

2024 Vol. 7

Original-, udviklings-,
og kvalitets artikler

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Keywords:

Pneumonia, chest X-ray,
sensitivity, diagnosis,
emergency department.

New infiltration on chest X-ray for emergency diagnosis of pneumonia

INTRODUCTION:

Pneumonia is a very common and severe infectious disease with high mortality.

Despite studies showing lack of sensitivity for new infiltration on chest X-ray (CXR) in the diagnosis of pneumonia, leading literature require a new infiltration on CXR.

AIM:

We aimed to examine the proportion of pneumonia patients in the emergency department with a new CXR infiltration and compare the clinical presentation and 7-days mortality of pneumonia patients with and without new infiltration on CXR.

METHODS:

This diagnostic retrospective chart reviewing study included pneumonia diagnosed patients who were discharged from the emergency department during 2018. Initial CXR was reviewed and sensitivity of new infiltration on CXR was calculated. Hereafter, compared patient characteristics of radiograph-confirmed pneumonia patients to those without by using a chi-square test.

RESULTS:

556 journals were enrolled of which 62% had a new infiltration on their CXR, resulting sensitivity of new infiltration on CXR to be 62%. There was no significant difference in patient characteristics and mortality.

CONCLUSION:

Absence of new infiltration on CXR does not appear to exclude pneumonia diagnosis in pneumonia suspected patients. Patients with positive CXR finding did not differ from those with negative CXR.

FUNDING: No funding was received.

TRIAL REGISTRATION: Not relevant

Introduction

Pneumonia is highly represented among the most common infectious diseases (1). There is a clinical spectrum for pneumonia that ranges from infections treated on an outpatient basis, with 1% mortality, to infections that present as medical emergencies (severe sepsis and septic shock) with mortality above 40% (2). In Denmark, the hospitalization rate for pneumonia infections is approximately 0,8% per year with a significant rise among the elderly and those with comorbidity (3). The incidence and the mortality of pneumonia infections are age- and comorbidity-dependent (4). Comorbidities include chronic obstructive pulmonary disease, diabetes mellitus, congestive heart failure, and malignancy. COPD patients are prone to frequent exacerbations in which bacterial infection is believed to play a role in at least half of these episodes (5). Hence the diagnosis of pneumonia is important to be done in early stage so the patient can be treated appropriately. Pneumonia can be diagnosed with various methods but according to the guideline developed by the Danish Society for Respiratory Medicine and Danish Society of Infectious Diseases, the diagnosis of pneumonia requires radiological confirmation of new infiltration as well as symptoms of lower respiratory tract infection (6). Symptoms may include fever, cough, mucus production, dyspnea, and respiration-related chest pain. Besides the guideline, Danish Doctor's Handbook set the same frame for diagnosing pneumonia (7). The literature emphasizes the importance of detecting a new infiltration on CXR for pneumonia diagnosis and has set it as a requirement for the diagnosis. Studies suggest that CXR should be performed in all patients admitted

with suspected pneumonia. As clinical manifestations such as respiratory symptoms, general symptoms of infection and corresponding physical findings are not sensitive or specific enough for a definitive diagnosis, a confirmatory CXR should be performed to detect infiltration (1, 2, 8).

Nevertheless, many patients present with symptoms or clinical findings suggestive of pneumonia, but the corroborating radiographic evidence required for a diagnosis is lacking or unclear. Despite this, these patients are commonly "clinically" diagnosed with pneumonia and are treated as such. Studies suggest one-third of pneumonia patients have CXR that do not provide radiographic evidence of pneumonia (9). The sensitivity of CXR in the diagnosis of pneumonia is reported to be between 67-75% (10). Despite numerous studies reporting that CXR lacks sensitivity and specificity in diagnosing pneumonia (10-13). It is still the most preferred imaging modality for the diagnosis of pneumonia (14).

Studies have shown CXR not to have an adequate sensitivity to detect a new infiltration in patients suspected with pneumonia. Leading literature requires not only symptoms of lower respiratory tract infection but also the detection of a new infiltration on CXR for the diagnosis of pneumonia. This incongruence between leading literatures requiring both symptoms of lower respiratory tract infection and a new infiltration on CXR, despite CXR's low sensitivity leaves a breach for investigation on how many patients diagnosed with pneumonia actually have new infiltration on their CXR.

Accepteret til publikation: 28.05.2024

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Aim and objective

We aim to examine the proportion of pneumonia patients in the emergency department with a new CXR infiltration and compare the clinical presentation and outcome of pneumonia patients with and without new infiltration on CXR.

Method

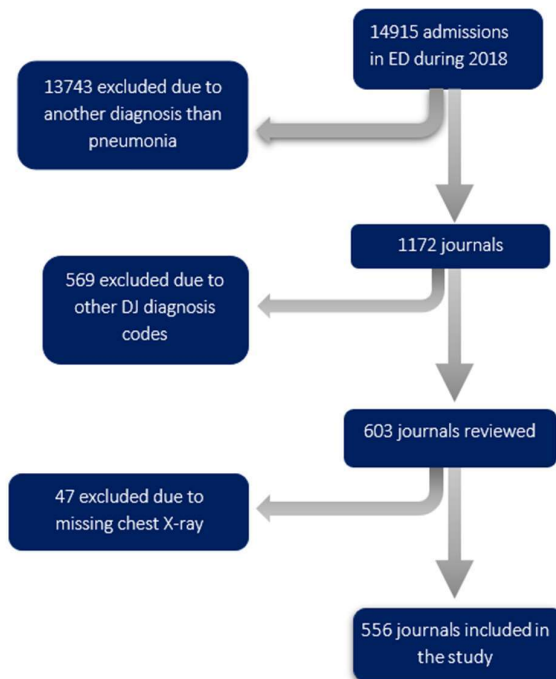
Study design

This diagnostic study was completed by retrospectively reviewing the hospital records of ED patients with a discharge diagnosis of pneumonia. The study adhered to the updated 2015 STARD reporting standards (15).

Study setting and participants

The study setting was the Emergency Department in Hospital Sønderjylland, Aabenraa, Denmark. Patients included in this study were discharged with a pneumonia diagnosis ICD-10 code of DJ13-DJ22 during 2018. Patient records that did not report completion of a

Figure 1: Selection of study population



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CXR during admission were excluded from the study population.

Test method

The reference standard was a discharge diagnosis of pneumonia amongst ED patients. New chest x-ray infiltration, described by the radiologists, was the index test.

Data collection

Two project assistants reviewed each medical record to collect clinical and radiographic data. Information from the medical records of patients with a pneumonia diagnosis included ID-number, age, sex, date of admission and ICD-10 discharge diagnosis, information about smoking status, symptoms, clinical signs, comorbidities, and C-reactive protein biomarker. Smoking was a categorical variable and patients were grouped according to whether they were active, non-, or former smokers. The most common signs and symptoms for pneumonia such as cough, mucus production, dyspnea, and fever, were collected from the eligible patient charts.

Comorbidities such as asthma, COPD, hypertension, diabetes mellitus (type 1 and type 2), and cardiovascular disease (congestive heart failure, aortic stenosis, mitral valve stenosis, infarction, atherosclerosis, and arrhythmias) were noted. For the radiographic data, the conclusion drawn by the on-call radiologist of each initial chest radiograph was recorded. A CXR was classified as positive if the description described “new infiltration”, “pneumonia” or “consolidation”. It was classified negative if the above-mentioned terms were not used or the description included “no new infiltration”,

“no pneumonia”, “no consolidation” or other specific terms excluding pneumonia.

Statistical analysis

Based on CXR results, patients were stratified into two groups: positive (chest radiograph findings in concordance with pneumonia) and negative (no chest radiograph findings indicating pneumonia). The sensitivity of the index test was determined. A chi-square test was performed to evaluate the statistical difference in factors such as age, sex, comorbidities, clinical signs, and symptoms between the two groups. Statistical significance was set as $\alpha \leq 0.05$. All statistical data were analyzed using STATA version 15.0 (Texas, USA).

Ethics

The study was a quality improvement study and did not require ethical approval by Regional Committees on Health Research Ethics.

Results

A total number of 14915 admissions were recorded during 2018 in the emergency department in Hospital Sønderjylland as shown in Figure 1. The number of patient journals excluded was 14312 due to another diagnosis than pneumonia and other DJ pneumonia diagnosis codes leaving 603 journals. The included diagnosis codes were Pneumonia due to Streptococcus pneumoniae (DJ-13), Pneumonia due to Hemophilus influenzae (DJ-14), Bacterial pneumonia not elsewhere classified (DJ-15),

Pneumonia due to other infectious organisms not elsewhere classified (DJ-16), Pneumonia in diseases classified elsewhere (DJ-17), Pneumonia unspecified organism (DJ-18) and unspecified acute lower respiratory infection (DJ-22). After reviewing 603 journals, there

were 47 patient records missing a CXR and these were excluded from the study resulting in 556 journals, as illustrated in Figure 1.

Patient characteristics on admission are shown in Table 1. The median age was 75 years (IQR; 64-83), 58% was male. 65% of the population had comorbidities, where CVD was dominating with 33%. 17% of the population were active smokers.

From the study population (n=556), 343 (62%) patients underwent a CXR with positive radiological findings for pneumonia. Therefore, the index test has a sensitivity of 62%. The characteristics of the study population are illustrated in Table 2. Patients with positive CXR did not display significantly different characteristics when compared with those with negative CXR.

Table 1: Patient characteristics

Patient characteristics	Study population N = 556
Age, median (IQR)	75 (64-83)
Male	321 (58%)
Female	235 (42%)
Smoking	96 (17%)
CVD	185 (33%)
HTN	171 (30%)
COPD	142 (25%)
DM	106 (19%)
Asthma	34 (6%)
Comorbidities	362 (65%)

COPD: Chronic Obstructive Pulmonary Disease, CVD: Cardiovascular Disease, DM: Diabetes Mellitus, HTN: Hypertension

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Table 2: Analysis of patient characteristics

Characteristics	Level	Missing	Positive	Negative	P-value
N			343	213	
Age	18 – 64		93 (27,1%)	50 (23,5%)	0,15
	65 – 74		64 (18,7%)	55 (25,8%)	
	75 – 84		107 (31,2%)	69 (32,4%)	
	>85		79 (23,0%)	39 (18,3%)	
Sex	Male		209 (60,9%)	112 (52,6)	0,053
	Female		134 (39,1)	101 (47,4%)	
Dyspnea		157	197 (83,5%)	135 (82,8%)	0,86
Cough		141	222 (86,4%)	128 (81,0%)	0,14
Mucus		225	151 (72,9%)	95 (76,6%)	0,46
Crackles		108	183 (64,4%)	105 (64,0%)	0,93
T>38		23	129 (39,8%)	82 (39,2%)	0,89
CRP	<10	34	13 (4,0%)	13 (6,5%)	0,16
	10 – 99		141 (43,9%)	99 (49,3%)	
	>100		167 (62,0%)	89 (44,3%)	
Smoking	Non-smoker	117	84 (31,5%)	63 (36,6%)	0,39
	Active		57 (21,3%)	39 (22,7%)	
	Former		126 (47,2%)	70 (40,7%)	
CVD			120 (35,0%)	65 (30,5%)	0,28
HTN			103 (30,0%)	68 (31,9%)	0,64
COPD			57 (26,8%)	85 (24,8%)	0,60
DM			64 (18,7%)	42 (19,7%)	0,76
Asthma			17 (5,0%)	17 (8,0%)	0,15
Comorbidities	0		119 (34,7%)	75 (35,2%)	0,75
	1		103 (30,0%)	57 (26,8%)	
	2		84 (24,5%)	58 (27,2%)	
	3		30 (8,7%)	17 (8,0%)	
	4		7 (2,0%)	5 (2,3%)	
	5		0 (0,0%)	1 (0,5%)	
7-Days- mortality			22 (6,4%)	7 (3,3%)	0,11

COPD: Chronic Obstructive Pulmonary Disease, CRP: C-Reactive Protein, CVD: Cardiovascular Disease, DM: Diabetes Mellitus,

HTN: Høvdertension, T: Temperature

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Discussion

This study is one of the recent studies to determine the efficacy of chest radiography for the diagnosis of pneumonia in ED patients. This study determines that chest radiography has a 62% sensitivity for pneumonia diagnosis. Interestingly, there are no clinically important features or patient characteristics that significantly distinguish radiographically confirmed pneumonia patients from those without radiographic confirmation.

The results of this study are comparable with those of previously published studies conducted in ED for the diagnosis of pneumonia, which aimed to determine the sensitivity of CXR for a pneumonia diagnosis. Bourcier et al. performed a single-center observational study and reported the CXR sensitivity for acute pneumonia as 60% (10). Basi et al. reported 66% of clinically suspected pneumonia patients had radiograph-confirmed pneumonia but 34% did not have radiographic confirmation (9). Egelund et al. screened 2501 patients with a pneumonia diagnosis, 961 patients had no new infiltrate on the CXR, resulting in a CXR sensitivity of 62% after analysis (16).

Patient characteristics and clinical features did not show any significant correlation with the presence or

absence of infiltration on CXR. Hagaman et al. presented no difference in age, sex, or comorbidities when the two patient groups were compared (11). Basi et al. showed a few characteristics that distinguished patients with opacification on CXR from patients without. Patients without infiltration on CXR were older than those with radiograph-confirmed pneumonia. Significantly, many more patients with new infiltration had dyspnea (9).

Uncontrolled variables not included in patient records such as the onset of symptoms may have an impact on the opacification on chest radiographs. The time gap between symptom debut and infiltration on CXR is not precisely known. Bourcier et al. analyzed patients with onset of pneumonia for symptoms both less than 24 hours and more than 24 hours. Chest radiography confirmed pneumonia in only 23% of those presenting with symptom onset less than 24 hours whilst 61% of patients with positive CXR finding had a symptom onset after more than 24 hours. Therefore, it is suggested that a CXR has low sensitivity in early stages of pneumonia in ED patients.

Alternative diagnostic tests are being explored which could replace CXR for the diagnosis of pneumonia in

Hvad ved vi?

- Vi ved at diagnosen pneumoni kræver radiologisk påvist nyttilkommet infiltrat ifølge retningslinjer

Hvad tilføjer denne afhandling til vores viden?

- Denne artikel viser at 62% af de patienter som diagnosticeres med pneumoni på akutmodtagelsen har et påvist nyttilkommet infiltrat på røntgen af thorax

Hvordan kan den bruges i danske akutmodtagelser?

- På akutmodtagelsen skal vi være opmærksomme på at selvom der ikke er påvist et nyttilkommet infiltrat på røntgen af thorax kan patienten godt have pneumoni alligevel.

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ED patients. Studies have shown ultrasound having superiority over chest X-rays for diagnosis of pneumonia with a higher sensitivity (10, 12). Therefore, providing a more timely and cost-effective alternative.

The difference between studies and leading literature created a gap for investigation on how many pneumonia patients had a new infiltration on CXR. This study suggests that according to literature, 62% of the discharged pneumonia patients from the ED would have gotten a pneumonia diagnosis, while the remaining 38% would not, since a new infiltration was not detected. This demonstrates that clinicians do give the diagnosis for pneumonia even though a new infiltration is missing on CXR. Other factors may play a role such as symptoms, clinical signs, and blood results besides for the CXR results. It is yet to be investigated what exactly these other factors are and what role they play in the diagnosis of pneumonia.

Limitations in this study include the retrospective study design. We were unable to control for factors in patient anamnesis done by different physicians causing missing data. In future studies, missing data could be avoided by conducting a systematic scheme for patient anamnesis in a prospective study design. Variations in the conclusions of on-call radiologists were challenging. Future research would be assisted if the same radiologist was describing all the CXRs or if the radiologist's only assignment was to detect pneumonia on the CXR. Hereby, would the CXR be described in a consistent and similar manner. Despite an adequate population size, the study was a single center. Future studies including patients from different regions in the world would allow the study's conclusions to be more representative on an international level.

Future studies ought to take into consideration the severity of the disease. A future prospective study could classify patients by CURB-65 score and examine if it has an impact on the presence or absence of infiltration on CXR.

Conclusion

This study determines sensitivity of new infiltration on CXR for pneumonia diagnosis in ED to be 62%, meaning absence of new infiltration on CXR does not appear to exclude pneumonia. Although, leading literatures require a new infiltration on CXR, it seems as clinicians not only diagnose pneumonia based on positive CXR but also other parameters, which is yet it be studied. Patients with positive CXR did not display significantly different characteristics when compared with those with negative CXR. Finally, a prospective study design would be necessary to confirm the study results since avoidable limitations occurred due to the chosen study design.

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