Diagnostic accuracy of pneumonia in Hospital Tuanku Ja'afar Seremban, a tertiary hospital

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ABSTRACT

Objectives: The primary objective of this study was to describe the accuracy of pneumonia diagnosis, both community-acquired pneumonia (CAP) and hospital-acquired pneumonia (HAP). Secondary objectives were describing the choice of antibiotics used, pathogens isolated, and predictive parameters in diagnosing pneumonia.

Methods: This was a prospective cross-sectional study to determine the accuracy of the diagnosis of CAP and HAP admitted to Hospital Tuanku Ja'afar. All patients aged ≥12 years admitted to the general medical ward with the diagnosis of CAP or HAP were included in the study. Chest radiograph interpretation was done by certified radiologists. An accurate diagnosis of pneumonia was defined by clinical signs and symptoms of pneumonia supported by radiographical evidence.

Results: A total of 159 patients were enrolled into the study from January 2018 to February 2018. Of these only 59(37.1%) cases were accurately diagnosed as pneumonia. Amongst those with pneumonia diagnosis made by the emergency department, medical officers and specialists of medical department; 65.4%, 60% and 47.3% respectively were not pneumonia. Amoxicillin with clavulanate and azithromycin were amongst the most common first choice of antibiotic used (46.5%). In this study, pathogens were isolated either by blood culture or sputum culture in only 20 (12.6%) patients. There was no significant predictive parameter identified in this study, which included white cell counts, C-reactive protein (CRP) levels, erythrocyte sedimentation rate (ESR), and Pao2/FiO2 ratio.

Conclusion: About two-thirds of patients diagnosed with pneumonia did not have a compatible radiological finding. Better tools and systems are needed to aid in the diagnosis of pneumonia.

KEY WORDS:
Pneumonia, diagnostic accuracy, chest radiograph, C-reactive protein

INTRODUCTION

Pneumonia remains as one of the most common diagnoses requiring admission to hospitals. Based on the Malaysia health fact 2019 (Survey data on year 2018), diseases of the respiratory system was the second leading cause of admission to hospitals and mortality in government hospital in Malaysia with 13.9% and 21.1% respectively.[1] A study by Soraya Azmi et al., on the incidence of pneumonia using the Casemix system data from contributing hospitals showed that the total cases of pneumonia admitted contribute to 6.4% of total admission including both community-acquired pneumonia (CAP) and hospital-acquired pneumonia (HAP).[2]

Data extracted from our census from March 2017 to September 2017 showed an average of 14.2% of admission was attributed to pneumonia. However, data from Patient Management System (PMS) upon discharge, the average percentage came down to 7.0%. This discrepancy shows that there is inaccuracy of pneumonia diagnosis in our clinical settings.

A diagnosis of pneumonia requires a compatible clinical presentation supported by radiographic evidence; as defined by both the British Thoracic Society (BTS) and Nice guidelines.[3,4] Non-infectious cause is one of the reasons for treatment failure in pneumonia, and inappropriate use of antibiotic could lead to antibiotic resistance.[5,6] Furthermore, administration of antibiotics within 8 hours improves outcomes in cases of pneumonia.[7] Hence, it is crucial to make an accurate diagnosis of pneumonia for optimal patient care outcomes.

In this study, we planned to assess our diagnostic accuracy of patients admitted with pneumonia. In addition, we describe the antibiotic choice, pathogens isolated, and identify any predictive parameters for diagnosing pneumonia.

MATERIALS AND METHODS

Study type and Design

This was a prospective cross-sectional study to assess the diagnostic accuracy of CAP and HAP admitted to the Hospital Tuanku Ja'afar Seremban (HTJS). All patients admitted to medical wards from the emergency department (ED) with the diagnosis of CAP or HAP were followed up from admission until time of discharge. All cases were managed according to the routine practice, and no additional intervention was involved. The initial chest radiograph done on admission was used for diagnostic interpretation by our resident certified radiologists in HTJS. This study was

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Table I. The prevalence of comorbidities of the enrolled patients

Comorbidity	Number (%)
Hypertension	90(56.6)
Diabetes mellitus	66(41.5)
Bronchial asthma	30 (18.9)
Chronic obstructive pulmonary disease (COPD)	23 (14.5)
Ischemic heart disease	22(13.8)
Chronic kidney disease / End-stage renal disease	11 (6.9)
Cerebrovascular disease	10 (6.3)
Heart failure	9 (5.7)
Bronchiectasis	6 (3.8)
Liver disease	3 (1.9)
Interstitial lung disease (not specified)	1 (0.6)
Autoimmune disease	1 (0.6)
No comorbid	23(20.1)

Table II The final diagnosis made by the treating doctors upon discharge

Final diagnosis upon discharge	Frequency (%)
Pneumonia or pneumonia-related [A]	103(64.8)
Bronchial asthma [B]	17(10.7)
Non-pulmonary in origin (non-cardiac causes)	12(7.5)
Non-pulmonary in origin (Cardiac related diagnosis)	11(6.9)
Upper respiratory tract infection	7 (4.4)
Chronic obstructive pulmonary disease (COPD) [C]	4 (2.5)
Bronchiectasis	2 (1.3)
Lung malignancy	2(1.3)
Hypersensitivity pneumonitis	1 (0.6)

[A] This category includes pneumonia as the only diagnosis or pneumonia-related diagnosis such as acute exacerbation of bronchial asthma due to pneumonia, etc.
[B] Bronchial asthma related disease such as acute exacerbation of bronchial asthma not associated with pneumonia.
[C] COPD related diseases such as acute exacerbation of COPD not associated with pneumonia.

Table III: The organism isolated from blood culture

Blood Culture Organism	Number (%)
No organism isolated	127 (88.8)
coagulase-negative staphylococci	8 (5.6)
Streptococcus pneumoniae	2 (1.4)
group A beta-hemolytic Streptococcus	2(1.4)
Burkholderia pseudomallei	1(0.7)
Klebsiella pneumoniae	1(0.7)
Escherichia coli	1(0.7)
Ewingella americana	1(0.7)

Table IV: The organism isolated from sputum culture

Sputum Culture organism	Number (%); Total=58
No organism isolated	43 (74.1)
Not suitable for culture	11 (19)
Klebsiella pneumoniae	1 (1.7)
Pseudomonas aeruginosa	1 (1.7)
Morganella morganii	1 (1.7)
extended-spectrum β-lactamase (ESBL)-producing Klebsiella pneumoniae	1 (1.7)

Table V: Regression logistic analysis of independent variables studied against the accuracy of pneumonia

	Wald	df	Sig.	OR	95% C.I. for OR	
					Lower	Upper
Mean arterial pressure	0.081	1	0.776	1.007	0.961	1.055
Serum urea Level	0.262	1	0.609	0.891	0.572	1.387
eGFR	1.082	1	0.298	0.983	0.950	1.016
White cells count	1.470	1	0.225	0.878	0.710	1.084
ESR	0.518	1	0.472	1.010	0.984	1.037
CRP	2.882	1	0.090	1.022	0.997	1.049
Pao2/Fio2	1.921	1	0.166	0.994	0.987	1.002
Temperature	0.194	1	0.66	1.232	0.487	3.117

df= degree of freedom, Sig. = significance level, C.I. = confidence interval, OR = odd ratio.

conducted between January 2018 and February 2018. An accurate diagnosis of pneumonia is defined by clinical signs and symptoms compatible with pneumonia and supported by radiographic evidence.

Study population & inclusion criteria
All patients aged 12 years and older admitted to the general medical ward from the emergency department with the diagnosis of CAP or HAP; or if the diagnosis was made later in ward were included.

Exclusion criteria
Diagnosis of aspiration pneumonia.

Definitions
An accurate diagnosis of pneumonia is by clinical signs and symptoms of pneumonia supported by radiographical evidence. Clinical signs and symptoms of pneumonia include fever (>38°C), pleuritic chest pain, dyspnoea, tachypnoea and signs on physical examination of the chest such as crepitation.

Positive chest radiograph is defined as chest radiograph finding compatible with pneumonia. Chest radiograph compatible with pneumonia is defined by the evidence of radiographic shadowing, which was at least segmental or present in more than one lobe, and was not present previously.[3] HAP is defined as pneumonia that occurred

during a hospital stay for at least 48 hours after admitssion and was not previously present upon admission.

Statistical Analysis

Data analysis was done using SPSS version 22. Descriptive data was expressed as mean or standard deviation. Missing data was replaced with the mean value of the variables. A logistic regression analysis was performed for the relationship between accuracy of pneumonia and the clinical variables studied including white cells count, erythrocyte sedimentation rate (ESR), C-reactive protein (CRP) levels, mean arterial pressure, temperature on presentation, urea levels and estimated glomerular filtration rate (eGFR) on presentation. Mean arterial pressure and urea levels were selected for analysis as these were the components involved in CURB65 score (confusion, urea levels, respiratory rate, blood pressure and age >65 years).[8] Mean arterial pressure was calculated by the formula of (2x systolic pressure + diastolic pressure) divided by three. The eGFR is calculated by Modification of Diet in Renal Disease (MDRD) equation.

RESULTS

Study Population & Data Analysis

A total of 159 patients were enrolled into the study and of these only 59 (37.1%) met the BTS criteria for pneumonia. Among the pneumonia diagnosis made by Emergency Department, medical officers and medical specialists, 65.4%, 60% and 47.3% respectively were not pneumonia. In all 92.5% of the chest radiograph were adequate for interpretation, as reported by the radiologists involved.

Among patients studied 41.9% were males and 58.5% were females. The mean age was 57 years. Table I shows the comorbidities of the patients. The final diagnosis made upon discharge by the treating doctors is shown in Table II. Amongst those discharged with the diagnosis of pneumonia, 45 (43.7%) had a negative chest radiograph. Amoxicillin with clavulanate and azithromycin was the most common first choice of antibiotic used (46.5%).

From the studied population, 143 of blood cultures were sent, and 16 patients did not have any blood culture done. The results are shown in Table III. For sputum culture, only 58 samples were sent, the result is shown in Table IV.

Independent variables selected for regression logistic analysis were temperature at presentation, CRP levels, ESR, mean arterial pressure, urea levels, eGFR, white cell counts, Pao2/Fio2 ratio. All these variables were not significant predictors for accurate diagnosis of pneumonia as shown in Table V.

DISCUSSION

In this study, we abided by the BTS criteria for the diagnosis of pneumonia, for which radiological evidence is required. According to these criteria, 65.4% of cases of pneumonia diagnosed by ED were not accurate. Unfortunately, there were no other Malaysian studies for comparison when this study was conducted. Our result was much lower compared to a multicentre study conducted by Chandra et al., in the United States of America (USA) on the ED diagnosis of pneumonia, which found that 27.3% of patients studied had a non-pneumonia diagnosis upon discharge.[9] Similarly, our diagnostic accuracy of pneumonia was also lower when compared to a study by Kanwar et al., in the USA, where 41.1% of pneumonia diagnosed was inaccurate.[10] Moreover, a study conducted at the University Hospital Llandough in the United Kingdom found that 30.2% of patients diagnosed with pneumonia were inaccurately made by BTS criteria.[11]

The sensitivity and specificity of chest radiographs is an important factor in accurately diagnosing pneumonia. Despite this there is a lack of study regarding the sensitivity and specificity of chest radiographs in adults diagnosed with pneumonia. A study by Hagaman et al., found that 21% of patients with pneumonia had an initial negative chest radiograph, but only about half of them had a follow-up chest radiographs done within 48 hours. Also, the sensitivity was not measured.[12] Hence, it is unable to conclude the sensitivity of chest radiographs from this study by Hagaman et al. Another study by Lefcoe et al., with portable chest radiographs was compared to protected brush catheter specimens in critical care setting in diagnosing pneumonia; demonstrated poor sensitivity (around 60%) of portable chest radiograph.[13] However, portable chest radiographs may have lower sensitivity than a conventional chest radiograph.

The sensitivity of chest radiographs in detecting opacities was low compared to chest computed tomography (CT) as described by Self et al. (2013); sensitivity of 43.5% but with a negative predictive value of 96.5%. However, this study was originally designed for evaluation of diagnosis of pulmonary embolism. Hence, the absence of signs and symptoms of pneumonia in this study population could be the reason for a high number of negative chest radiographs.[14] Several studies have also indicated that chest CT has a higher chance of detecting pneumonia or opacities.[15-17] HRCT improves the sensitivity in detecting pneumonia when compared to plain chest radiographs. This was shown in a study by Syrjala et al., where HRCT was able to identify eight additional pneumonia in those who have had a negative chest radiograph.[15]

Despite all the above studies, BTS and NICE guidelines requires the presence of new radiographic shadowing compatible with pneumonia in order to make such diagnosis, although not limited to chest radiograph. The consensus guidelines on the management of community-acquired pneumonia in adults by Infectious Diseases Society of America and American Thoracic Society also focus on the clinical syndrome of pneumonia in diagnosing pneumonia and supported by imaging of the lung, usually by chest radiography. However, they do recognise the possibility of negative chest radiograph. When pneumonia is suspected, it may be reasonable to treat their condition presumptively with antibiotics and repeat the imaging after 24–48 hour.[18] Hence, it is reasonable to repeat a chest radiograph when initial chest radiograph is negative as we know that opacities may eventually develop over time.[12,19] However, it should be noted that there is currently no study done on the sensitivity of repeated chest radiograph within 24-48 hour from an initial negative chest radiograph. In addition, our study method was comparable with Kanwar et al. and Chandra et

al., in which both studies use chest radiograph as the mainstay of radiological investigation.

In our study, only 20 (12.6%) patients had isolated pathogens identified. Of these numbers, eight were coagulase-negative staphylococci, which are usually regarded as contaminants. Amongst the sputum sample that was not sent (101 in numbers), 34(33.6%) of them had an accurate diagnosis of pneumonia. A study at the Penang Hospital to determine the pattern of microbiological organisms causing CAP in adult patients, had causative organisms identified in 42.9% of their studied patients.[20] Aetiological diagnosis was achieved in 53 cases (41.7%) in a study at the University of Malaya Medical. *Klebsiella pneumoniae* was the most frequently isolated pathogen and caused 10.2% of all cases.[21] A low pathogen isolation rate could be explained by our low diagnostic accuracy and a significant portion of non-infective final diagnosis.

Our study also indicated that parameters such as white cells count, ESR, CRP, mean arterial pressure, temperature on presentation, urea level and eGFR on presentation, are poor predictors for accurate diagnosis of pneumonia.

It is not surprising that CRP remains a poor predictor of pneumonia in our studies as CRP may also be raised in other infections such as bacteraemia, fungemia, periodontal infection and abdominal sepsis.[23-29] Furthermore, CRP can also be raised in viral infections such as herpes simplex, adenovirus, and cytomegalovirus.[30-34] Nevertheless, CRP is also raised in inflammatory diseases and trauma, such as systemic lupus erythematosus (SLE), inflammatory bowel disease, and burns.[35-39] Perhaps, it is better to think of CRP as a marker of inflammation rather than a marker of infection. In relation to pneumonia, CRP could aid in differentiating bacterial versus viral but it is not definite; and shall not be used to diagnose pneumonia.

LIMITATIONS

There were some limitations to our study. Patients diagnosed with pneumonia and subsequently discharged from the ED were not included in the study. Inclusion of patients who were treated as outpatients may give a more accurate representation of data. Patients admitted to intensive ward were also not included. This study was done based on the initial chest radiograph and no follow-up chest radiograph was done.

CONCLUSION

Diagnosing pneumonia relies on a combination of clinical signs, symptoms, and radiographic findings. About two-thirds of patients diagnosed with pneumonia do not have compatible radiological finding. There is a need for better tools and system to aid with the diagnosis of pneumonia.

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