Iran Red Crescent Med J. 2020 June; 22(6):e102425. doi: 10.5812/ircmj.102425.

Published online 2020 June 27. **Research Article**

Effect of Delayed Admission to Intensive Care Units from the Emergency Department on the Mortality of Critically Ill Patients

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Received 2020 March 07; **Revised** 2020 June 02; **Accepted** 2020 June 14.

Abstract

Background: Increasing in emergency department need to critical care, the number of intensive care unit bed worldwide is inadequate to meet these applies.
Objectives: The aim of this study was to investigate the effect of waiting for admission to the Intensive Care Unit (ICU) in the Emergency Department (ED) on the length of stay in the ICU and the mortality of critically ill patients.
Methods: This retrospective cohort study carried out between January 2012 - 2019 patients admitted to the ICU of a training and research hospital. The data of 1297 adult patients were obtained by searching the Clinical Decision Support System.
Results: The data of the patients were evaluated in two groups as those considered to be delayed and non-delayed. It was determined that the delay of two hours increased the risk of mortality 1.5 times. Hazard Ratios (HR) was 1.548 (1.077 - 2.224). Patients whose ICU admission was delayed by 5 - 6 hours were found to have the highest risk in terms of mortality (HR = 2.291 [1.503 - 3.493]). A statistically significant difference was found in the ICU mortality, 28-day and, 90-day mortality between the two groups. ICU mortality for all patients' general was 25.2% (327/1297). This rate was 11.4% (55/481) in the non-delayed group and 33.3% (272/816) in the delayed group ($P < 0.001$). The 28-day mortality rate for all patients' general was 26.9% (349/1297). This rate was found to be 13.5% (65/481) in the non-delayed group and 34.8% (284/816) in the delayed group ($P < 0.001$). The 90-day mortality for all patients' general was 28.4% (368/1297). This rate was 14.1% (68/481) in the non-delayed group and 36.8% (300/816) in the delayed group ($P < 0.001$).
Conclusions: Prolonged stay in the ED before admission to the ICU is associated with worse consequences, and increased mortality.

Keywords: Critically Patients, Delayed Admission, Emergency Department, Intensive Care Unit, Mortality Rate

1. Background

Critically ill patients are generally defined as physiologically unstable patients requiring continuous follow-up, close monitoring and treatment (1). Prolonged time from the early organ dysfunction to performing appropriate interventions in critically ill patients may have a direct impact on survival (2). Therefore, critically ill patients often require time-sensitive medical interventions to decrease mortality and morbidity (3-5). If septic shock occurred, rapid early fluid resuscitation and appropriate antibiotic treatment, arterial revascularization in myocardial infarction, aggressive resuscitation after major trauma, and thrombolytic therapy in stroke patients (6-10) are some of these interventions.

The increasing number of critically ill patients has become a major concern, as the global population is getting older and becoming morbid. Timely access from crowded emergency departments (EDs) to intensive care (IC) beds is becoming an increasingly significant problem (3, 11-13). In a study conducted on 17,900 patients admitted to EDs in the United States, 8.5% of patients admitted to ED and 25% of hospitalized patients are reported to be critically ill patients (14). Increasing demand worldwide brings about an insufficient number of beds in the intensive care unit (ICU) (15, 16). This demand often exceeds existing beds and resources in many hospitals all around the world. This leads to more complicated decisions made about the admission of patients to ICU (17, 18). While a large number of ICU beds causes admission of patients whose conditions are too good or too severe to be beneficial, a low number of ICU beds causes ICU triage decisions to be harder and rejection of patients who will benefit from ICU (18-

20). When the number of patients requiring IC management is more than the number of available beds, ICU admission is delayed and critically ill patients are monitored in the ED where non-ICU personnel is present (21, 22). On the other hand, the literature shows that EDs are not designed, equipped, or staffed to provide the treatment and care required by critically ill patients (1, 21). Emergency physicians have limited time and nurses do not have a 1:1 or 1:2 nurse-to-patient ratio, which is present in most ICUs (16, 23-26). Whilst managing a patient requiring ICU in the ED, the physician often faces the dilemma of transferring the patient or monitoring him/her in the ED (16). While transferring the patient to another hospital means potential complications during the transfer, keeping the patient in the ED means taking the risk of a potential setback during the indefinite period of waiting for the ICU bed (27, 28).

Intensive care admission time varies among countries and hospitals. Critically ill patients spend hours or even days in ED while waiting for an IC bed to be available for them (16). This duration ranges from 2 hours to 3.5 days in 87% of patients waiting to be admitted to ICU in the ED (12, 17, 29-32). The American Hospital Association stated that the average waiting time to be transferred from the ED to the IC bed was 5.8 hours (33).

In previous studies, delayed admission to ICU was found to be associated with prolonged length of ICU and hospital stay and higher mortality (15, 16, 18, 29, 34). In pursuit of physiological deterioration, delays of four or more hours in ICU admission are associated with 3.5-fold increase in mortality (5). Even though the negative effects of extended ICU waiting time have been reported, some study results contradict others and show that there is no relationship between delayed admission and prolonged ICU and hospital stay and higher mortality (28, 31, 35-37).

Since previous studies show inconsistent results based on population and ED examined and there is limited available data nationwide, we esteem that a study on the relationship between admission to ICU from ED should be conducted.

2. Objectives

The aim of the present study was to investigate the effect of waiting for admission to the ICU in the ED on the length of stay in the ICU and the mortality of critically ill patients. The main outcomes of interest included 28-day and 90-day mortality and ICU length of stay.

3. Methods

3.1. Study Design and Setting

This a retrospective, observational cohort study was carried out at Health Sciences University, Bakırköy Dr. Sadi Konuk Training and Research Hospital between January 2012 and 2019 in Istanbul, Turkey. This hospital is a general government hospital which health services are provided free of charge to all citizens within the scope of social insurance. This referral hospital contains 40 different medical departments and 652 general ward sickbeds. The ICU of hospital has a 27 sickbeds and is an important health center in Istanbul, the most populous city in Europe, with a population of more than 15 million. The ICU accepts an average of 1346 medical, surgical and trauma patients per year who need medical treatment. ICU is a closed unit controlled by the clinical decision support system (CDSS) and medical applications such as extracorporeal treatments (extracorporeal membrane oxygenation (ECMO), hemodialysis, plasmapheresis) are carry out. The nurse-patient ratio is 1:2 in ICU.

The Emergency Department of the hospital provide 7/24 emergency health service by emergency physicians-nurses and admit an average of 280,000 patients a year. The ED implements a 5-stage triage system to patients (i.e., resuscitation, emergency, urgent, less urgent, and not urgent). Patients who are met by specially trained nurses and whose first complaints and medical history are taken, are carried to sickrooms specially designed for ED according to the severity and urgency of their complaints. Patients who are considered to need IC by the emergency physician are evaluated by the IC specialist or assistant physician before being admitted to the ICU. After the patients are evaluated, they are admitted to the ICU as soon as possible if sickbeds were available. If there is no vacancy in the ICU, the patient is transferred to other hospitals or treatment is continued in the ED while the waits for admission to the ICU. In country, the Ministry of Health electronically monitors the number of sickbeds in all ICUs and the number of transfers to ICUs of other hospitals with available sickbeds when no vacancies are available in the ICU. In addition, IC specialists cannot keep an ICU bed vacant or reserve one without justification per the regulation of the Ministry of Health.

3.2. Study Population and Sample

Between January 2012 and 2019, 9424 admissions were made to the ICU. In this period, all of the 1704 patients who admitted to the ICU from the ED was constituted the study population. A total of 1155 patients was calculated to detect a 9.4% reduction of absolute risk (12) with 95% confidence interval, 80% power, and a 1:2 non-exposure/exposure ratio. According to study inclusion criteria, 1297 patients was constituted the study population. No sample selection was made as it was aimed to reach the all study population. All of the 1297 patients were reached by scanning backwards in the study.

3.2.1. Inclusion Criteria

The inclusion criteria were as follows:

- Admission from the ED of the hospital to the ICU
- Patients who were followed for more than 24 hours in the ICU
- Patients who were admitted from other hospitals
- Without missing data

3.2.2. Exclusion Criteria

The exclusion criteria were as follows:

- Transfer to wards within the first 24 hours of ICU admission
- Admissions via theatre
- Transfer from other hospitals
- Admissions from wards
- Admissions from other hospital ICUs
- Dead within 24 hours
- Missing data

3.3. Ethical Considerations

Before conducting the study, ethical and institutional approval was obtained from Health Sciences University Bakırköy Dr. Sadi Konuk Training and Research Hospital Clinical Research Ethics Committee (Ethical code: 2019/21, ethical approval date: 07.01.2019, permission number: 2019-01-18). Written consent was obtained from all patients. The research conforms to the provisions of the Declaration of Helsinki in 1995 (as revised in Brazil 2013).

3.4. Data Collection

The data of the ED patients who were given ICU consultation were collected by searching the hospital electronic database EMRall-QlinICU CDSS, and the consultation response time to determine the patients' ICU treatment decision was calculated. This registry system was containing the complete and continuous registration of all available data of the patients in ICU. The following demographic data were collected: age, gender, length of hospital stay, length of ICU stay, ICU admission diagnosis, and comorbidities, acute physiology and chronic health evaluation (APACHE) 2 score, APACHE 4 score, simplified acute physiology score (SAPS) 3 score, sequential organ failure assessment (SOFA) score, therapeutic intervention scoring system (TISS) 28 score, Glasgow coma scale (GSC) score on the first day of ICU, results of blood samples taken on the first day of ICU, need for mechanical ventilation (MV) and tracheal intubation, vasoactive agents use, invasive procedures used, treatments, and exit information.

3.5. Statistical Analysis

The data collected by the study were evaluated with the SPSS V. 22.00 program. The Shapiro-Wilk test was used to test the normal distribution of the data. Categorical variables were given as frequency (n) and percent (%), while numerical variables were given as median and interquartile ranges (IQR). The Mann-Whitney U test was used for the comparison of the quantitative data. A chi-square test was used to test categorical variables, and Fisher's exact test was used when the conditions of the chi-square test could not be met. Since independent variables are not normally distributed and there may be proportional relationships between these values, the Cox regression model was used for the ICU mortality. After controlling the assumptions of the Cox regression model, the factors that may affect ICU mortality was implemented by entering the variables related to a stepwise backward method and then removing the non-meaningful variables. Cox regression analysis was used for variables affecting ICU mortality. The percentage of patients censored for surviving the ICU follow-up was 74.8% (972). Kaplan-Meier analysis was used for 28-day and 90-day mortality. The log rank test was used to determine the difference between groups. Since the patients with missing data were excluded the study and was reached all of the patients' mortality information, was no censored (missing data) data in the study sample. In the survival analysis used, did not have right-censored data. Patients who did not develop mortality during the follow-up period were identified as left-censored data. The level of significance was set as $P = 0.05$.

3.6. Primary Outcomes

The primary outcome was to compare the ICU mortality of ED patients who were admitted without delay to the ICU with those whose admission to the ICU was delayed.

3.7. Secondary Outcomes

The secondary outcomes were to determine the comorbidities of patients, diagnosis of admission, scores calculated after admission to the ICU, laboratory values, treatments, and 28-day and 90-day mortality. As most of the patients do have health insurance and their date of decease is included in the insurance and hospital database, we were able to assess re-admittance to the hospital, 28-day mortality and 90-day mortality endpoints.

4. Results

During the study period (2012 - 2019) there were 1704 ICU admissions. After excluding 188 patients who were transferred to other wards within the first 24 hours, 123 patients who died within the first 24 hours, and 96 patients

with missing identity details, there were 1297 admissions included in the final analysis (Figure 1).

General comparisons between patient groups are presented in Table 1. The patients were divided into two groups: those who were admitted non- delayed to the ICU (37.1%; n = 481) and those whose admission to the ICU was delayed (62.9%; n = 816).

Patients were mainly male (58%), with a mean age of 60 (IQR, 40 - 75 years). The group admitted to the ICU non- delayed was younger than the other group (56 [37 - 73]). Of the patients, 61% had at least one comorbid disease, and comorbid diseases were found to be similar between the two groups. The most common admission diagnoses were multi-trauma (14.7%), pneumonia (14%), intracranial hemorrhage (11.8%), and sepsis (11.6%). A diagnosis of sepsis was most common in the group whose ICU admission was delayed, while intoxication was found to be the main diagnosis in the other group.

During ICU treatment, interventions such as a central catheter, dialysis catheter, thorax drain, and orotracheal intubation were applied more to the delayed admission group than to the other group. No statistically significant difference was found between the groups in terms of arterial catheter hemodialysis and tracheostomy interventions. Vasoactive agents (42.5%) and antibiotic therapy (74.4%) were used more frequently to the delayed group, while sedative drug use was found to be similar in the two groups.

Transfusion of blood and blood products was similar between the groups. The one exception difference was platelet use; platelet replacement therapy was applied more frequently to the group whose admission was delayed. No statistically significant difference was found between groups for the acute kidney injury (AKI) warning given by the CDSS. However, the CDSS gave more frequent septic shock warnings in the group whose admission was delayed (Table 1).

The duration of admission was 33 (18 - 46) minutes in the non- delayed group and 148 (98 - 252) minutes in the delayed group. After the patients' admission to the ICU, APACHE2, APACHE4, SAPS3, TISS28, and SOFA scores were found to be statistically significantly higher in the delayed group, while the GCS score was significantly lower in the same group. White blood cell (WBC) and bilirubin were significantly higher in the delayed group. For other laboratory parameters, no statistically significant difference was found between the groups. The patients' stay in the ICU was found to be 3.95 (2.0 - 8.33) days. No statistically significant difference was found between the patients' duration of mechanical ventilator use and their duration of stay in the ICU (Table 2).

4.1. Mortality Analysis

In-ICU general mortality, 28-day, and 90-day mortality were compared between the two groups, as shown in Table 3. During the study period, ICU mortality for all patients' general was 25.2% (327 - 1297). This rate was 11.4% (55 - 481) in the non-delayed group and 33.3% (272 - 816) in the delayed group ($P < 0.001$). The patients were subdivided according to their admission diagnosis, and as a result of the analyses, the mortality of the patients with multi-trauma, pneumonia, intracranial hemorrhage, sepsis, chronic obstructive pulmonary disease (COPD), acute renal failure (ARF), and myocardial infarction (MI) was found to be higher in the non-delayed group. For the other admission diagnoses, no statistically significant difference was found between the groups in terms of mortality.

Cox regression analysis was performed to determine the factors affecting ICU mortality. The risk of mortality was found to increase in the delayed group compared to the non- delayed group. In the group whose ICU admittance was delayed up to two hours, Hazard Ratios (HR) was 1.548 (1.077 - 2.224). In the group delayed 6 - 12 hours, HR increased to 1.959 (1.203 - 3190). Patients whose ICU admission was delayed by 5 - 6 hours were found to have the highest risk in terms of mortality (HR = 2.291 [1.503 - 3.493]). In addition, high APACHE 2 (HR = 1.029 [1.008 - 1.051]) and SAPS3 (HR = 1.015 [1.006 - 1.025]) scores, high lactate (HR = 1.078 [1.039 - 1.117]) and WBC (HR = 1.013 [1.002 - 1.024]) values, inotropic agent treatment (HR = 2.771 [2.075 - 3.700]), MV (HR = 9.916 [3.133 - 31.388]), and septic shock warning by the CDSS (HR = 1.911 [1.520 - 2.402]) were high risk factors for mortality (Table 4).

The Kaplan-Meier method was used to compare the 28-day and 90-day mortality between the delayed and non-delayed groups. A statistically significant difference was found in the 28-day and 90-day mortality between the groups ($P < 0.001$). The 28-day mortality rate for all patients' general was 26.9% (349 - 1297). This rate was found to be 13.5% (65 - 481) in the non-delayed group and 34.8% (284 - 816) in the delayed group (log rank $P < 0.001$) (Figure 2).

The 90-day mortality for overall patients was 28.4% (368 - 1297). This rate was 14.1% (68 - 481) in the non-delayed group and 36.8% (300 - 816) in the delayed group (log rank $P < 0.001$) (Figure 3).

5. Discussion

In present study, it has been determined that there is a relationship between delayed admission to the ICU and a higher mortality rate. The intensive care unit mortality was lower in the group who did not wait in ED. Patients in the delayed admission group experienced an increase in APACHE II and SAPS3 scores despite the medical care provided by ED staff while patients were waiting for IC beds.

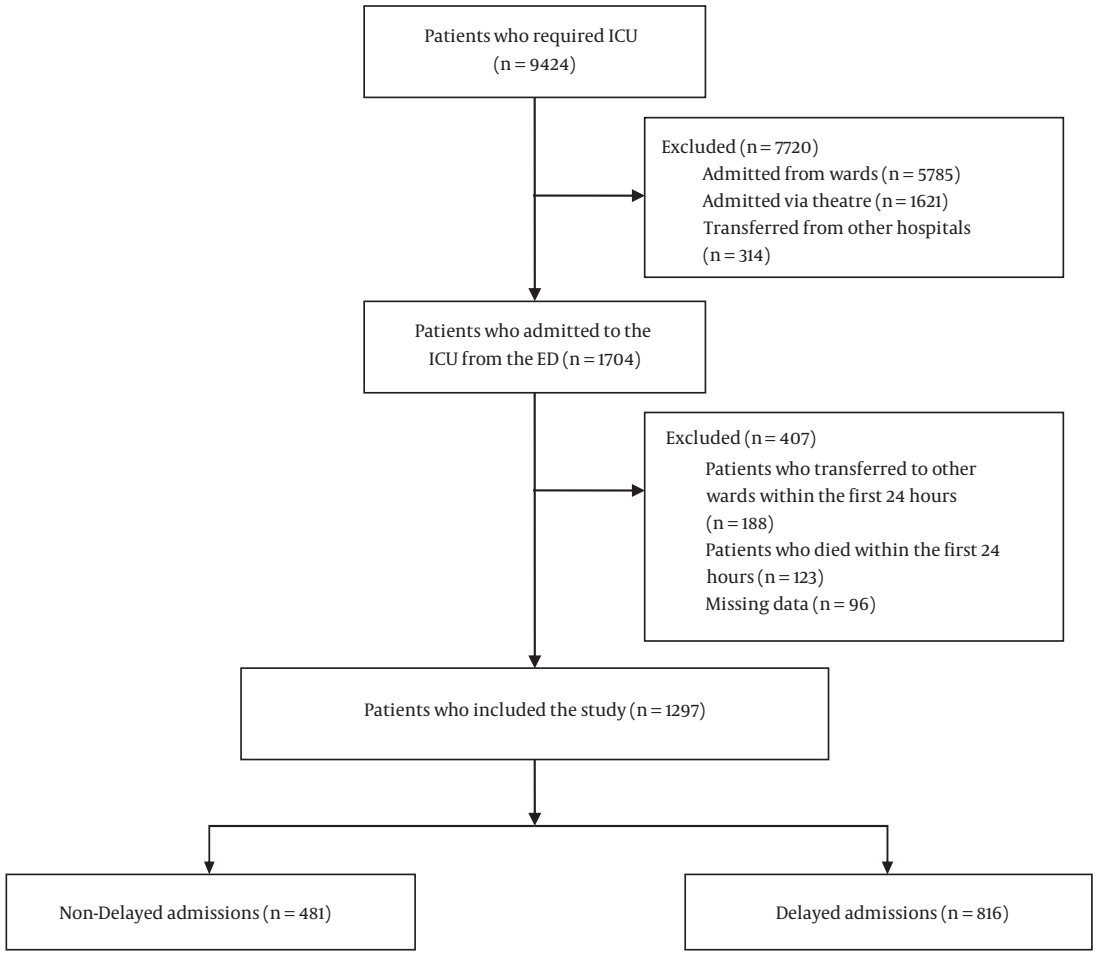

Figure 1. Flow diagram of patients selection

This reflects that the physiological condition deteriorates during the waiting period. The ED are not designed to provide long-term care to critically ill patients (29). It is not surprising that delayed admission to ICU deteriorates patient outcomes since a great deal of advanced intervention performed on critically ill patients require personnel qualified on IC, supplies which are not available in ED, and staff has limited time. The fact that electronic IC is associated with reduced mortality and ICU stay of patients in ED waiting to be transferred to ICU and using less resource of ICU in the study by Kadar et al. has shown the effect of IC training and experience on patient outcomes. The ED crowd can reduce the quality of care due to delays in initiating treatments and the compliance with clinical guidelines. Previous studies have reported that prolonged bed waiting time in critically ill patients leads to the development of complications and an increased mortality rate (5, 15, 22).

In many studies conducted, the effects of ICU waiting time on patient outcomes have been examined and various results related to how long after staying in ED before being transferred to ICU is considered as delayed have been obtained pursuant to countries. In our study, before the admission to the ICU, the waiting time in the ED was determined to be 90 minutes. While the waiting period for ICU admission in ED in New Zealand was determined to be 3.9 hours, it was 4.6 hours in Spain, 4.8 hours in Finland, 2.2 hours in the Netherlands, 2.2 hours in Canada and 12.7 hours in Taiwan (5, 35, 37-40). Compared to these results, the admission time from ED to ICU is shorter in our hospital. This can be explained by the health policies of our country. If an IC bed cannot be found in any public hospital in our country, patients are transferred to the ICU of private hospitals and treatment expenses are covered by the state. This privilege granted to IC patients and the treatment expenses paid enabled the private sector to focus more on ICUs and increase the number of beds. This ensures that

Table 2. Scores and Laboratory Parameters of Patients After Admission to the ICU[a]

Parameters	Total Sample (N = 1297)	Non-Delayed (N = 481)	Delayed (N = 816)	P Value
Admission duration (min)	90 (41 - 83)	33 (18 - 46)	148 (98 - 252)	
IC scores				
GCS	12 (6 - 15)	12 (7 - 15)	11 (6 - 15)	0.033
APACHE2	16 (10 - 22)	14 (9 - 21)	17 (11 - 23)	< 0.001
APACHE4	70 (46 - 96)	63 (41 - 88)	74 (50 - 98)	< 0.001
SAPS3	43 (33 - 56)	42 (30 - 52)	45 (34 - 58)	< 0.001
SOFA	6 (3 - 10)	6 (2 - 9)	7 (3 - 10)	< 0.001
TISS28	17 (12 - 23)	15 (11 - 22)	18 (12 - 24)	< 0.001
Laboratory				
pH	7.37 (7.29 - 7.42)	7.38 (7.30 - 7.42)	7.36 (7.28 - 7.42)	0.173
PO_2, mmHg	73.2 (43.2 - 111)	72.7 (43.3 - 109.5)	73.7 (43.1 - 111.9)	0.908
PCO_2, mmHg	39.4 (33.1 - 47.6)	39.3 (33.1 - 47.2)	39.4 (33.1 - 48.2)	0.577
Lac, mmol/L	2.40 (1.49 - 4.48)	2.30 (1.40 - 4.30)	2.50 (1.49 - 4.49)	0.062
WBC, $\times 10^9$/L	12.99 (8.99 - 18.09)	12.4 (8.75 - 22.87)	13.42 (9.13 - 18.85)	0.024
PCT, ug/L	0.7 (0.3 - 2.79)	0.61 (0.28 - 2.50)	0.75 (0.31 - 3.07)	0.071
Cr, mg/dL	0.90 (0.66 - 1.70)	0.84 (0.64 - 1.37)	0.96 (0.67 - 1,88)	0.001
BILI, mg/dL	0.61 (0.41 - 1.01)	0.55 (0.41 - 0.93)	0.64 (0.41 - 1.04)	0.046
MV (h) (n = 826)	100.1 (46.3 - 166.3)	96.3 (46.4 - 158.5)	103.8 (45.7 - 168.0)	0.403
LOS ICU (day)	3.95 (2.0 - 8.33)	3.70 (2.0 - 8.0)	4.18 (1.96 - 8.45)	0.304

Abbreviations: APACHE, acute physiology and chronic health evaluation; BILI, bilirubin; Cr, creatinine; IQR, interquartile range; GCS, Glasgow coma scale; IC, intensive care; Lac, lactate; LOS, length of stay; MV, mechanical ventilation; PCO_2, partial pressure of carbon dioxide; PCT, procalcitonin; PO_2, partial pressure of oxygen; SAPS, simplified acute physiology; SOFA, sequential organ failure assessment; TISS, therapeutic intervention scoring system; WBC, white blood cell.
[a]Values are expressed as median (IQR).

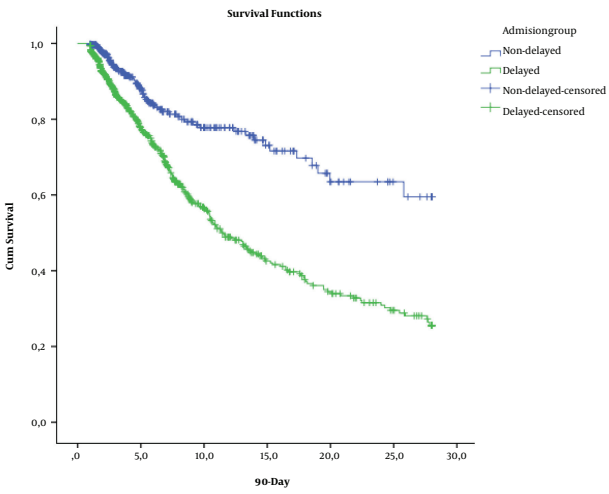

Figure 2. 28-day mortality; log rank p

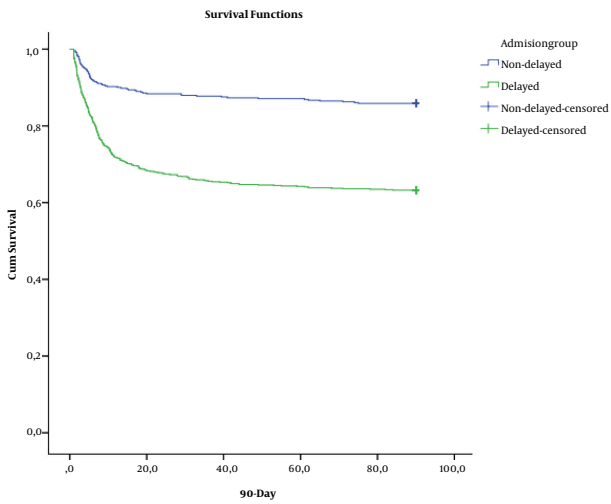

Figure 3. 90-day mortality; log rank p

the waiting times of patients waiting for an ICU bed are shortened.

The difference of our study from previous studies is that we determined that mortality was decreased in the second hour of the waiting time, and the longer the waiting time is, the more evident mortality risk becomes, and after the sixth hour, the mortality risk starts to decrease compared to the early hours. In previous studies, it has been explained that the effect of waiting time increasing mortality shows up later. In a study conducted in the

Table 3. Mortality

Parameters	Total Sample	Non-Delayed	Delayed	P Value
ICU mortality	327 (25.2)	55 (11.4)	272 (33.3)	< 0.001
28-day	349 (26.9)	65 (13.5)	284 (34.8)	< 0.001
90-day	368 (28.4)	68 (14.1)	300 (36.8)	< 0.001
Admission diagnosis				
Multi-trauma	191	5 (7.0)	26 (21.7)	0.008
Pneumonia	182	7 (10.1)	37 (32.4)	0.001
Intra-cranial bleeding	153	5 (9.4)	36 (36.0)	< 0.001
Sepsis	151	11 (28.2)	56 (50.0)	0.018
Intoxication	123	0 (0)	4 (6.8)	0.050[b]
COPD	66	0 (0)	7 (20.0)	0.009[b]
ARF - renal	60	4 (16.7)	21 (58.3)	0.001[b]
MI - cardiac	58	6 (27.3)	20 (55.6)	0.036
Cerebrovascular accident	45	2 (18.2)	12 (35.3)	0.250[b]
DKA - metabolic	40	2 (11.8)	3 (13.0)	0.646[b]
Pulmonary - other	36	1 (9.1)	7 (28.0)	0.210[b]
ARDS	24	2 (22.2)	9 (60.0)	0.084[b]
GIB - hemorrhage	25	1 (16.7)	10 (52.6)	0,141[b]
Hepatic cirrhosis	21	1 (10.0)	3 (27.3)	0.331[b]
Gunshot injuries - sharp object injury	24	2 (20.0)	3 (21.4)	0.668[b]
Malignancy	33	5 (55.6)	11 (45.8)	0.619
SE	16	0 (0)	1 (11.1)	0.563[b]
Pancreatic	15	0 (0)	4 (33.3)	0.363[b]
Other	34	1 (6.7)	2 (10.5)	0.591
Total pulmonary	308	10 (8.3)	60 (31.9)	< 0.001
Total trauma	215	7 (8.6)	29 (21.6)	0.013
MI	41	4 (23.5)	13 (54.2)	0.049[b]
Chronic HF	17	2 (40.0)	7 (58.3)	0.437[b]
Total cranial	198	7 (10.9)	48 (35.8)	< 0.001

Abbreviations: ARDS, acute respiratory distress syndrome; ARI, ccute renal failure; COPD, chronic obstructive pulmonary disease; DKA, diabetic ketoacidosis; GIB, gastrointestinal bleed; HF, heart failure; ICU, intensive care unit; MI, myocardial infarction; SE, status epilepticus.
[a] Values are expressed as No. (%).
[b] Fisher's exact test.

United States, more than 50,0000 critically ill patients in nearly 120 ICUs were examined and it was determined that ICU mortality increased in the ones who waited longer than 6 hours in ED (29). In another study, it was determined that a significant increase in mortality in the ED patients waiting for ICU beds started in the fourth hour and the mortality gap between them and patients who did not wait became evident in the early hours and decreased in the following hours (40). In contrast to these studies in which the evident mortality gap is explained with the longer periods of staying in the ED in accordance with our results, in a study recently conducted in the Netherlands in 6 training hospitals, it was determined that ICU mortality increased in the patients who waited over 2.4 hours for beds, similar to our results (21). In the same study, it was determined in the sub-analysis of the diagnoses that the waiting time of ED was associated with mortality only in cardiac arrest patients. Considering the effect of admission diagnosis on mortality alone, mortality was found to be higher in patients who were admitted to the hospital with the diagnoses of sepsis, intracranial hemorrhage, myocardial infarction, and multi-trauma. A triage to be applied in order

Table 4. Hazard Ratios for ICU Mortality

	ICU Mortality	95% CI	P Value
Vacancy ready	Reference		
< 2 h	1.548	1.077 - 2.224	0.018
2 - 3 h	1.859	1.301 - 2.657	0.001
3 - 4 h	2.123	1.415 - 3.184	< 0.001
4 - 5 h	2.208	1.367 - 3.566	0.001
5 - 6 h	2.291	1.503 - 3.493	< 0.001
6 - 12 h	1.959	1.203 - 3.190	0.007
MV	9.916	3.133 - 31.388	< 0.001
Lac, mmol/L	1.078	1.039 - 1.117	< 0.001
APACHE2_first	1.029	1.008 - 1.051	0.007
SAPS3_first	1.015	1.006 - 1.025	0.001
APACHE4_first	1.000	0.995 - 1.006	0.920
SOFA_first	1.001	0.965 - 1.038	0.968
Inotrope agent	2.771	2.075 - 3.700	< 0.001
Septic shock warning	1.911	1.520 - 2.402	< 0.001
WBC, $\times 10^9$/L	1.013	1.002 - 1.024	0.019

Abbreviations: APACHE, acute physiology and chronic health evaluation; CI, confidence interval; HR, hazard ratio; ICU, intensive care unit; Lac, lactate; h, hour; MV, mechanic ventilation; SAPS, simplified acute physiology; SOFA, sequential organ failure assessment; WBC, white blood cell.

for the ED crowds not to deteriorate the outcomes of these patients is thought to decrease the ICU bed waiting time and ICU mortality. It has been determined in the studies that waiting in ED more than 5 hours in stroke patients increased ICU mortality (41), in cranial patients, ED crowd increased door-to-imaging time (42) and increased door-to-needle time in myocardial infarction (43).

There is also a study that shows another reason for the delay in the admission is that capacity agitation as well as care provided in ED crowd and triage. This study shows that immediate admission is possible when two or more ICU beds are available compared to one or fewer beds (44). For this reason, utilizing ICU bed occupancy properly and timely brings about quicker admission when needed and lower capacity agitation.

In the study, the most common admission diagnosis was determined as trauma and secondly pneumonia in both groups, similar to the previous study results (40, 45). There are more sepsis patients in the waiting group. This is found to be particularly remarkable considering that early diagnosis and treatment is lifesaving for sepsis patients. The fact that the SOFA score of the patients waiting for beds is higher shows that deterioration in organ functions is increased within the waiting period. SOFA increase shows that golden hours in sepsis cannot be utilized effectively in patients waiting for beds (46). The fact that the CDSS gives septic shock warning more often in the group waiting in ED also supports this. In a study conducted in North America, it was found that required interventions antibiotic treatment being in the first place were administered to sepsis patients with delay in crowded ED and early goal-directed therapy rate was decreased (47). It is thought that vasoactive agents and antibiotic treatment to be administered to patients waiting for beds more frequently results from the fact that these patients have sepsis and thus the mortality rate is higher. In similar studies, it has been found that antibiotic use rate (22) and vasoactive agents use (5) are higher in the group waiting for the IC bed.

As a result of this study, 30-day and 90-day mortality rates were found to be higher in the delayed admission group. The increase in mortality even in the patients who survived the acute phase of the critical illness shows that delayed admission may be responsible for prolonged morbidity and mortality. Even though organ failures in patients with physiologically limited reserves do not cause mortality in the acute phase, it may result in mortality increase related to decompensated failures not responding to treatment in the long term. In a study analyzing 4 prospective cohort studies conducted in North America and Europe, delayed ICU stay was determined to be associated with 28-day mortality. In another multi-center study, the delay in admission to ICU more than 2.4 hours was found to increase the 30-day and 90-day mortality rates (21).

5.1. Conclusions

Delayed admission to ICU and prolonged waiting of critically ill patients in ED are associated with mortality. Mortality started to increase in the second hour of the delay. Using triage to diagnose particularly the patients who have illnesses in which early intervention is lifesaving and to determine the patients who will benefit the most from ICU service may reduce the mortality. Larger and multicenter studies are needed to determine patients and diagnoses that will benefit from ICU service for an objective triage.

5.2. Strengths and Limitations

The utmost strength of the study is the CDSS and the full data acquired for the main outcome measures of the patients involved in the study taken from electronic medical records by preventing human errors. Manually extracting additional data from hospital medical records provided more contextual information. In terms of limitations, the study was conducted in a large general hospital of a metropolitan city. The results could not be generalized Results may not be the same in Turkey or other countries. Another limitation is the retrospective selection of

patients requiring ED-ICU admission. Some patients who required ICU admission may be immediately diagnosed and successfully treated by the emergency physician and therefore may not have received ICU treatment. Due to the presence of neurology and coronary ICUs in our hospital, it may have affected the incidence of critically ill patients with cardiac and neurological illnesses in this ICU.

Footnotes

Authors' Contribution: Study design, data collection, analysis, and manuscript writing: Mehmet Suleyman Sabaz, Nagihan Sabaz, Halil Doğan, Sinan Asar, Zafer Cukurova, Gokhan Sertcakacilar; statistical expertise: Mehmet Suleyman Sabaz; critical revision for important intellectual content: Mehmet Suleyman Sabaz, Halil Doğan, and Zafer Cukurova; contributed to the final version of the manuscript: Mehmet Suleyman Sabaz and Nagihan Sabaz.

Conflict of Interests: The authors declare they have no conflict of interest.

Ethical Approval: Before conducting the study, ethical and institutional approval was obtained from Health Sciences University Bakırköy Dr. Sadi Konuk Training and Research Hospital Clinical Research Ethics Committee (ethical code: 2019/21, ethical approval date: 07.01.2019, permission number: 2019-01-18). The research conforms to the provisions of the Declaration of Helsinki in 1995 (as revised in Brazil 2013).

Funding/Support: This research received no financial support.

Patient Consent: Written consent was obtained from all patients.

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Table 1. Characteristics, Comorbidity, Diagnosis, Intervention, and Treatments of the Patients[a]

Parameters	Total Sample (N = 1297)	Non-Delayed (N = 481)	Delayed (N = 816)	P Value
Gender				0.100
Male	752 (58)	293 (60.9)	459 (56.25)	
Female	545 (42)	188 (39.1)	357 (43.75)	
Age, median (IQR)	60 (40–75)	56 (37–73)	61 (42–75)	0.014
Comorbidity	792 (61.1)	291 (60.5)	501 (61.4)	0.749
Hypertension	374 (28.8)	125 (26.0)	249 (30.5)	0.082
Diabetes	259 (20)	91 (18.9)	168 (20.6)	0.468
CAD	213 (16.4)	80 (16.6)	133 (16.3)	0.876
CHF	123 (9.5)	47 (9.8)	76 (9.3)	0.786
Cerebrovascular disease	100 (7.7)	37 (7.7)	63 (7.7)	0.985
COPD	131 (10.1)	50 (10.4)	81 (9.9)	0.787
CRF	121 (9.3)	39 (8.1)	82 (10)	0.246
Dementia	82 (6.3)	30 (6.2)	52 (6.4)	0.923
Malignancy	135 (10.4)	44 (9.1)	91 (11.2)	0.254
Hepatic disease	24 (1.9)	11 (2.3)	13 (1.6)	0.371
Psychiatric disorder	40 (3.1)	17 (3.5)	23 (2.8)	0.471
Other	138 (10.6)	53 (11.0)	85 (10.4)	0.734
Admission diagnosis				
Pulmonary	308 (23.7)	120 (24.9)	188 (23.0)	0.435
Pneumonia	182 (14)	69 (14.3)	113 (13.8)	0.859
COPD	66 (5.1)	31 (6.4)	35 (4.3)	0.088
ARDS	24(1.9)	9 (1.9)	15 (1.8)	0.966
Pulmonary, other	36 (2.8)	11 (2.3)	25 (3.1)	0.411
Trauma	215 (16.6)	81 (16.8)	134 (16.4)	0.845
Multi-trauma	191 (14.7)	71 (14.8)	120 (14.7)	0.978
Gunshot injuries/sharp object injury	24 (1.9)	10 (2.1)	14 (1.7)	0.639
Cranial	198 (15.3)	64 (13.3)	134 (16.4)	0.132
Intracranial bleeding	153 (11.8)	53 (11)	100 (12.3)	0.505
Stroke	45 (3.5)	11 (2.3)	34 (4.2)	0.074
Cardiac	58 (4.5)	22 (4.6)	36 (4.4)	0.892
MI	41 (3.2)	17 (3.5)	24 (2.4)	0.555
Chronic HF	17 (1.3)	5 (1.0)	12 (1.5)	0.510
Sepsis	151 (11.6)	39 (8.1)	112 (13.7)	0.002
Intoxication	123 (9.5)	64 (13.3)	59 (7.2)	< 0.001
ARF - renal	60 (4.6)	24 (5.0)	36 (4.4)	0.632
DKA - metabolic	40 (3.1)	17 (3.5)	23 (2.8)	0.471
GIB - hemorrhage	25 (1.9)	6 (1.2)	19 (2.3)	0.171
Hepatic cirrhosis	21 (1.6)	10 (2.1)	11 (1.3)	0.314
Malignancy	33 (2.5)	9 (1.9)	24 (2.9)	0.237
SE	16 (1.2)	7 (1.5)	9 (1.1)	0.579

Pancreatic	15 (1.2)	3 (0.6)	12 (1.5)	0.192[b]
Other	34 (2.6)	15 (3.1)	19 (2.3)	0.390
Interventions				
Hemodialysis	173 (13.3)	61 (12.7)	112 (13.7)	0.593
Arterial catheter	740 (57.1)	264 (54.9)	476 (58.3)	0.226
Central catheter	490 (37.8)	151 (31.4)	339 (41.5)	< 0.001
Dialysis catheter	304 (23.4)	93 (19.3)	211 (25.9)	0.007
Thorax drain	79 (6.1)	21 (4.4)	58 (7.1)	0.046
Nasogastric	660 (50.9)	223 (46.4)	437 (53.6)	0.012
MV	826 (63.7)	275 (57.2)	551 (67.5)	< 0.001
Tracheostomy	198 (15.3)	62 (12.9)	136 (16.7)	0.068
Treatments				
Inotrope	469 (36.2)	122 (35.4)	347 (42.5))	< 0.001
Noradrenaline	546 (42.1)	166 (34.5)	380 (46.6)	< 0.001
Adrenaline	144 (11.1)	31 (6.4)	113 (13.8)	< 0.001
Dobutamine	49 (3.8)	14 (2.9)	35 (4.3)	0.208
Dopamine	216 (16.7)	51 (10.6)	165 (20.2)	< 0.001
Glypressin	30 (2.3)	9 (1.9)	21 (2.6)	0.416
Sedation	738 (56.9)	271 (56,3)	467 (57.2)	0.755
Antibiotics	928 (71.5)	321 (66.7)	607 (74.4)	0.003
Blood product	181 (18.0)	66 (18.0)	115 (18.0)	0.995
Erythrocyte suspension	168 (13.0)	59 (12.3)	109 (13.4)	0.572
Fresh frozen plasma	99 (7.6)	34 (7.1)	65 (8.0)	0.557
Platelets (109 cells/L)	63 (4.9)	16 (3.3)	47 (5.8)	0.049
Warning - alarm				
AKI	809 (62.4)	301 (62.6)	508 (62.3)	0.908
Septic shock	482 (37.2)	153 (31.8)	329 (40.3)	0.002

Abbreviations: AKI, acute kidney injury; ARDS, acute respiratory distress syndrome; ARF, acute renal failure; CAD, coronary artery disease; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; CRF, chronic renal failure; DKA, diabetic ketoacidosis; GIB, gastrointestinal bleed; HF, heart failure; IQR, interquartile range; MI, myocardial infarction; MV, mechanic ventilation; SE, status epilepticus.
[a] Values are expressed as No. (%).
[b] Fisher's exact test.