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Original Contributions

Impact of delayed admission to intensive care units on patients with acute respiratory failure☆,☆☆,★,★★,☆☆☆

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ABSTRACT

Background/Purpose: To determine the impact of delayed admission to the intensive care unit (ICU) on the clinical outcomes of patients with acute respiratory failure (ARF) in the emergency department (ED).
Methods: This retrospective cohort study included non-traumatic adult patients with ARF and mechanical ventilation support in the ED of a tertiary university hospital in Taiwan from January 1, 2013, to August 31, 2013. Clinical data were extracted from chart records. The primary and secondary outcome measures were a prolonged hospital stay (>30 days) and the in-hospital crude mortality within 90 days, respectively.
Results: For 267 eligible patients (age range 21.0-98.0 years, mean 70.5 ± 15.1 years; male 184, 68.9%), multivariate analysis was used to determine the significant adverse effects of an ED stay >1.0 hour on in-hospital crude mortality (odds ratio 2.19, $P < .05$), which was thus defined as delayed ICU admission. In-hospital mortality significantly differed between patients with delayed ICU admission and those without delayed admission, as revealed by the Kaplan-Meier survival curves ($P < .05$). Moreover, a linear-by-linear correlation was observed between the length of ICU waiting time in the ED and the lengths of total hospital stay ($r = 0.152$, $P < .05$), ICU stay ($r = 0.148$, $P < .05$), and ventilator support ($r = 0.222$, $P < .05$).
Conclusions: For patients with ARF who required mechanical ventilation support and intensive care, a delayed ICU admission more than 1.0 hour is a strong determinant of mortality and is associated with a longer ICU stay and a longer need for ventilation.

1. Introduction

Despite considerable advancements in respiratory support techniques that have improved the survival of patients with acute respiratory failure (ARF) over the years [1-3], ARF in critical patients is still associated with mortality rates of 40%–65% [1,4,5]. ARF that necessitates mechanical ventilator support was reported to be crucial in the development of intensive care medicine as a specialty [6]. ARF remains a common reason for admission to the intensive care unit (ICU) [7].

When managing a patient who needs ICU admission in the emergency department (ED), but there are no available ICU beds, the clinical physician often faces a dilemma of whether to transfer the patient. Transferring the patient for admission to another hospital means risking possible complications during transportation, while keeping the patient in the same ED means risking potential deterioration during the uncertain length of waiting for an ICU bed. This issue is especially important in an era in which ED overcrowding is becoming a common scene [8]. ED overcrowding interferes with the delivery of effective and timely care [9] and is associated with an increased length of ED stay and waiting time for admission [10]. The phenomena of ED overcrowding could spread from one hospital to other hospitals in a region, which increases the difficulty of transferring critical patients [11,12].

Although adverse effects of prolonged ICU waiting time were reported [13-17], the association between delayed ICU admission and the outcomes of patients with ARF was rarely validated. Regarding

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whether to transfer a critical patient, the definition of an optimal waiting time for an ICU bed to avoid adverse effects is crucial for physicians. Thus, we conducted this study to define the optimal time for ICU admission and to determine the adverse effects of delayed ICU admission in ED patients with ARF who require mechanical ventilation support.

2. Methods

2.1. Study design, setting and population

This retrospective, observational cohort study was conducted in the ED of a tertiary university hospital in Taiwan with a capacity of 1045 general ward beds and 148 ICU beds. The institutional review board of the study hospital approved this study.

The ICU in the study hospital was a closed system managed by fixed physician staff. The ED adopted a 5-level triage system (i.e., resuscitation, emergency, urgent, less urgent, and not urgent). The ED patients who experienced ARF and required ventilator support were to be admitted to the ICU as soon as possible if beds were available. Patients on mechanical ventilation remained in the ED only when ICU beds were unavailable. Subsequently, an ICU bed was booked after connecting the patient to a ventilator.

2.2. Data collection and processing

All of the ED visits between January 1, 2013 and August 31, 2013 were screened according to the *International Classification of Diseases, 9th Revision, Clinical Modification* codes (ARF, 518.81) using a computer database. The data for eligible ED patients were retrieved from medical records by using a predetermined form that included their medical information, namely demographic data, vital signs in the ED, consciousness levels, use of mechanical ventilation, use of inotropic agents, comorbidities, laboratory findings, hospitalization period, the cause of ARF, and patient outcomes. Patients who met the following criteria were excluded: a lack of information on hospitalization or transfer before the ED visit, an unsuccessful return of spontaneous circulation for out-of-hospital and in-hospital cardiac arrest, and a lack of complete information after ED arrival (eg, patients transferred out or left against medical advice). Furthermore, to provide a clear definition of delayed ICU admission, patients who died while waiting during the ED stay were also excluded. Medical records of the eligible patients were reviewed for the aforementioned clinical information by two of the authors, who collectively resolved any discrepancy observed in the medical records.

All of the patients were followed for at least 90 days after ED arrival. The primary outcome was a prolonged length of hospital stay (>30 days), and the secondary outcome was in-hospital crude mortality within 90 days.

2.3. Definitions

After the ICU bed booking, the ICU waiting time was measured as the number of hours from ventilator connection in the ED until ICU admission. The length of hospital stay was the period from ED presentation to discharge from the hospital; the length of ICU stay was the period between ICU admission and hospital discharge or transfer to the general ward. ARF was defined on the basis of a PaO2/fraction of inspired oxygen (Fio_2) ratio< 200 mmHg and the requirement of mechanical respiratory support, including all methods of artificial ventilation with or without an artificial airway [6,7]. As previously reported [18], the severity of acute illness was measured using the modified rapid emergency medicine score at ED arrival, and a score ≥ 8.0 indicated critical illness. Comorbidities were defined as previously reported [19]. Severe sepsis was defined as the coexistence of sepsis and at least one of the following signs or symptoms of acute organ dysfunction or hypoperfusion: metabolic acidosis, arterial hypoxemia (Pao_2< 75 mmHg or Pao2/Fio_2<250), oliguria (<0.03 L/h for 3 h or 0.7 L/24 h), coagulopathy (increase in prothrombin time or a drop in platelet count by 50% or to $<100 \times 10^7$/L), and encephalopathy (defined as a Glasgow Coma Scale score <14) [20]. Septic shock was defined as the presence of systemic inflammatory response syndrome and a systolic blood pressure ≤ 90 mmHg after a crystalloid fluid challenge of 20 to 30 mL/kg of body weight over a 30-minute period or a blood lactate concentration ≥4 mmol/L [21].

2.4. Statistical analysis

Statistical analyses were performed using the Statistical Package for the Social Sciences for Windows, Version 15.0 (SPSS, Chicago, IL). Continuous variables were expressed as the means ± SDs and compared using the Student *t* test. Categorical variables, expressed as numbers and percentages, were compared using the chi-square or Fisher exact test. The Pearson correlation coefficient was used to measure the strength of the linear-by-linear relationship between 2 continuous variables.

The primary and secondary outcomes were first analyzed using a univariate regression model, and all of the variables with a $P < .1$ in the univariate analysis were then incorporated into a stepwise, backward logistic regression model. The time demarcating either a delayed or not delayed admission was proposed to be the time when the effect of ICU waiting on in-hospital mortality began to emerge. To determine this time demarcation, the overall data were divided into subsets on the basis of different lengths of ICU waiting time. To compare the adverse effects of delayed ICU admission on survival rate, Kaplan–Meier plots along with a log-rank test were used. $P < .05$ was considered statistically significant.

2.5. Ethics

The study was in accordance with the ethical standards and was approved by the institutional review board in the hospital.

3. Results

3.1. Demographics and clinical characteristics

The total ED visits during the study period was 57 272 (age range 0.5-113.0 years, mean ± SD 46.0 ± 26.3 years; male 29 272, 51.1%) and the percentages of triage acuities were 2.2% resuscitation, 8.8% emergency, 52.1% urgent, 36.2% less urgent, and 0.8% not urgent.

A total of 267 patients (age range 21.0-98.0 years, mean 70.5 ± 15.1 years; male 184, 68.9%) were enrolled in the study, as shown in Fig. 1. The overall mean (±SD) of the modified rapid emergency medicine score was 8.0 (±3.2). The median (interquartile range) lengths of ICU waiting time and ED stay were 5.0 (1.0-17) hours and 5.1 (1.5-17.0) hours, respectively. The leading diagnostic category of ARF was pneumonia (140 patients, 52.4%); other major categories included acute stroke (29, 10.9%), acute coronary syndrome (17, 6.4%), massive gastrointestinal bleeding (16, 6.0%), arrhythmia (10, 3.7%), and intra-abdominal infection (9, 3.4%). The most common comorbidity was hypertension (145 patients, 54.3%), followed by diabetes mellitus (97, 36.3%), malignancy (76, 28.5%), chronic kidney disease (72, 27%), old stroke (48, 18.0%), chronic obstructive pulmonary disease (42, 15.7%), coronary artery disease (45, 16.9%), and liver cirrhosis (24, 9%). The median (interquartile range) lengths of total hospital stay and ICU stay were 15.0 (9.0-27.0) and 8.0 (8.0-16.0) days, respectively. The 30-day and in-hospital crude mortality rates were 21.0% (n = 56) and 26.6% (n = 71), respectively.

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