Original Article

Effects of Emergency Department Crowding and Time to Antibiotics in Pneumonia

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Objective: To evaluate the relationship between emergency department (ED) crowding and time to antibiotic treatment in pneumonia patients. The secondary objective was to look for other factors related to delayed antibiotic treatment.

Materials and Methods: The present study was a retrospective medical chart review between February 1 and June 30, 2015 of the patients aged 18 years and older with the ED diagnoses of pneumonia. The present study was performed in the ED of a tertiary care teaching hospital. One hundred seventy patients met the enrollment criteria. The patients were divided into ED crowded or non-crowded using the National Emergency Department Overcrowding Study tool for the main outcome of ED crowding and time to antibiotic treatment in pneumonia.

Results: In the 170 pneumonia patients, 117 patients (68.8%) came to the ED during a crowded shift. The characteristics of the patients were similar in both the crowded and non-crowded shifts. Of the 170 pneumonia patients, 51.8% had CURB-65 scores of 1 or 2. Patients who came to the ED during the crowded shift and non-crowded shift received antibiotics at the median times of 125 and 110 minutes, respectively (p=0.125). Delayed antibiotic treatments of more than four hours occurred in 19 patients (16.2%) during the crowded shift and in three patients (5.7%) in the non-crowded shift (p=0.098). Other factors related to time to antibiotics were the first doctor to see the patient (p=0.05), severity of disease (p<0.01), and admission type (p=0.01).

Conclusion: ED crowding was not related to time to antibiotic treatment in pneumonia patients. However, if the clinical conditions of the patients looked severe or the doctor who cared for the patients was an emergency medicine resident, the patients received early administration of antibiotics.

Keywords: Emergency department crowding, Pneumonia, Time to antibiotics

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Emergency department (ED) crowding can potentially impact the work of physicians, nurses, and technicians. Crowding can cause delays resulting in increased morbidity and mortality of the patients[1]. Since delayed management is an important indicator to show the effects of ED crowding, the present study was conducted to determine the effects of ED crowding on delayed antibiotic treatment in pneumonia patients in an ED[2,3]. The Joint Commission and the Centers for Medicare & Medicaid Services have proposed two time-sensitive indicators of ED quality that include antibiotic administration within four hours of arrival for admitted patients with community-acquired pneumonia and percutaneous intervention within two hours for patients with acute myocardial infarction[4]. Pneumonia accounts for 16.1 deaths per 100,000 population, making it the eighth leading cause of death, particularly among older adults, with an age-adjusted death rate of 22%. Emergency physicians play a prominent role in the initiation of treatment for pneumonia[5]. Previous studies showed that ED occupancy rates, patient hours, and the number of boarding inpatients were associated with increased time to antibiotics in sepsis and severe sepsis patients[6,7]. The limited amount of data available demonstrated that the factors associated with delayed antibiotic treatment in pneumonia patients in the ED included ED crowding and atypical clinical presentations[2,3,8]. The impact of ED crowding upon time to antibiotic administration in a specific group, such as pneumonia, has not been extensively studied in the ED setting in Thailand.

The present study aimed to evaluate the relationship between ED crowding and time to antibiotic treatment in pneumonia patients. Another objective was to identify other factors related to delayed antibiotic administration.

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Materials and Methods

The present study was a retrospective medical chart review of 170 patients between February 1 and June 30, 2015. The study was performed in the ED of Songklanagarind Hospital in southern Thailand, which is a teaching hospital and a tertiary care medical center with a capacity of 850 beds. In the study period, the authors' ED was staffed by one to two interns, three to four emergency medicine residents, one to two other specialty residents, one board certified emergency medicine physician as a consultant who attended each shift, and eight to ten round-the-clock registered nurses per shift. Enrolled patients were 18 years or older who had an ED diagnosis of pneumonia. The patients were divided into ED crowded or non-crowded by the National Emergency Department Overcrowding Study (NEDOCS) score for the main outcome of ED crowding and time to antibiotic treatment in pneumonia. The exclusion criteria included referral from other hospitals, did not receive antibiotics at the ED, or no definite time to antibiotics in the ED. The authors enrolled pneumonia patients from a review of the ED data registry. The data consisted of patient demographic data, time of arrival, time to receive antibiotics, and the NEDOCS score. Ethics approval was obtained from the Institutional Ethics Committee Board of the Faculty of Medicine at Prince of Songkla University, registration number REC 58-024-20-4.

Definitions

Pneumonia was defined as an infection of the pulmonary parenchyma by various pathogens either community-acquired or hospital-acquired[9]. Clinical diagnosis was based on a group of signs and symptoms related to a lower respiratory tract infection with the presence of fever, cough, expectoration, chest pain, dyspnea, and signs of invasion of the alveolar space[5].

The confusion, urea, respiratory rate, blood pressure, age over 65 years (CURB-65) score refers to an in-hospital mortality risk assessment of pneumonia patients that includes confusion, uremia or BUN of more than 20 mg/dL or 7 mmol/L, increased respiratory rate at RR of 30 or more breaths per minute, low blood pressure measure with diastolic blood pressure of 60 mmHg or less, or systolic blood pressure of 90 mmHg or less, and age of 65 years or older[10]. The NEDOCS refers to a crowding scale calculated using the following formula[11]: NEDOCS = –20 + 85.8 × (total patients/ED beds) + 600 × (admissions/hospital beds) + 13.4 × (ventilators) + 0.93 × (longest admission time [hours]) + 5.64 × (Waiting time for patient to have a bed in the ED). The interpretation of the score is: 0 to 50 normal, 51 to 100 busy, 101 to 140 overcrowded, 141 to 180 severe, and more than 180 disaster. The NEDOCS scores of the present study were measured from data in the ED registry and the Electronic Hospital Information System. In the present study, ED overcrowding was defined as a NEDOCS score greater than 100. The Emergency Severity Index (ESI) is a five-level triage protocol used in the ED to facilitate the prioritization of patients based on the urgency of treatment based upon the patient's conditions[12].

Statistical analysis

The statistical analysis was conducted using R software version 3.2.2. Continuous variables were analyzed and reported as mean, standard deviation, median, and interquartile range while discrete variables were reported as percentage. The chi-squared and Wilcoxon rank sum tests were used to compare between two groups of data. The Kruskal-Wallis H test was used to identify the factors related to delayed antibiotics. A p-value of less than 0.05 was considered statistically significant.

Results

General characteristics of the ED and patient demographic data

Three significant factors were related to either a crowded or non-crowded shift, 1) the total number of patients, 2) admitted patients, and 3) ventilators (Table 1).

Two hundred seventeen pneumonia patients were treated in the ED during the present study period. One hundred seventy patients met the enrolment criteria. The median age was 75.5 years and there were 109 (64%) men and 61 (36%) women. They were divided into non-crowded shift of 53 (31%) patients and crowded shift of 117 (69%) patients (Figure 1). Most of the patients 162 (95.3%) had underlying diseases. The three main underlying diseases were pulmonary diseases (40.6%), neoplastic diseases (28.8%), and diabetes mellitus type II (22.9%). There were no significant variables between the crowded shift and non-crowded shift (Table 2). When the pneumonia patients were categorized according to the NEDOCS scale, 117 (69%) of them came to the ED during the overcrowded shifts, which included the overcrowded, severe, and disaster ranges (Figure 2). The severity of the patients was also similar in both groups. Most patients had a triage level of 2 and had

Table 1. General characteristics of the emergency department

Factors	Non-crowded; median (IQR)	Crowded; median (IQR)	p-value
Total number of patients	28 (21, 42)	55 (49, 61)	<0.001
Admissions	4 (2, 5)	7 (6, 9)	<0.001
Ventilators	0 (0, 1)	1 (1, 2)	<0.001
Longest admission (hour)	7.5 (5.3, 8.5)	7.2 (6, 9.2)	0.355
Waiting time for last patient called (hour)	0.5 (0.2, 0.5)	0.5 (0.3, 0.7)	0.150

IQR=interquartile range

The ED shift work is 8 hours

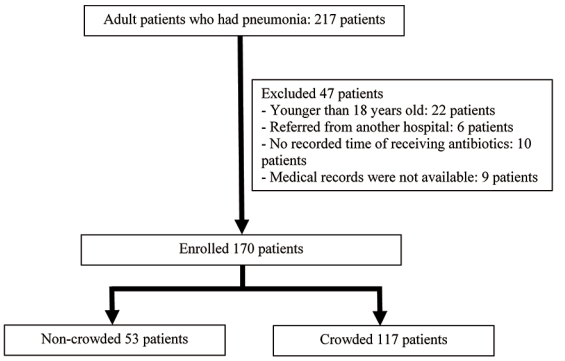

Figure 1. Study flow diagram.

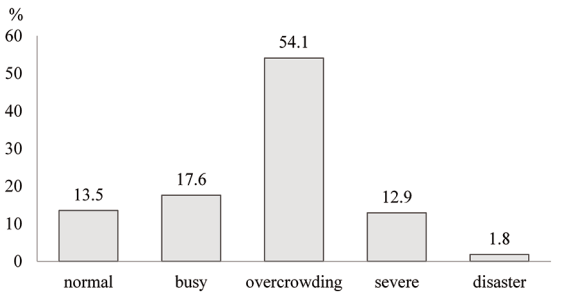

Figure 2. Percent distribution of pneumonia patients according to the ranges of ED crowding based on the NEDOCS scale[11].

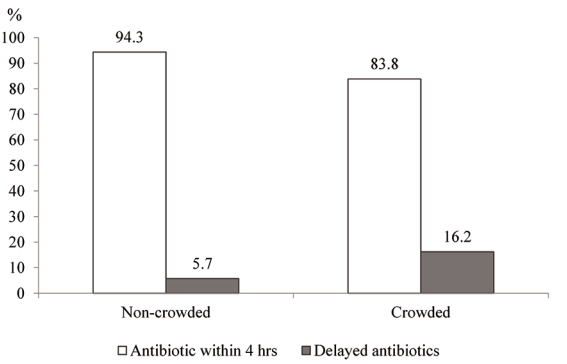

Figure 3. Relationship between ED crowding and time to antibiotics in pneumonia.

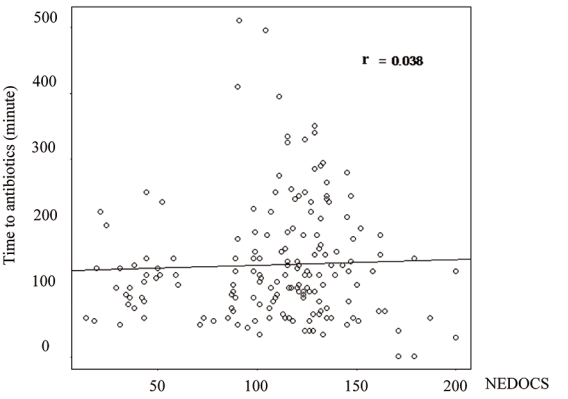

Figure 4. A scatter plot of the relationship between ED crowding and time to antibiotics in pneumonia.

a CURB-65 score of 1 or 2. Baseline characteristics of the pneumonia patients were similar in both the non-crowded and crowded shifts. The most common clinical presentations were tachypnea and fever (Table 2).

Primary and secondary outcomes

The primary outcome found that most pneumonia patients received antibiotics within four hours in both non-crowded (94.3%) and crowded shifts (83.8%). However, there was a minimal decrease during the crowded shift (Figure 3). A scatter plot was done to find the relationship of NEDOCS and time to antibiotics. The authors found that as ED crowding increased, the time to antibiotics also increased but there was no statistical significance (Figure 4). The secondary outcomes found that, if the first doctor who treated the patient was an emergency medicine resident, the CURB-65 score was more than 3, triage level was 1, the patient was admitted into intensive care unit (ICU), and the patient received antibiotics significantly faster (Table 3).

Table 2. Demographic and baseline characteristics of pneumonia patients

Characteristics	Non-crowded group (n=53); n (%)	Crowded group (n=117); n (%)	Total (n=170); n (%)	p-value
Age (year); median (IQR)	74 (65 to 82)	76 (68 to 81)	75.5 (66 to 81.8)	0.805
Sex				0.225
Male	38 (71.7)	71 (60.7)	109 (64.1)	
Female	15 (28.3)	46 (39.3)	61 (35.9)	
Comorbidity				
Absent	2 (3.8)	6 (5.1)	8 (4.7)	1.000
Present	51 (96.2)	111 (94.9)	162 (95.3)	1.000
Pulmonary disease	25 (47.2)	44 (37.6)	69 (40.6)	0.314
Diabetes mellitus	15 (28.3)	24 (20.5)	39 (22.9)	0.357
Liver disease	3 (5.7)	6 (5.1)	9 (5.3)	1.000
Renal disease	8 (15.1)	11 (9.4)	19 (11.2)	0.407
Congestive heart failure	4 (7.5)	8 (6.8)	12 (7.1)	1.000
Cerebrovascular disease	9 (17.0)	23 (19.7)	32 (18.8)	0.840
Neoplastic disease	13 (24.5)	36 (30.8)	49 (28.8)	0.516
Others	34 (64.2)	65 (55.6)	99 (58.2)	0.376
Disease/patient severity; mean±SD				
Triage level				0.421
ESI 1	2 (3.8)	12 (10.3)	14 (8.2)	
ESI 2	36 (67.9)	71 (60.7)	107 (62.9)	
ESI 3	14 (26.4)	28 (23.9)	42 (24.7)	
ESI 4	1 (1.9)	6 (5.1)	7 (4.1)	
ESI 5	0 (0.0)	0 (0.0)	0 (0.0)	
CURB-65 score				0.379
0	2 (3.8)	11 (9.4)	13 (7.6)	
1 to 2	27 (50.9)	61 (52.1)	88 (51.8)	
≥3	24 (45.3)	45 (38.5)	69 (40.6)	
Laboratory test				
BUN ≥20	25 (47.2)	56 (47.9)	81 (47.6)	1.000
Arterial pH ≤7.35	9 (17.0)	13 (11.1)	22 (12.9)	0.149
PaO_2 ≤60 mmHg	11 (20.8)	19 (16.2)	30 (17.6)	0.184
Patient status at presentation				
Altered mental status	13 (24.5)	30 (25.6)	43 (25.3)	1.000
RR >30/minute	32 (60.4)	66 (56.4)	98 (57.6)	0.751
SBP <90 mmHg	0 (0.0)	6 (5.1)	6 (3.5)	0.178
BT <36.0°C or >38.0°C	24 (45.3)	52 (44.4)	76 (44.7)	1.000
PR >120/minute	22 (41.5)	39 (33.3)	61 (35.9)	0.392

IQR=interquartile range; ESI=emergency severity index; BUN=blood urea nitrogen; RR=respiratory rate; SBP=systolic blood pressure; BT=body temperature; PR=pulse rate

Discussion

The primary finding of the present study was that ED crowding was not related to time to antibiotic administration in pneumonia patients. Pneumonia patients presented with severe clinical manifestations, including low oxygen saturation, altered mental status, and increased pulse rate, were associated with the likelihood of receiving early antibiotics[13]. These findings corresponded with the present study results. Patients who had a CURB-65 score greater than 3, a triage level of 1, and admitted into the ICU indicating severe disease, received antibiotics

Table 3. Factors related to time to antibiotics

Factors	Time to antibiotics; median (IQR)	p-value
Shift		0.897
Morning	125 (70, 187.5)	
Evening	125 (78.8, 172.5)	
Night	120 (90, 137.5)	
ED crowding		0.125
Non-crowded	110 (75, 150)	
Crowded	125 (85, 190)	
Present of comorbidities		0.125
Yes	125 (76.2, 168.8)	
No	187.5 (107.5, 242.5)	
First doctor		0.005
Emergency medicine resident	110 (70, 155)	
Others	135 (95, 240)	
CURB-65 score		<0.001
0	220 (185, 245)	
1 to 2	125 (88.8, 202.5)	
≥3	105 (65, 140)	
Triage level		<0.001
ESI 1	75 (42.5, 123.8)	
ESI 2	110 (75, 160)	
ESI 3	135 (110, 215)	
ESI 4	240 (192.5, 245)	
ED Disposition		0.001
General ward	125 (83.8, 180)	
ICU	75 (55, 117.5)	
Discharge	235 (130, 280)	

IQR=interquartile range; ED=emergency department; CURB-65=confusion, urea, respiratory rate, blood pressure, age over 65 years; ESI=emergency severity score; ICU=intensive care unit

significantly faster.

One large study of 17,403 pneumonia patients regarding time to first antibiotics and in-hospital mortality reported that patients who required admission to a critical care unit had 15% mortality rate and the rate was significantly lower in patients who received early administration of the first dose of antibiotics within four hours[14].

Triage is an important categorizing tool to determine which patients should be immediately resuscitated to prevent death and disability[12]. Patients who were categorized into triage level 1 are the sickest patients. Most critically ill patients need aggressive resuscitation, especially in airway management and breathing, and circulatory support[12]. If the first doctor who treated the patient was an emergency medicine resident, the patient received early administration of antibiotics. As a part of an emergency medicine training program, emphasize on the identification of life-threatening conditions and providing emergent treatment with limited information leads to a rapid response to infection and early administration of antibiotics.

The two most well-known clinical risk prediction tools of pneumonia are the pneumonia severity index and CURB-65 score. The CURB-65 score had very good accuracy to predict 30-day mortality among patients discharged from the ED[15]. This severity tool seems to be the preferred method to predict mortality and the need for ICU admission in patients with pneumonia, and it is much easier to implement[16].

The overall definition of ED crowding is the functional state of high service demand coupled with a limited supply of space and personnel[2]. The measurement of ED crowding is based on this information, an increased overall ED length of stay and length of stay for admitted patients, radiograph turnaround times, departed the ED without being seen, and ambulance diversion status[2,3,17-19]. Previously published studies have shown that ED crowding tends to have a negative impact on patient mortality and outcome among various emergency conditions[20-23]. Fee et al and Pines et al demonstrated an association of increased ED volume or crowding with delayed and non-receipt of antibiotics within four hours in pneumonia patients[2,3]. The number of pneumonia patients who received antibiotics within four hours in the present study was more than in a previous study by Fee et al[2]. When looking at the numbers of patients in all studies, the numbers of patients who had delayed antibiotics during the crowded shift were more than in the non-crowded shift[2,3]. However, in the present study the median number of patients who had delayed administration of antibiotics during the crowded shift was slightly greater compared to the non-crowded shift. One article mentioned that the time to antibiotics in pneumonia patients took more time than in the current study[2]. The factors related to delayed antibiotics mentioned in the article by Fee et al were similar to the present study. Both admission type and triage level were related to delayed antibiotics in pneumonia patients[2].

The NEDOCS score is complex and sometimes it does not generalize well among different emergency settings[24-26]. The usability of the NEDOCS score to detect ED overcrowding has been studied by many researchers. Boyle et al published a comparison between NEDOCS and the International Crowding

Measure in Emergency Department (ICMED). They concluded that both scoring systems may have potential use to assess crowding variations in long-time-scale data acquisition, but they are less sensitive in hour-to-hour variations. Both measuring scales appeared to be strongly correlated with senior emergency clinician perceptions concerning ED danger and crowding[27]. This conclusion is in contrast to a study by Ilhan et al[28], which found the biggest limitation of the NEDOCS score is an empty waiting room. They also found a significant difference between the NEDOCS score and the perception of crowdedness by the ED staff ($p<0.05$). The NEDOCS score was higher than the perception of crowdedness by the ED staff, and the correlations were weak[28]. Other published literature demonstrated that the NEDOCS score overestimated the extent of crowding and it may not produce reliable results in extremely high-volume ED settings where the number of visits is greater than 110,000 visits annually[29]. However, the authors chose the NEDOCS score as a tool because the average annual volume of the present study ED was quite similar to the academic settings that participated in the development of the NEDOCS score[11].

There were several limitations of the present study. The study was retrospective in nature and was conducted in a single ED, therefore, some data may be missing. Second, the small number of patients for the non-crowded shift was usually during the night shift, which had fewer doctors than during the other shifts. The other limitation is the severity of disease and the doctor's experience, which were confounders in patient management.

Conclusion

ED crowding was not related to time to antibiotic treatment in pneumonia patients. Other factors related to time to antibiotics were the first doctor to see the patient, severity of disease by CURB-65, triage level, and admission type. However, if the clinical conditions of the patients looked severe or the doctor who cared for the patients was an emergency medicine resident, the patients received early administration of antibiotics.

What is already known on this topic?

Previous studies showed that the impact of ED crowding can cause delayed antibiotics administration in pneumonia patients who present to the ED.

What this study adds?

The study explored other related factors to time to antibiotics in pneumonia patients treated in an ED, which were the first doctor who cared for the patient, patient severity, and disposition type.

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Authors' contributions

Pethyabarn W, MD, performed the literature search, study design, data collection, data analysis, and data interpretation. Dadeh A, MD did the study design, critical revision, and manuscript writing.

Data availability

The retrospective data used to support the findings of the present study are available from the corresponding author upon request.

Conflicts of interest

The authors declare no conflict of interest.

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