pleural line and the absence of lung parenchyma distal to this line on the graph. The chest radiographs imaged with pneumothorax pre-diagnosis are initially evaluated by emergency clinicians. Due to the complexity of the emergency de-

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Received: 28.07.2017 • **Accepted:** 26.08.2017

DOI: 10.5152/eajem.2018.52523

partment and the clinicians' need for rapid decision-making, cases are often diagnosed without radiological consultation, and clinical management is based on these decisions.

This study aims to quantify the emergency clinicians' (residents' and physicians') accuracy to diagnose pneumothorax on chest radiograph. We aim to raise awareness to pneumothorax, which may be a life-threatening situation requiring emergent treatment, and improve the accurate interpretation by listing the factors that will affect the skills and time of recognition.

Materials and Methods

The study was carried out in the Medeniyet University Goztepe Training and Research Hospital Emergency Medicine Department using 100 chest radiographs collected from the Radiology Department's archive after obtaining approval from the Medeniyet University Goztepe Training and Research Hospita Ethics Committee (10.02.2015 /2015/0007). All radiographs were examined by radiology specialists; one-half of the radiographs were selected from the pneumothorax graphs and the remaining one-half from normal lung graphs. For the detection of pneumothorax in chest radiography, to eliminate the false negative condition stated in the study titled "NEXUS Chest Validation of a Decision Instrument for Selective Chest Imaging in Blunt Trauma," cases with computed tomography of the thorax were preferred (2). Thus, all pneumothorax cases that are expected to be evaluated and recognized in the radiographs have been confirmed using the "gold standard" technique.

Eleven emergency residents and 4 emergency physicians participated in the study. Emergency medicine residents who have been working in the clinic for 2 years are considered junior, while those in their third year were considered middle senior, and those in the fourth year were considered senior residents after successful completion of exams. Among the 11 emergency residents who participated in the study, 3 were seniors, 4 were middle-seniors, and 4 were juniors. The emergency physicians who participated in our study had been working in our clinic for 3-4 years.

The quantification of pneumothorax was determined using the Light formula in radiographs (Figure 1). This formula helps classify pneumothorax cases into three groups: as complete (total collapse, loss of contact between lungs and diaphragm), moderate (50% collapse in the lung), and small (thin air surrounding the lung). Digital copies of chest radiographs that were compiled in a random order and numbered from 1 to 100, by de-identifying patients' details. A folder was created, which contained the radiographs' reference numbers given by our clinic, patients' identification details, and the clinical diagnosis. Each participant evaluated 100 chest X-rays in turn, and stated in the evaluation form regarding the presence and absence of pneumothorax. Participants were requested to re-evaluate the same X-rays in a different sequence after 2 weeks. We aimed to evaluate the significance of statistical data by showing intraobserver variability using this method. All participants were informed that the radiographs were taken with a pneumothorax pre-diagnosis prior to evaluations. Also, the length of employment for each emergency resident and physicians was recorded before each evaluation.

$$\%\ \text{of Pneumothorax}\ (\%) = \frac{(\text{Diameter of hemithorax})^3 - (\text{Diameter of collapsed lung})^3}{(\text{Diameter of hemithorax})^3}$$

Figure 1. Calculation of percentage of pneumothorax using the light formula

After the evaluation forms were collected, the accuracy of the answers were assessed. The number of radiographs that were diagnosed correctly as normal, small pneumothorax suspicion, moderate pneumothorax, and complete pneumothorax were recorded. In addition, the number of radiographs considered by the participants as "pneumothorax" situation, "normal," and "not sure" were recorded for each clinician. Hence, the factors that might affect the recognition of pneumothorax by emergency clinicians, the effect of their clinical experience, and the amount of pneumothorax were aimed to be measured.

Statistical analysis

The data were analyzed using Mann-Whitney U, Wilcoxon and Chi-square tests by the Statistical Package for Social Sciences (SPSS Inc.; Chicago, IL, USA) software, version 16.0.

Results

A total of 15 emergency clinicians participated in the study with 11 residents and four physicians. According to the Light formula, 26 were small pneumothorax, 15 were moderate pneumothorax, and 9 were complete pneumothorax of the 50 pneumothorax radiographs among the 100 chest radiographs evaluated.

The rate of pneumothorax defined correctly at the initial evaluation was 72.4% and misidentified pneumothorax was 20.1%; the rate of pneumothorax correctly identified after 2 weeks was 72.8%, and the rate of misidentified pneumothorax was 18.8%. There was no significant difference between the two trials in terms of the correct diagnosis of pneumothorax (X^2=0.762; p>0.05). The rate of normal radiographs correctly diagnosed at initial evaluation was 82.5%, the rate of normal radiographs thought to be pneumothorax was 4.8%, and the rate of unsure normal radiography was 12.7%. The rate of normal radiographs correctly diagnosed after 2 weeks was 82.0%, the rate of normal radiographs thought to be pneumothorax was 5.1%, and the rate of unsure normal radiographs was 12.9%. There was no significant difference between the two trials in terms of recognizing healthy people (X^2=0.088; p>0.05).

As a result of the evaluation of the radiographs, pneumothorax size was found to be significantly effective in defining pneumothorax correctly (X^2=209.86; p<0.05; Table 1).

Among the emergency residents, the rate of correct diagnosis of pneumothorax was 72.9%, wrong diagnosis was 18.4%, and unsure radiographs was 8.4%; among the emergency physicians, the rate of correct diagnosis of pneumothorax was 71.0%, wrong diagnosis of pneumothorax was 24.0%, and unsure radiographs was 5%. It was found that being a resident or a physician in terms of defining pneumothorax was not significantly effective (X^2=4.322; p>0.05).

Table 1. Chi-squared test analysis of the comparison of pneumothorax diagnosis depends on the pneumothorax size

Size	n	Correct (%)	Incorrect (%)	Unsure (%)	X^2	p
Small	390	49.7	36.9	13.3	15	0.000
Moderate	225	95.1	3.1	1.8	1.9	
Complete	135	100.0	0.0	0.0	7*	

**Linear by Linear Association*

Table 2. Chi-squared test analysis of the comparison between residents and physicians diagnosing normal graphs

Title	n	Correct	Incorrect (%)	Unsure (%)	X^2	p
Resident	550	79.3	5.5	15.3	15.5	0.000
Physician	200	91.5	3.0	5.5	56	0

Table 3. Chi-squared test analysis of size-based comparison of diagnosing pneumothorax between residents and physicians

Size	Title	n	Correct	Incorrect	Unsure	X^2	p
Small	Senior	78	69.2	23.1	7.7	24.442	0.000
	Middle	104	54.8	33.7	11.5		
	Senior						
	Junior	104	34.6	41.3	24.0		
Moderate	Senior	45	97.8	2.2	0.0	5.640	0.228
	Middle	60	96.7	1.7	1.7		
	Senior						
	Junior	60	88.3	8.3	3.3		
Complete	Senior	27	100.0	0.0	0.0	-	-
	Middle	36	100.0	0.0	0.0		
	Senior						
	Junior	36	100.0	0.0	0.0		

It was determined that being a resident or a physician is significant in terms of defining normal graphs correctly (X^2=15.556, p<0.05; Table 2).

The rate of correct diagnosis of pneumothorax was 83.3%, 75.5%, and 62.5% among senior, middle, and junior residents, respectively. In the first trial, the experience of the residents was found to have a significant effect on the correct diagnosis of the pneumothorax (X^2=20.702, p<0.05). As the experience of residents decreased, the rate of correct recognition of pneumothorax also decreased, and similarly, the rate of misdiagnosis of pneumothorax increased. The rates of correct diagnosis of small pneumothorax and misdiagnosis was 69.2% and 23.1%; 54.8% and 33.7%, and 34.6% and 41.3% among senior, middle senior, and junior residents, respectively. The experience of the residents was found to have a significant effect on the correct diagnosis of the small pneumothorax (X^2=24.442; p<0.05; Table 3).

Discussion

Despite all the improvements in radiological imaging, chest radiographs are still the first imaging method used in many pathologies because of their rapid results (3). The radiographs taken are often initially evaluated by the clinician, especially in emergency departments, where clinicians' own experience and skills play a major role. Emergency clinicians plan the treatment on their assessment without having the opportunity to interact with the radiology specialists in life-threatening and urgent situations. Due to this common situation, several studies have been carried out to compare the emergency medical team's success on evaluating radiographs with radiologists (4-13). In these studies, it is often said that clinicians in different specialties evaluate radiographs not as adequately as radiologists.

In a study conducted by Brunswick et al. (6) in 1996, the diagnostic inconsistency between radiologists and emergency physicians was found to range from 0.3% to 3%, and the treatment modality resulting from this incompatibility was ranged from 0.06% to 0.3%. Al Aseri (12) reported that 66% of the emergency reports of chest radiographs were in agreement with those of radiologists. Petinaux et al. (13) reviewed the radiology discrepancies of emergency department radiograph interpretations and performed the largest study with 151693 radiographs during a 9-year study period. They reported that 85 of 5308 discrepancies required emergent change in medical management and 24 of the cases were pneumothoraxes.

In our study, the abilities of emergency medical residents and physicians were evaluated using radiographs reported by radiologists. The

cases of complete pneumothorax requiring immediate intervention were identified by all of the participants, and there was no disruption in the treatment plan.

Significant pathologic findings can be detected by all clinicians regardless of clinical experience and skill, and the assessments made with these pathologic findings may not reveal differences between observers. In this study, the large pneumothorax cases observed in the radiographs were detected by all the observers. Pathologies that are more challenging to detect could reveal the skill diversity among the participants from the same class (4). In this study, most of the pathologic radiographs were "small pneumothorax" cases. The difference between the senior resident, middle resident, and junior resident was statistically significant, although there was no significant difference in finding small pneumothorax cases when all the residents and physicians were compared. The increase of the ability of evaluating chest radiographs among emergency physicians supports the view that radiography evaluation skills are gained during emergency residency training.

Our study showed that there may be differences in achieving accurate diagnosis within the emergency room clinicians, but that there is no missing case in life-threatening situations, such as complete pneumothorax. However, since statistically significant differences were found in the diagnosis of small pneumothorax radiographs, all radiographs in the emergency departments should be evaluated not only by residents but also by physicians with sufficient clinical experience.

Study limitations

Participants in the study were selected from a single center. The higher the number of participants in the subgroups adjusted for each class indicates a higher level of significance of the data. The only pathology in the radiographs was pneumothorax. Participants evaluated the graphs in an environment isolated from emergency services. The data of the evaluation done beside the patient and in emergency room conditions could be more meaningful.

Conclusion

In future studies more radiographs with different pathologies can be shown to the emergency physicians and residents to quantify the ability of radiographic evaluation in other mortal situations.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Medeniyet University Göztepe Training and Research Hospital (10.02.2015 /2015/0007).

Informed Consent: Written informed consent was not obtained from patients because patients were not participated in this study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – B.A.K., V.O.; Design – D.A.; Supervision – H.T., B.A.K.; Resources – V.O., D.A.; Materials – H.T.; Data Collection and/or Processing – B.A.K., D.A.; Analysis and/or Interpretation – V.O.; Literature Search – D.A., B.A.K.; Writing Manuscript – B.A.K.; Critical Review – V.O.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study has received no financial support.

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