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Original Contribution

ED crowding is associated with inpatient mortality among critically ill patients admitted via the ED: post hoc analysis from a retrospective study☆,☆☆,★

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ABSTRACT

Background: Adverse effects of emergency department (ED) crowding among critically ill patients are not well known.
Objectives: We evaluated the association between ED crowding and inpatient mortality among critically ill patients admitted via the ED, and analyzed subsets of patients according to admission diagnosis.
Methods: We performed a post hoc analysis using data from a previous retrospective study. We enrolled admitted patients via the ED with an initial systolic blood pressure of 90 mm Hg or lower when presenting to the ED. The ED occupancy ratio was used as a measure of crowding. The primary outcome was inpatient mortality. Multivariable logistic regression models adjusted for potential confounding variables were constructed for the entire cohort and for subsets according to admission diagnosis (infection, cardiac and vascular disease, trauma, gastrointestinal bleeding, and other factors).
Results: A total of 1801 patients were enrolled, with a mortality rate of 14.6% (262 patients).
The mortality rate by ED occupancy ratio quartile was 9.7% for the first quartile, 15.9% for the second quartile, 18.2% for the third quartile, and 14.4% for the fourth quartile. This resulted in adjusted odds ratios of 1.95, 2.51, and 1.93 and corresponding 95% confidence intervals of 1.23-3.12, 1.58-3.99, and 1.21-3.09 for the second, third, and fourth quartiles, respectively, compared with the first quartile. The effect of ED crowding was highest in the trauma subset, followed by the infection subset, whereas ED crowding did not appear to have any effect on the cardiac and vascular disease subsets.
Conclusion: Emergency department crowding was associated with increased inpatient mortality among critically ill patients admitted via the ED.

1. Introduction

1.1. Background

Emergency department (ED) crowding has been a problem in health care systems worldwide, and concerns about ED crowding are increasing [1,2]. Previous studies have shown an association between ED crowding and an unfavorable outcome in general ED patients [3,4] and admitted patients [5,6].

However, to the best of our knowledge, no previous research has directly evaluated the association between ED crowding and critically ill patients. Thus far, there have been some studies that have shown an association between delayed admission to the intensive care unit (ICU) and poor outcome for critically ill patients [7–9]. However, these are out of the scope of ED crowding. Because delayed admission, which is nearly same as prolonged boarding time, is attributed to hospital crowding, it remains uncertain whether delayed admission accompanies ED crowding. For example, if there is no available bed in an ICU and ward (full hospital occupancy), then the critically ill patient has to be boarded in the ED where there are sometimes few patients in the ED (low ED occupancy). In other words, prolonged ED stay is limited in its use as an ED crowding measurement.

Recently, the authors reported the harmful effect of ED crowding on early mortality among general ED patients [10]. Using this data set, we evaluated the effect of ED crowding on critically ill patients admitted via the ED. Associations between ED crowding and procedural times were also investigated.

If there is an association between ED crowding and outcome of critically ill patients, then medical teams are more likely to review their ED

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process and hospital administrators may modify the hospital policy. Furthermore, determining how ED crowding affects patients with specific diagnoses could help staff managers to focus their limited resources on specific conditions.

For critically ill patients, the timely completion of procedures, such as advanced airway management, vasopressor or inotropic use, central line catheterization, and blood transfusions, are very important. Thus, investigations of the association between ED crowding and these procedures in critically ill patients may reveal the mechanism of ED crowding.

1.2. Objectives

The purpose of the present study was to explore the potential effect of ED crowding on critically ill patients admitted via the ED. In addition, we explored the effect of ED crowding on mortality in subsets of patients categorized according to the specific disease condition including infection, cardiac and vascular disease, trauma, gastrointestinal bleeding, and others factors. Finally, we investigated the association between ED crowding and the procedure time for intubation, vasopressor or inotropic use, central line catheterization, and blood transfusions.

2. Materials and methods

2.1. Study design and participants

This study is a post hoc analysis using data from a previous retrospective cohort study of general ED patients seen between January 1, 2009, and December 31, 2010. Of the approximately 70 000 patients seen in that time frame, 54 410 were 15 years or older. From this data set, we selected patients who were admitted to the study hospital via the ED and had systolic blood pressure (SBP) at or less than 90 mm Hg (n = 1846); these patients were designated as critically ill patients. Among the patients, we excluded patients who were cardiac arrest patients upon arrival to the ED (n = 45); thus, 1801 patients were included in the analysis.

This study was approved by the institutional review board of the study hospital, and a waiver for informed consent was obtained. The study hospital is a 1000-bed urban academic tertiary care hospital equipped with 42 licensed ED beds during the study period. The study hospital's annual consensus was 35 000. There were 3 shifts in the study hospital, from 7 AM to 3 PM (day), 3 PM to 11 PM (evening), and 11 PM to 7 AM (night). The same number of emergency doctors (1 board-certificated emergency medicine physician and 3 emergency medicine residents) and emergency medical technicians (n = 2) worked in each shift. There were 9 nurses during the day, 10 during the evening, and 8 during the night shifts.

2.2. Data collection and processing

Baseline variables were extracted from previously constructed data including age; sex; use of emergency medical service (EMS); transferred cases; weekend and holiday visits; shifts; triage acuity; vital sings upon ED arrival, such as the mean blood pressure, pulse rate, respiratory rate, body temperature, and mental status using the AVPU scale (alert, verbal, painful, unresponsive scale); ICU admission; surgical intervention; ED occupancy ratio (EDOR); ED length of stay (ED LOS); hospital LOS; date and time of ED arrival; and survival status upon discharge.

In addition, we obtained data on comorbidities (malignancy, liver cirrhosis, and chronic kidney disease), admission diagnostic classification (infection, cardiac and vascular disease, trauma, gastrointestinal bleeding, and others), and date and time of the initiation of various procedures (intubation, vasopressor or inotropic use, successful central line, and any blood transfusion) performed during the ED stay via medical record reviews by trained abstractors following the guidelines recommended by Gilbert et al [11]. The procedural time was calculated from the date, hour, and minute of ED arrival for each procedure.

We used EDOR as a measure of ED crowding. The EDOR is a ratio of the total number of ED patients to the number of licensed ED beds. In a previous study, a computer program was used to calculate the EDOR for every patient based on the patient's ED arrival and discharge time.

2.3. Outcome measures

The primary study outcome was inpatient mortality. Mortality categorized according to admission diagnosis (infection, cardiac and vascular disease, trauma, gastrointestinal bleeding, and others) was set as secondary outcomes.

2.4. Primary data analysis

All continuous data were presented as the mean and SD. In addition, we used interquartile ranges to show more accurate data distributions. All discrete data were presented as both counts and percentages. Logistic regression analyses results were presented as odds ratios (ORs) with a 95% confidence interval (CI). Statistical significance was defined as a 2-sided $P < .05$.

The Kruskal-Wallis test was used to compare nonparametric variables for each EDOR quartile, and 1-way analysis of variance (ANOVA) with a Scheffe, Bonferroni, Sidak posttest was used for parametric variables.

Logistic regression analyses were performed to control for potentially confounding factors. Logistic regression analyses, which are generally applied to predict whether the patient experiences an outcome based on observed characteristics and provide unbiased results adjusted for other covariates, were used to present ORs with a 95% CI. The EDOR variable was used as the quartile. The variables included age, sex, EMS transport, transferred case, day of the week (weekend or holiday vs nonweekend), shift (day, evening, or night), triage acuity (immediate, emergent, urgent, semiurgent, and nonurgent), visit cause (injury or noninjury), comorbidities (malignancy, liver cirrhosis, or chronic kidney disease), surgical intervention, mean arterial pressure, pulse rate, respiratory rate, body temperature, mental status (AVPU scale), whether to admit (ED discharge, ward admission, or ICU admission) and ED LOS (by quartile).

We calculated the mean time from ED arrival to the initiation of various procedures and estimated whether the mean time differed according to ED crowding. The EDOR was analyzed by quartile as categorical variables.

All analyses were performed using STATA 11.1 (StataCorp LP, College Station, Texas) and SAS 9.1 (SAS Institute Inc, Cary, North Carolina).

3. Results

3.1. Study subjects characteristics

We enrolled 1846 admitted patients via the ED who presented with SBP at or less than 90 mm Hg from a prior data set. A total of 1801 patients were included in the analysis after excluding 45 cardiac arrest patients upon arrival to the ED. There were minimal missing data on covariates (7 missing EMS use, 2 missing transferred cases, 6 missing triage level).

Table 1 presents baseline characteristics for the entire cohort and each quartile. Most of the demographic variables were not significantly different among quartiles, except visits during the weekends and holidays. Physiological variables, admission diagnosis, and the disposition of patients also showed no significant differences. Scheffe, Bonferroni, and Sidak post hoc analyses also revealed no between-group differences. At the time of admission, 552 patients (30.6%) were diagnosed as having infectious diseases, 214 (11.9%) patients as having cardiac and vascular disease, 306 (17.0%) patients as having traumatic injuries, and 235 (13.0%) patients as having gastrointestinal bleeding. The mean (SD) EDOR was 1.26 (0.27; interquartile range, 1.07-1.40). Importantly, the ED LOS and total hospital LOS were not different among quartiles.

There were 262 (14.6%) deaths. The mortality by EDOR quartiles for all patients and for subsets categorized by admission diagnosis are