Factors related to delayed intensive care unit admission from emergency department - a retrospective cohort study

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Abstract

Background

The delays in transferring patients from emergency department (ED) to intensive care unit (ICU) are known to be linked with several adverse events, including prolonged ICU stay and hospital mortality. The factors associated with delayed ICU admission include shortage of ICU beds, organizational factors, ED overcrowding, and patient-related factors, including sepsis as admission diagnosis. The aim of this study was to examine ED-related factors associated with prolonged ED stay.

Methods

The study population consisted of adult patients admitted (n=479) from ED to ICU between May 31, 2016, and March 19, 2017, in Oulu University Hospital. A patient's ED length of stay (LOS) exceeding 180 minutes was considered delayed.

Results

Most of the patients (380, 79.3%) were admitted to the ICU within three hours of hospital admission. In a logistic regression analysis, odds ratios (ORs) for ED LOS >180 minutes were as follows: for Glasgow Coma Scale score > 9, 2.73 (1.39-5.32); for thrombocytes <100 x 10^9/mmol, 6.69 (2.32-19.26); for absence of pre-arrival notification, 5.27 (3.04-9.14); and for radiological examination, 3.95 (1.72-9.10). There was a higher frequency of admissions due to trauma and intoxication in patients with ED LOS <180 minutes, while the frequency of admissions due to medical conditions such as infections was higher in those with ED LOS > 180 minutes.

Conclusion

The delays in ICU admissions were linked to therapeutic and diagnostic procedures and absence of pre-arrival notification. Patients were admitted to the ICU on the basis of diagnosis instead of

clinical risk. However, the delays were not associated with worsening outcome, which indicates that *sufficient* care can be provided at the ED while the ICU admission is pending.

Introduction

The delays in transferring patients from the emergency department (ED) to the intensive care unit (ICU) are known to be linked with several adverse events, including increase in hospital mortality (1,2,3,4,5) and ICU length of stay (LOS) (2,3,6) as well as increased requirement of mechanical ventilation during ICU stay (6,7). The factors associated with delayed ICU admission include shortage of ICU beds (7,8,9), organisational factors (10,11), ED overcrowding (2,12) and patient-related factors including sepsis as admission diagnosis (2).

Different studies have determined delayed ED LOS with critically ill patients to be between 1 and 24 hours (1,2,3,6,7). A three-hour cut-off value for delayed ICU admission has been used in an earlier study investigating the effect of delayed ICU admission on outcome (7). The effect of delayed admission on patient outcome has been controversial with either no association in critically ill patients (7,13,14) or with worse patient outcome (15).

Previous studies have not, however, been focusing on the impact of diagnostic procedures or the severity of illness on the delayed admissions. The current study was performed to find factors for improvement of patient flow from the ED to the ICU. To this end, we investigated the impact of clinical parameters, diagnostic and therapeutic procedures, as well as the pre-arrival notification on the time spent in ED before ICU admission in a single academic tertiary-level referral hospital.

Methods

This retrospective observational study was conducted at Oulu University Hospital, which is located in northern Finland and provides university hospital level medical and trauma care for a population of 741 950 inhabitants and 51% of the land area in Finland. Emergency medical services (EMS) have instructions to perform pre-notification to ED if a critical injury or illness is suspected on the field. In the area, there is one physician-staffed helicopter emergency services unit. The ICU is a 26-bed, intensivist-led, closed, mixed medical surgical unit treating adult patients with critical illness. Annual admission rate is 2300 admissions with 6500 treatment days.

The study protocol was accepted by hospital administration (251/2016). Due to retrospective study design, the requirement for a statement from the local ethics committee was waived in accordance with local policy.

Study population

The study population consisted of all the adult patients admitted directly from the ED to the ICU between May 31, 2016, and March 19, 2017, recorded into the electronic data management system (Centricity Critical Care, GE Healthcare). May 31, 2016, was the first day of the ED's new electronic patient record in use and has for that reason been selected as the first day of the study span. We targeted the study sample size to 500 patients, and the 500th patient was the last screened patient for the study. As this study had a retrospective design, no formal sample size analysis was made. Patients requiring immediate operative care were excluded. During the study period, a total of 3416 patients were admitted to the ICU; the median number of admissions per day was 6 (4-8). The median bed occupancy rate of each day was 74.8% (67.0-80.5), and the

median number of available ICU beds was 26 (23-26). In a total of 4 (1.4%) of the 291 included days during the study period, the occupancy rate was above 90%.

Data extraction

The data extraction was performed manually using electronic medical records, laboratory results and the radiological examinations. The ICU's patient data management system was used to extract data accumulated during the ICU stay. National Early Warning Score (NEWS) on ED admission, Sequential Organ Failure Assessment (SOFA) score and Acute Physiology and Chronic Health Evaluation (APACHE) II score on ICU admission were obtained to assess the severity of illness during the ED stay and the first hour of ICU stay (16-18). NEWS score over 7 indicating a high-risk patient was based on classification by Royal College of Physicians (18). The clinical parameters obtained included Glasgow Coma Scale (GCS) score, urine output, blood pressure, oxygen saturation, respiratory rate, pulse rate, body temperature, use of oxygen or form of mechanical ventilation, and use of vasoactive medication. Chronic illnesses and medications were recorded. The worst physiological parameter scores during *ED* stay were used for the analysis. Diagnostic procedures and treatments recorded included chest x-ray, blood cultures, antibiotic treatment, CT scans, laboratory test results and vital parameters.

Causes of ICU admissions were categorized into the following eight categories: neurological, cardiovascular, infection including pneumonia and sepsis, respiratory, gastrointestinal, intoxication, trauma, and other causes.

Patients' ICU and hospital LOS as well as 90-day mortality were recorded.

Definition of delayed admission to ICU

A patient's ED LOS was determined delayed if the transfer time from the ED to the ICU was more than 180 minutes. This definition was based on a previous study by O'Callaghan and sepsis and trauma guidelines (7, 19-21)

Statistics

The statistical analyses were performed using SPSS for windows (IBM Corp. Released 2018. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp.). Proportional data are presented as numbers and percentages (%) and continuous variables as medians with 25th and 75th percentiles. Pearson chi-square was used to compare proportional data, and continuous variables were tested using non-parametric Kruskal-Wallis test. A multivariable logistic regression model was built to assess risk factors for prolonged stay (≥180 minutes) in the ED. Variables with a *P* value <0.20 were entered into the logistic regression model. A variable was left in the model if it had $P < 0.05$ or if it had a significant effect on log likelihood function. Odds ratios (ORs) with 95% confidence intervals (CIs) are presented as results generated by the logistic regression model. Since this study was designed to be an observational audit study, no formal power analysis was performed.

Results

Patient characteristics

During the study period, there were a total of 26 479 admissions to the ED, of which 500 (1,9%) involved a subsequent admission to the ICU. After excluding patients who did not have enough information in patient records for statistical analysis, the final number of patients was 479 (1,8%). Most of the patients (380, 79.3%) were admitted to the ICU within three hours of hospital admission; 55 patients (11.5%) waited over four hours and 26 (5.4%) over six hours (Table 9). The median ED LOS was 92 (60-162) minutes. Those admitted within three hours were younger and had fewer chronic diseases (Table 1). When classified by NEWS aggregate score 7 or more, high-score patients were represented equally in both groups (36.3% vs 42.4%, *P*=0.264).

The NEWS, SOFA and APACHE II scores did not differ between patients admitted to the ICU within three hours and those with delayed admission (Table 3). Patients with ED LOS above 180 minutes had lower blood pressures, lower levels of oxygen saturation, higher C-reactive protein (CRP) and creatinine levels, and a higher rate of diagnostic procedures (Table 4).

Diagnostic and therapeutic procedures

In delayed group it was more common that chest x-ray was taken (47.5% vs 25.5%, *P*<0.001) at the ED. It was also more common that blood cultures were drawn (43.4% vs 23.2%, *P*<0.001) and antibiotic treatment was started (36.4% vs 10.4%, *P*<0.001).

Organizational factors

Pre-arrival notification, pre-hospital intubation and HEMS transportation were more frequent in those with ED LOS less than 180 minutes (Table 2).

Causes of admissions

There was a higher frequency of admissions due to trauma and intoxication in patients with ED LOS time less than 180 minutes while the frequency of admissions due to medical conditions such as infections was higher in those with ED LOS above 180 minutes (Table 6).

Multivariable analysis

In a logistic regression analysis, OR for ED LOS more than 180 minutes was significantly increased for GCS score above 9, thrombocytes less than 100 x 10^9/mmol, absence of pre-arrival notification, and performed radiological examination (Table 7).

Outcome

There was no statistically significant difference in ICU LOS or mortality between delayed and non-delayed groups *(0.01 [95% CI, -0.07 to 0.05]) or hospital mortality (-0.01 [95% CI, -0.1 to 0.05]). ICU mortality was 7.5% (95% CI, 0.055-0.102) and hospital mortality 12.1% (95% CI, 0.095-0.153).* Delays did not affect mortality even in patients with high NEWS score or high risk of in-hospital death. There were no statistically significant differences in hospital LOS between groups (Table 8). The 90-day mortality in patients with longer than 4-hour delay was 18.2% and in those with 6-hour delay 19.2% *(Table 9).* The 180-day mortality was *18.4% (95% CI, 0.152-0.221), and it was the same between the two* groups (0.002 [95% CI, -0.09 to 0.08]).

Discussion

There are three main findings in the present study: (1) delays in patient transfer from the ED to the ICU were linked to therapeutic and diagnostic procedures and diagnostic groups; (2) patients with lowered consciousness and a pre-arrival notification performed by EMS were admitted to the ICU more often within 180 minutes; and (3) the delayed admissions were not associated with unfavourable outcomes, including prolonged hospital LOS or mortality.

In line with our finding with a cohort of mixed critically ill patients, pre-arrival notification has been shown to reduce delays in patients with stroke and myocardial infarction (22-26). In our study, absence of pre-arrival notification was associated with prolonged stay at the ED.

We found out that the therapeutic and diagnostic procedures were more common in the delayed group. The OR for delayed ED LOS was higher if imaging was performed. Neal et al have reported results suggesting that abdominal CT performed before laparotomy is associated with higher mortality (27). There is also controversial study that showed that CT scan reduced admission time to ICU in some patient groups (28). In our study, imaging studies were not linked to higher mortality even though they were linked to delayed ICU admission.

In the non-delayed group imaging studies were also made (Table 5), but there were many patients with trauma (22.6 %) and neurological diseases (21.8 %) with whom there is a protocol when they arrive at ED. NEWS scoring could be used to detect patients with sepsis, but in our ED during the study period NEWS was not automatically in use. (29)

When we compared different diagnostic groups, patients with trauma or neurological diseases and those who were intoxicated were admitted to the ICU faster than those with infections or gastrointestinal diagnoses as causes of admission. This may be explained by the fact that the patient groups who were admitted faster represent those that are often in need of

mechanical ventilation. In a previous study by Chalfin (2) there was a similar finding when diagnoses in the delayed group were compared. Patients in that study were categorized with APACHE II diagnostic categories, and the study revealed that sepsis was a more common diagnosis in the delayed group. Need of ICU admission may not be so evident in patients with sepsis when compared to those who are comatosed or have multiple trauma. Symptoms of sepsis may vary, which makes sepsis harder to recognize, despite the Sepsis-3 definition (30). It should be noted, however, that in the management of sepsis, delayed stays in the ED have been shown not to increase compliance with the sepsis protocol or influence achievement of optimal resuscitation (13). A prompt administration of antibiotic treatment is one of the cornerstones in sepsis treatment affecting patient outcome (19). In our series the administration of antibiotics early in the ED was more prevalent in the non-delayed group.

Surprisingly, we did not find differences in the outcomes of 3-month mortality or ICU LOS between the delayed and non-delayed patients. Earlier studies have shown that each hour of delay independently associates with increased risk of ICU mortality (5) and that delays of 4 to 6 hours increase mortality (2,4,31). One recent study showed that in addition to increased mortality, longer stay at the ED is associated with more persistent organ dysfunction (15). However, there are also other studies with no effect on outcome (14). In our series there was also no difference in the 90-day mortality rate for those with longer than 4-hour delay compared with those with longer than 6-hour delay. These discrepancies can be explained by differences in the case-mix and different cut-off values for the delay. Similarly to our study, O'Callaghan et al did not find difference in mortality or LOS. Compared to our study population, their patients had higher APACHE II scores (20 vs 16); however, they included also patients in need of urgent operative care and were able to include intensivists in the patient care before the actual ICU admission, which could have had an impact on their results. In our study the equal outcome in both groups could be

explained by the better diagnostic performance in our study: a high rate of body CT scans may increases the diagnostic accuracy and thereby contribute more specific care. Firstly, most of the resuscitated patients as well as those with severe trauma were in the non-delayed group. Secondly, the initiation of antibiotic therapy and use of vasoactive medication were more frequent in the delayed group indicating that even though admission to ICU was delayed, necessary procedures were started already at the ED. It should be taken into account that patients in our series in the delayed group and non-delayed group had differences in case-mix. It is noteworthy that there are protocols for trauma patients, and intoxicated patients do not usually require lot of resources, that is to say their ED visits do not take as much time as those of other patient groups. Finally, it is notable that most of the patients (75%) in the delayed group were admitted to ICU within 4 hours, which has previously been shown to be the cut-off value for increased mortality (2,4,31). When taking all this into account, the differences between the present results and those presented in previous literature can be explained by case-mix, differences in severity of illness, and the relatively small number of delayed patients in our study.

Clinical significance

The results highlight the importance of recognizing high-risk patients both in pre-hospital and hospital setting. Even though delays in ICU admission did not affect survival in this study, patients with sepsis or acute respiratory failure should be recognized early because the ICU has more capacity to treat these patients. Early recognition of critical injury or illness by EMS personnel is a key factor in this process, as pre-notification reduces time spent in ED. Even though NEWS scoring did not have an effect on delay in our study, use of clinical tools such as NEWS or quickSOFA may

be beneficial in detection of severe conditions already on the field (32,33). If a severe condition is recognized, the pre-notification is more likely performed too.

The time spent in the ED could be reduced for the patients with low blood pressure, decreased oxygen saturation, elevated CRP, and elevated creatinine levels, if they could be evaluated early in the ED.

Limitations

The main limitation of the present study is that we did not have data on arrivals' triage class, ED occupancy rates, or delays in seeing ICU physicians. We were not able to analyze the impact of ICU bed capacity on the delays for individual patients, which can also be considered a limitation of the study. However, during the study period, in 97.6% of the days the occupancy rate was less than 90%, indicating that lack of ICU bed capacity was not a significant factor in the present results. Secondly, this study may have been underpowered to detect difference in outcome between the groups due to limited number of patients; thus, this was not a confirmatory study to refute the possibility that a delayed admission affects outcome. These results must be interpreted as hypothesis generating. Further studies are needed to show weather measures targeted to shorten the ED stays of the critically ill improve patient outcome.

Conclusion

In conclusion, the delays in ICU admission were linked to therapeutic and diagnostic procedures and absence of pre-arrival notification. Patients were admitted to ICU by diagnosis instead of clinical risk. However, the delays were not associated to worsening outcome, which indicates that *sufficient* care can be provided at the ED while waiting for the patient to be admitted to the ICU.

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