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Research

Identification of Factors Associated with Prolonged Stay in the Intensive Care Unit

Yoğun Bakım Ünitesinde Uzun Süre Kalış ile İlişkili Faktörlerin Belirlenmesi

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ABSTRACT

Objective: This study aimed to determine the factors associated with prolonged intensive care unit length of stay (ICU-LOS), which is increasingly common in ICU, and to evaluate its effect on patient outcomes.

Methods: This retrospective study was evaluated by obtaining data of 5,022 patients who were followed in the ICU of a tertiary education and research hospital between January 2014 and January 2021 and met the research criteria in electronic environment.

Results: Patients were divided into two groups as patients with ICU-LOS <14 days (n=4,083, 81.3%) and patients with ICU-LOS ≥14 days (n=939, 18.7%). Sepsis and pulmonary diseases were more common in the prolonged ICU-LOS group than in the non-prolonged ICU-LOS group (p<0.05). While 61.8% (2,525) in the non-prolonged ICU-LOS group needed mechanical ventilator support, this rate increased to 97.4% (915) in the prolonged ICU-LOS group (p<0.001). The duration of MV was higher in the prolonged ICU-LOS group [20.3 (14.9-29.2)] than in the non-prolonged ICU-LOS group [3.4 (1.7-6.2)] (p>0.001). Although 18.7% of the patients had prolonged ICU-LOS, they consumed 66.3% and 59.7% of all mechanical ventilator days and ICU hospitalization days, respectively. ICU mortality was higher in the prolonged ICU-LOS group (n=376; 40%) than in the non-prolonged ICU-LOS group (n=1219; 29.9%). The development of acute kidney injury (odds ratio (OR): 1,807; 95% confidence interval (CI) 1,434-2,277), development of pressure sores (OR: 3,572; 95% CI: 2,663-4,792), total parenteral nutrition use (OR: 2,014; 95% CI: 1,639-2,475), increase in body mass index (OR: 1,015; 95% CI: 1.001-1.031), and mechanical power increase (OR: 1.041; 95% CI: 1.002-1.082) were associated with prolonged ICU-LOS (OR: 1.015; 95% CI: 1.001-1.031).

Conclusion: Prolonged ICU-LOS is associated with increased costs, use of resources, and morbidity and mortality.

Keywords: Intensive care units, length of stay, mechanical ventilation, mortality

ÖZ

Amaç: Bu araştırma yoğun bakım ünitesinde (YBÜ) gittikçe daha sık rastlanan uzamış YBÜ kalış süresi (YBÜ-LOS) ile ilişkili faktörleri belirlemek ve hasta sonuçlarına etkisini değerlendirmek amacı ile planlandı.

Gereç ve Yöntem: Bu retrospektif araştırma Ocak 2014- Ocak 2021 döneminde üçüncü düzey bir eğitim ve araştırma hastanesinin YBÜ'de takip edilen ve araştırma kriterlerini karşılayan 5.022 hastanın verileri elektronik ortamda elde edilerek değerlendirildi.

Bulgular: Araştırmaya dahil edilen hastalar YBÜ-LOS <14 gün olan 4.083 (81,3) hasta ve YBÜ-LOS ≥14 gün olan 939 (18,7) hasta olacak şekilde iki gruba ayrıldı. Uzamış YBÜ-LOS grubunda sepsis ve pulmoner hastalıklar uzamamış YBÜ-LOS grubundan daha sık görüldü (p<0,05). Uzamamış YBÜ-LOS hastalarının %61,8'i (2.525) mekanik ventilatör desteğine ihtiyaç duyarken bu oran uzamış YBÜ-LOS hastalarında %97,4'e (915) yükseldi (p<0,001). Mekanik ventilasyon süresi uzamış YBÜ-LOS hastalarında [20,3(14,9-29,2)], uzamamış YBÜ-LOS hastalarına [3,4(1,7-6,2)] göre daha yüksekti (p>0,001). Uzamış YBÜ-LOS hastalarının oranının %18,7 olmasına rağmen tüm mekanik ventilatör günlerinin %66,3'ünü ve tüm YBÜ yatış günlerinin %59,7'sini işgal ettikleri saptandı. YBÜ mortalitesi uzamış YBÜ-LOS grubunda (376; %40), uzamamış YBÜ-LOS grubuna göre (1.219; %29,9) daha yüksek bulundu. YBÜ'de akut böbrek hasarı gelişmesinin [risk ornaı (OR): 1.807; güven aralığı (CI): %95 1.434-2.277],

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University of Health Sciences Turkey, bası yarası gelişmesinin (OR: 3.572; CI: %95 2.663-4.792), TPN kullanımının (OR: 2.014; CI: %95: 1.639-2.475) vucüt kitle indeksi artışın (OR: 1.015; CI: %95: 1.001-1.031) ve mechanical power artışının (OR: 1.041; CI: %95: 1.002-1.082) uzamış YBÜ-LOS ile ilişkili olduğu belirlendi (OR: 1.015; CI: %95: 1.001-1.031).

Sonuç: YBÜ uzun süre kalma, artan maliyet ve kaynak kullanımı ile ilişkilidir. Ek olarak hastaların morbidite ve mortalitesinin de artmasına neden olmaktadır.

Anahtar Kelimeler: Yoğun bakım üniteleri, kalış süresi, mekanik ventilasyon, mortalite

INTRODUCTION

The science of intensive care has developed significantly in the last decade, and emerging technological developments and new treatments have reduced the mortality rates in intensive care units (ICUs) (1). Increasing survival and aging population as a result of advances in the early management of critical illnesses have led to the formation of a patient profile that is increasingly encountered in the ICUs and requires prolonged ICU follow-up. The number of patients with this profile, who are dependent on a particular type of technology or medical care, is expected to increase in the coming years (2,3).

There is no consensus on the definition of long-term intensive care. Different criteria have been used for its definition, and it has been variously defined as staying in the ICU for >10 days or >21 days (4-7). In a more recent study, ICU stay of at least 14 days was defined as a prolonged ICU length of stay (ICU-LOS) (6). Depending on the definition used, 4%-11% of patients admitted to the ICU have been determined to have a prolonged ICU-LOS (8-10). Patients with ICU-LOS >14 days use approximately half of all ICU hospitalization days and mechanical ventilation (MV) use days, although they constitute a small proportion of patients admitted in the ICU (10,11). Prolonged ICU-LOS is associated with increased cost and resource use and may affect morbidity and mortality. Long-term ICU-LOS can adversely affect health by increasing the risk of infection, complications, and possibly mortality (9,12). Operationally, it affects ICU bed availability and results in the cancellation of elective surgeries, leading to long waiting times (9). Bed waiting time is prolonged before admission to the ICU, a factor known to affect patient outcomes (13). Identifying patients at risk of long-term stay can assist ICU management and prevent ICU bed shortage.

In patients followed up in the ICU, prolonged LOS causes increased costs and resource use, as well as prolonged ICU waiting time. Therefore, early identification of patients at risk of prolonged ICU-LOS is important. This study aimed to determine the factors associated with prolonged ICU-LOS and to evaluate its effect on patient outcomes.

METHODS

Data Center

This study was performed retrospectively in the ICU of a third-level training and research hospital in Istanbul, the most populous city in Turkey. Consisting of 27 tertiary hospital beds, the ICU accepts an average of 1340 patients per year. The nurse-patient ratio in these ICUs, which is controlled by the clinical decision support system (CDSS) and where extracorporeal treatments (ECMO, hemodialysis, and plasmapheresis) can be applied, is 1:2.

When a patient is admitted to the ICU, the patient's identity information, anamnesis, and examination findings are recorded in the patient file created in CDSS. Information that requires dynamic measurement, such as urine output and glasgow coma scale (GCS), is recorded in the CDSS patient file at regular intervals by the patient's physician. Intensive care scores are calculated and recorded with the algorithms defined in CDSS, taking into account the worst values in the last 24 h. In addition, all bedside monitor parameters, MV data, extracorporeal applications, laboratory test results, and dose information of all infusions administered for treatment are transmitted to the CDSS from the applied devices, thanks to the electronic ecosystem created during the patient's ICU follow-up. Thus, all patient data are collected in the patient file in CDSS.

Data Collection

Data of patients admitted to the ICU between January 2014 and January 2021 from the EMRall-QlinICUImd Soft Metavision CDSS database used in the ICU were obtained by using Structured Query Language queries. In addition to the patients' LOS in the ICU, demographic data, admission diagnoses, comorbid diseases, scores calculated in the ICU, blood gas and biochemical values, MV data, treatments, and interventions, developed complications, and mortality results were evaluated.

Sample

A total of 9,380 patients were admitted to the ICU during the research period, of which 4,358 did not meet the research and exclusion criteria. The remaining 5,022 patients constituted the study population (Figure 1).

In the present study, similar to the study by Zampieri et al. (6), a 14-day or longer stay in the ICU was considered

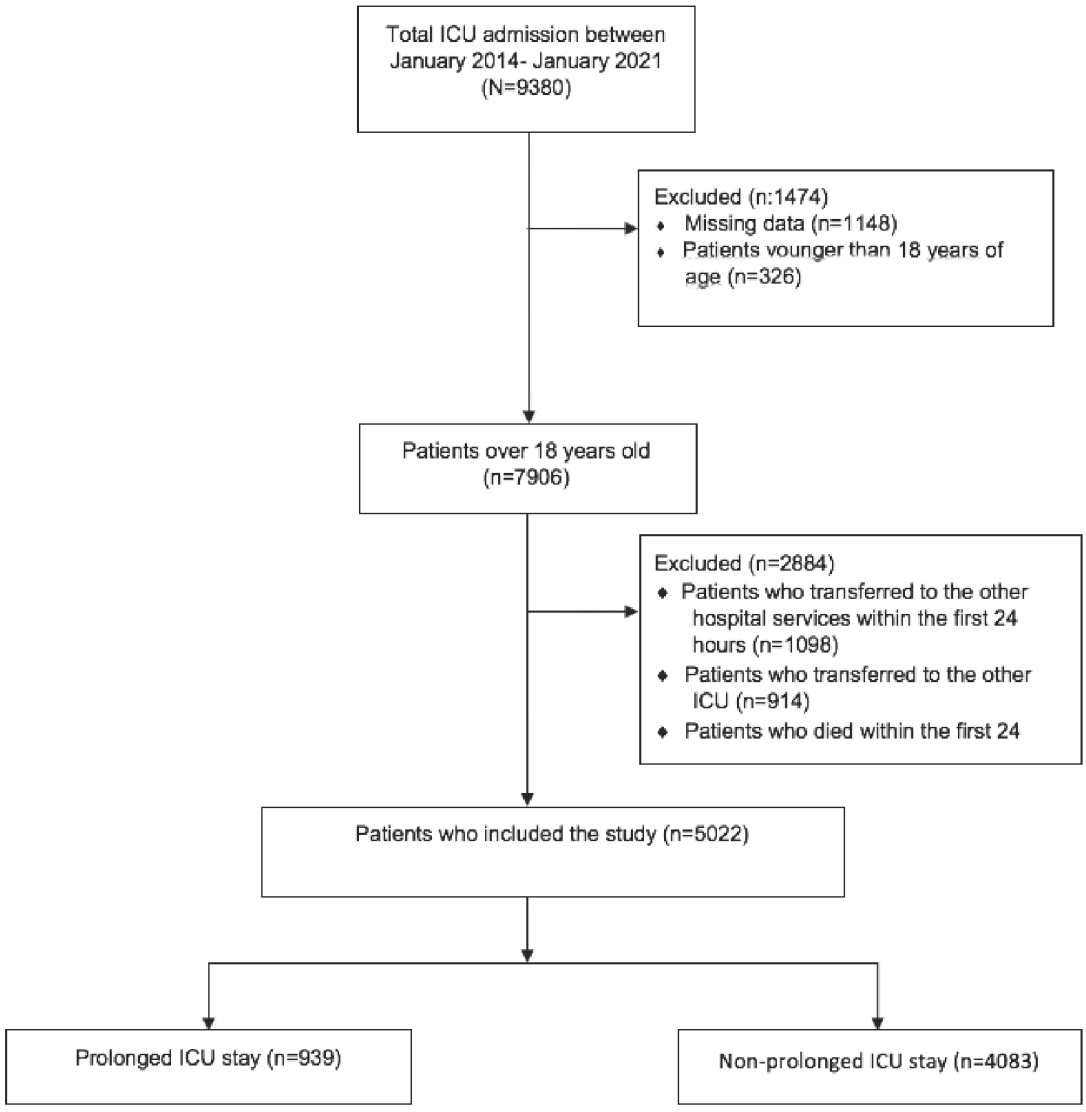

Figure 1. Flow diagram of patient selection
ICU: Intensive care unit

a prolonged ICU-LOS. Patients included in the study were divided into two groups: 4,083 (81.3) patients hospitalized for <14 days and 939 (18.7) patients with a hospitalization period of ≥14 days.

Admission Criteria

The study planned to include the entire patient population aged ≥18 years who stayed in the ICU for >24 h.

Exclusion Criteria

Patients aged <18 years (n=326), admitted to the service within 24 h of ICU admission (n=1,098), died within the first 24 h in the ICU (n=872), referred to another ICU (n=914), and had missing data (n=1,148) were excluded from the study.

Primary Outcome

The primary outcomes were factors associated with prolonged hospital stay in the ICU and their effects on patient outcomes.

Secondary Outcomes

The secondary outcomes were comorbid diseases, admission diagnoses, scores, treatment, and interventions.

Ethical Issues

Before the study, ethical committee approval and institutional permission were obtained from the Clinical Research Ethics Committee (protocol code: 2021/405; decision no. 2021-16) of the public hospital where the study was conducted.

Statistical Analysis

SPSS 22.00 program was used in the analysis of the research data. The Shapiro-Wilk test was used to determine the normal distribution of numerical data. Normally distributed numerical data were expressed as mean ± standard deviation, and non-normally distributed numerical data were expressed as median and interquartile ranges. The independent samples t-test was used to compare the numerical data between groups, and the Mann-Whitney U test was used when the conditions of this test were not met. Categorical variables were expressed as frequency and percentage. The chi-square test was used to compare categorical variables between groups, and Fisher's Exact test was used when the conditions of the chi-square test were not met. Logistic regression analysis was used to determine parameters associated with the risk of prolonged ICU hospitalization; $p<0.05$ was accepted for the significance level.

RESULTS

In this study, 56.9% of the 5022 patients constituting the study population were male, and the mean age was 60.49±19.24 years. The mean body mass index (BMI) was 27.11±5.58 kg/m^2. Moreover, 74.6% of the patients had at least one comorbid disease. The most common comorbid disease was hypertension (n=1,835; 36.5%). Sepsis (n=1,116; 22.2%) was the most common admission diagnosis in the ICU, and 68.5% (n=3,440) of the patients with a calculated acute physiology and chronic health evaluation (APA-CHE) II score of 20 (n=1327) needed MV support. Acute kidney injury (AKI) was detected in 3,309 (65.8) patients. The median ICU-LOS of the patients was 4.54 (1.91-10.45) days. The ICU mortality rate was 31.7% (n=1595).

Comparison of Groups in Terms of Clinical Characteristics

Patients were divided into two groups as non-prolonged ICU-LOS group with <14 days and prolonged ICU-LOS group with ≥14 days. While ICU-LOS was <14 days in 4,083 (81.3%) of 5,022 patients, ICU-LOS was ≥14 days in 939 patients (18.7). The general characteristics of the groups are given in Table 1. No significant difference was found in age and gender between the groups. The frequency of the male gender was higher in both groups. The frequency of comorbid disease was lower in the prolonged ICU-LOS group (671; 71.5) than in the non-prolonged ICU-LOS group (3,075; 75.3) ($p<0.05$). Hypertension was the most common comorbid disease in both groups. Considering other comorbidities, the frequency of chronic obstructive pulmonary disease (COPD), malignancies, and hepatic diseases was higher in the non-prolonged ICU-LOS group,

Table 1. Characteristics of patient groups and admission diagnosis

Parameters	ICU-LOS of ≥ 14 n=939 (18.7%)	ICU-LOS<14 n=4083 (81.3%)	p
Age (year)	59.78±19.55	60.66±19.16	0.210
18-65	502 (53.5)	2145 (52.6)	0.608
65-74	174 (18.5)	821 (20.1)	0.274
75-84	174 (18.5)	732 (17.9)	0.665
≥85	89 (9.5)	385 (9.4)	0.963
Gender			0.298
Female	390 (41.5)	1772 (43.4)	
Male	549 (58.5)	2311 (56.6)	
Body mass index (kg/m^2)	26.12 (24.22-29.38)	25.95 (23.87-29.29)	0.003
Comorbidity	671 (71.5)	3075 (75.3)	0.014
Hypertension	327 (34.8)	1508 (36.9)	0.226
Diabetes	189 (20.1)	925 (22.7)	0.093
Cerebrovascular disease	69 (7.3)	288 (7.1)	0.751
CAD	106 (11.3)	424 (10.4)	0.416
COPD	106 (11.3)	574 (14.1)	0.025
CRF	81 (8.6)	381 (9.3)	0.500
Malignancy	78 (8.3)	536 (13.1)	<0.001
Hepatic disease	9 (1.0)	79 (1.9)	0.040
Psychiatric disorder	20 (2.1)	84 (2.1)	0.888
Dementia	35 (3.7)	173 (4.2)	0.480
Obesity	214 (22.8)	790 (19.3)	0.017
Other	95 (10.1)	390 (9.6)	0.597
Admission diagnosis			
Cerebrovascular disease	141 (15.0)	587 (14.4)	0.616
Cardiac	56 (6)	227 (5.6)	0.628
Pulmonary	159 (16.9)	454 (11.1)	<0.001
Pneumonia	96 (10.2)	252 (6.2)	<0.001
COPD	48 (5.1)	134 (3.3)	0.007
Pulmonary, others	15 (1.6)	68 (1.7)	0.883
Renal-metabolic	44 (4.7)	234 (5.7)	0.207
Hepatic cirrhosis	1 (0.1)	54 (1.3)	<0.001*
Trauma	153 (16.3)	399 (9.8)	<0.001
Sepsis	245 (26.1)	871 (21.3)	0.002
Pneumosepsis	46 (4.9)	180 (4.4)	0.513
Intra-abdominal sepsis	116 (12.4)	405 (9.9)	0.027
Urosepsis	22 (2.3)	79 (1.9)	0.422
Sepsis, other	61 (6.5)	207 (5.1)	0.080
Malignancy	44 (4.7)	325 (8.0)	<0.001
Postoperative	31 (3.3)	471 (11.5)	<0.001
Intoxication	13 (1.4)	162 (4.0)	<0.001
GIB-hemorrhage	19 (2.0)	123 (3.0)	0.099
Others	33 (3.5)	176 (4.3)	0.271

CAD: Coronary artery disease, COPD: Chronic obstructive pulmonary disease, CRF: Chronic renal failure, GIB: Gastrointestinal bleeding, *Fisher's Exact test

and the prevalence of obesity was higher in the prolonged ICU-LOS group (p<0.05). The BMI values were 26.12 (24.22-29.38) in the prolonged ICU-LOS group and 25.95 (23.87-29.29) in the non-prolonged ICU-LOS group (p<0.05). The frequency of any other comorbid diseases was not significantly different between the groups. In both groups, the most common diagnosis on ICU admission was sepsis. Furthermore, a diagnosis of sepsis (n=245; 26.1%) was more common in the prolonged ICU-LOS group than in the non-prolonged ICU-LOS group (n=871; 21.3%) (p<0.05). Although the most common sepsis source was intra-abdominal sepsis in both groups, intra-abdominal sepsis was more common in the prolonged ICU-LOS group (p<0.05). While pulmonary diseases (n=96; 10.2%) and trauma (n=153; 16.3%) were more common in the prolonged ICU-LOS group (due to COPD, pneumonia, and other causes), malignancy (n=325; 8.0%), intoxication (n=162, 4.0%), hepatic diseases (n=54; 1.3%), and postoperative follow-up (n=471; 11.5%) were more common in the prolonged ICU-LOS group (p<0.05) (Table 1).

The scores of the patients calculated during ICU admission, interventions, and treatments are shown in Table 2. APACHE II, APACHE IV, simplified acute physiology (SAPS) III, sequential organ failure assessment, and therapeutic intervention scoring system 28 scores were higher in the prolonged ICU-LOS group, whereas GCS and richmond agitation and sedation scale scores were lower (p<0.001). Arterial and central venous catheterization was performed more frequently in the prolonged ICU-LOS group. MV and dialysis were more needed and the rate of tracheostomy was higher in the prolonged ICU-LOS group than in the non-prolonged ICU-LOS group (p<0.001). The rates of using antibiotics, total parenteral nutrition (TPN), and vasoactive drugs were higher in the prolonged ICU-LOS group (p<0.001). The average daily energy amounts given in the ICU of both groups were comparable (p>0.05). The frequency of pressure sores and AKI was higher in the prolonged ICU-LOS group than in the non-prolonged ICU-LOS group (p<0.001).

Table 2. Scores, interventions, and treatments during ICU-LOS

Parameters	ICU-LOS of ≥ 14 n=939 (18.7%)	ICU-LOS<14 n=4083 (81.3%)	p
APACHE II	24 (19-29)	19 (12-27)	<0.001
APACHE IV	85 (64-107)	71 (49-100)	<0.001
SAPS III	47 (39-53)	42 (33-53)	<0.001
SOFA	7 (5-9)	5 (2-9)	<0.001
TISS	22 (17-27)	19 (15-24)	<0.001
GCS	10 (8-13)	12 (7-15)	<0.001
RASS	-2 [-4- (-1)]	-1 (-3-0)	<0.001
Interventions			
Arterial catheter	783 (83.4)	2704 (66.2)	<0.001
Central catheter	763 (81.3)	1783 (43.7)	<0.001
MV	915 (97.4)	2525 (61.8)	<0.001
Tracheostomy	617 (65.7)	284 (7.0)	<0.001
Dialysis	323 (34.4)	624 (15.3)	<0.001
Treatments			
Nutrition (kcal/day)	1765 (1537-2089)	1752 (1523-2039)	0.135
TPN	582 (62.0)	1218 (29.8)	<0.001
Antibiotics	938 (99.9)	3355 (78.2)	<0.001
Vasoactive agents	730 (77.7)	2102 (51.5)	<0.001
Complications			
AKI	699 (74.4)	2610 (63.9)	<0.001
Pressure sores	221 (23.5)	171 (4.2)	<0.001
MV (day)	20.3 (14.9-29.2)	3.4 (1.7-6.3)	<0.001
LOS ICU (day)	23.6 (17.9-32.9)	3.6 (1.8-6.5)	<0.001
28-day mortality	248 (26.4)	1219 (29.9)	0.036
ICU mortality	376 (40.0)	1219 (29.9)	<0.001

APACHE: Acute physiology and chronic health evaluation, SAPS: Simplified acute physiology, SOFA: Sequential organ failure assessment, TISS: Therapeutic intervention scoring system, GCS: Glasgow coma score, RASS: Richmond agitation and sedation scale, MV: Mechanical ventilation, TPN: Total parenteral nutrition, AKI: Acute kidney injury, LOS: Length of stay, ICU: Intensive care unit

MV and Blood Gas Parameters

Patients with prolonged ICU-LOS needed mechanical ventilator support more frequently. While 61.8% (2525) of the patients in the non-prolonged ICU-LOS group needed mechanical ventilator support, this rate increased to 97.4% (915) in the prolonged ICU-LOS group (p<0.001). The duration of MV was longer in the prolonged ICU-LOS group [20.3 (14.9-29.2)] than in the non-prolonged ICU-LOS group [3.4 (1.7-6.2)] (p>0.001). Although the proportion of patients with prolonged ICU-LOS was 18.7%, they consumed 66.3% of all mechanical ventilator days. When the mechanical ventilator parameters were examined, the positive end-expiratory pressure [6.6 (5.6-7.4)], peak pressure [14.8 (13.2-16.6)], and minute respiratory rate [19 (17-21)] values in the prolonged ICU-LOS group were higher, and work of breathing ventilator, pulmonary compliance, and tidal volumes were comparable. The mechanical power value was higher in the prolonged ICU-LOS group [9.72 (8.54-11.54)] than in the non-prolonged ICU-LOS group [8.85 (7.42-10.88)]. Partial pressure of carbon dioxide and bicarbonate levels

were higher and lactate levels were lower in the prolonged ICU-LOS group when blood gas results were compared between the groups. Moreover, pH and PO_2 values were comparable. Considering other laboratory parameters, blood glucose and procalcitonin levels were higher in the prolonged ICU-LOS group. Hemoglobin, hematocrit, platelet, and white blood cell counts were comparable between the groups. International normalized ratio and activated partial thromboplastin time were increased in the prolonged ICU-LOS group (Table 3).

Table 3. Mechanical ventilator values and blood parameters of the patients during ICU follow-up

Parameters	ICU-LOS of ≥ 14 n=939 (18.7%)	ICU-LOS<14 n=4083 (81.3%)	p
Mechanical ventilation			
FiO_2 (%)	43 (40-46)	44 (40-49)	0.063
PEEP (cm H_2O)	6.6 (5.6-7.4)	6.0 (5.1-6.7)	<0.001
P peak (cm H_2O)	14.8 (13.2-16.6)	14.1 (12.3-16.2)	<0.001
Tidal volume	492 (439-556)	499 (444-559)	0.455
Tidal volume (mL/kg)	6.83 (6.17-7.60)	6.80 (6.08-7.60)	0.344
Respiratory rate (min)	19 (17-21)	17 (15-20)	<0.001
Compliance (mL/cm H_2O)	37.0 (30.1-46.0)	37.6 (30.9-46.8)	0.068
WOBv (j/L)	1.13 (0.99-1.26)	1.12 (0.98-1.30)	0.134
Mechanical power (J/min)	9.72 (8.54-11.54)	8.85 (7.42-10.88)	<0.001
Blood gas			
PH	7.40 (7.36-7.44)	7.40 (7.35-7.44)	<0.092
PO_2 (mm Hg)	89.5 (72.1-104.9)	85.5 (61.2-108.6)	0.400
PCO_2 (mm Hg)	44.6 (40.1-51.4)	40.6 (36.1-46.0)	<0.001
HCO_3 (mEq/L)	26.7 (24.2-30.0)	24.4 (21.2-27.1)	<0.001
Lactate (mmol/L)	1.61 (1.33-2.14)	1.87 (1.36-3.35)	<0.001
Laboratory			
Glucose (mg/dL)	146 (126-178)	141 (117-178)	<0.001
Hemoglobin (g/dL)	10.5 (8.9-12.5)	10.8 (9.2-12.8)	0.140
Hematocrit (%)	33.0 (27.6-39.0)	33.5 (28.4-38.7)	0.231
Platelet (x10^9/L)	216 (152-295)	218 (157-293)	0.971
White blood cell (x10^9/L)	12.7 (9.5-16.8)	13.0 (10.4-16.2)	0.284
Procalcitonin (µg/L)	1.03 (0.40-5.07)	0.82 (0.35-3.98)	0.026
INR	1.20 (1.09-1.38)	1.17 (1.06-1.41)	0.045
APTT (sec)	36.6 (28.9-46.0)	33.3 (27.1-43.3)	<0.001

FiO_2: Fraction of inspired oxygen, PEEP: Positive end-expiratory pressure, WOBv: Work of breathing ventilator, PCO_2: Partial pressure of carbon dioxide, PO_2: Partial pressure of oxygen, HCO_3: Bicarbonate, CRP: C-reactive protein, INR: International normalized ratio, APTT: Activated partial thromboplastin time, AST: Aspartate aminotransferase, ALT: Alanine aminotransferase, IQR: Interquartile range

LOS in the ICU and Mortality

The ICU-LOS in the prolonged ICU-LOS group was 23.6 (17.9-32.9) days and that in the non-prolonged ICU-LOS group was 3.6 (1.8-6.5) days. Although only 18.7% (n=939) of the patients had ICU-LOS ≥14 days, they consumed 59.7% of the total hospitalization days. The 28-day mortality rate was 26.4% (n=248) in the prolonged ICU-LOS group and 29.9% (n=1219) in the non-prolonged ICU-LOS group (p<0.05). Despite the lower 28-day mortality in the prolonged ICU-LOS group, ICU mortality was higher in the prolonged ICU-LOS group (n=376; 40%) than in the non-prolonged ICU-LOS group (n=1,219; 29.9%) (Table 2). In the subgroup analysis performed according to the admission diagnoses of the patients, the mortality rate in the prolonged ICU-LOS group was higher in patients followed up with the diagnoses of pulmonary diseases, sepsis, malignancy, postoperative follow-up, intoxication, and gastrointestinal bleeding (p<0.05). The mortality rate in other admission diagnoses was not different between the groups (Table 4). The logistic regression model created to determine the factors associated with prolonged ICU-LOS found that the development of AKI in the ICU increased the probability of prolonged ICU-LOS by 1.8 times (OR: 1,807; 95% CI: 1,434-2,277), development of pressure sores by 3.5 times (OR: 3,572; 95% CI: 2,663-4.792), and TPN use by 2 times (OR: 2,014; 95% CI: 1,639-2,475) (p<0.001). In addition, the increase in BMI was associated with prolonged ICU-LOS (OR: 1,015; 95% CI: 1,001-1,031). Additionally, a one-unit increase in mechanical power increased the probability of prolonged ICU-LOS by 4.1% (OR: 1,041; 95% CI: 1,002-1,082). Patient age, APACHE II score, pulmonary compliance values, and need for vasoactive agents were not associated with prolonged ICU-LOS (Table 5).

DISCUSSION

This study, which aimed to determine the factors associated with prolonged ICU hospitalization, determined that increased BMI, TPN use, AKI, and pressure ulcer development were associated with prolonged ICU. In addition, the increase in mechanical power in patients who were intubated increased the possibility of prolonged ICU, and pulmonary compliance was not associated with prolonged ICU. Moreover, patient age, APACHE II score,

Table 4. Mortality rates of the groups according to the diagnosis upon ICU admission

Admission diagnosis	ICU-LOS of ≥ 14 n=939 (18.7%)	ICU-LOS<14 n=4083 (81.3%)	p
Cerebrovascular disease	41 (29.1)	177 (30.2)	0.802
Cardiac	22 (39.3)	98 (43.2)	0.598
Pulmonary	65 (40.9)	136 (30.0)	0.012
Pneumonia	41 (42.7)	89 (35.3)	0.203
COPD	16 (33.3)	29 (21.6)	0.107
Pulmonary, Other	8 (53.3)	18 (26.5)	0.042
Renal-metabolic	21 (47.7)	84 (35.9)	0.138
Hepatic cirrhosis	0 (0)	29 (53.7)	0.286*
Trauma	31 (20.3)	91 (22.8)	0.519
Sepsis	127 (51.8)	363 (41.7)	0.005
Pneumosepsis	21 (45.7)	74 (41.1)	0.578
Intra-abdominal sepsis	56 (48.3)	165 (40.7)	0.148
Urosepsis	11 (50)	17 (21.5)	0.008
Sepsis, other	39 (63.9)	107 (51.7)	0.091
Malignancy	24 (54.5)	85 (26.2)	<0.001
Postoperative	16 (51.7)	54 (11.5)	<0.001
Intoxication	6 (46.2)	17 (10.5)	<0.001
GIB-hemorrhage	15 (78.9)	53 (43.1)	0.004
Other	8 (24.2)	32 (18.2)	0.417
28-day mortality	248 (26.4)	1219 (29.9)	0.036
ICU mortality	376 (40.0)	1219 (29.9)	<0.001

COPD: Chronic obstructive pulmonary disease, GIB: Gastrointestinal bleeding, *Fisher's Exact test

Table 5. Parameters associated with prolonged ICU-LOS

Parameters	OR	95% CI	P-value
Age	0.995	0.989-1.000	0.055
Body mass index	1.015	1.001-1.031	0.036
APACHE II	0.990	0.978-1.004	0.156
AKI	1.807	1.434-2.277	<0.001
Pressure sores	3.572	2.663-4.792	<0.001
TPN	2.014	1.639-2.475	<0.001
Vasoactive agents	0.977	0.749-1.274	0.861
Pulmoner compliance	0.998	0.990-1.005	0.525
Mechanical power	1.041	1.002-1.082	0.040

APACHE: Acute physiology and chronic health evaluation, AKI: Acute kidney injury, TPN: Total parenteral nutrition

and use of vasoactive agents were not associated with prolonged ICU-LOS. The rate of prolonged ICU-LOS was higher in patients diagnosed with sepsis and pulmonary diseases.

The increase in MV application, hemodynamic support, and organ support systems together with the developing technology in the ICU has enabled more patients to recover from acute critical illnesses (7). Decreased mortality in the acute period has led to the formation of a patient population that remains dependent on MV and other supportive treatments applied in the ICU for a long time. Despite the different definitions of long-term ICU-LOS in the literature, regardless of the definition employed, the proportion of this patient population was small. The small number of patients who stayed in the ICU for long periods tended to overuse resources disproportionately for their number. As a result of this study, although only 18.7% (n=939) of the patients has prolonged ICU-LOS, they consumed 66.3% of MV days and 59.7% of total hospitalization days. This finding is consistent with those of previous studies. In a similar study conducted in Canada, the average ICU-LOS was 4.74 days and 7.3% of the applications remained >14 days (14). In another study, 11% of the patients had prolonged ICU-LOS, but they consumed 45% of intensive care days and 56% of ventilation days (9). The modest number of patients with prolonged ICU-LOS consuming more than half of the MV days can be explained by the increased mechanical power in this patient group. Considering the potential causes of prolonged ICU-LOS, the suppression of the immune system is considered common after trauma, sepsis, and other serious diseases, and this immune dysfunction plays a role in patients who stayed in the ICU for a long time (15). Another study suggested endocrinopathy acquired in the ICU (16). In another study, early nutritional needs of patients in the ICU were given sufficient attention, and the resulting iatrogenic malnutrition may lead to long-term hospitalization (17).

In line with the results of this study, which determined that prolonged ICU-LOS is more common in patients hospitalized in the ICU with the diagnosis of pulmonary diseases and sepsis, other studies have reported that long-term hospitalization is associated with sepsis and acute respiratory failure requiring MV (9,18,19). Pulmonary diseases and sepsis increased proinflammatory activity that can lead to organ failures, neuromuscular weakness, and dysfunction, leading to prolonged hospitalization (20). This finding indicates that early treatment of pulmonary diseases that cause sepsis and acute respiratory failure is an important goal for the prevention of long-term hospitalization. Treatments and practices such as early

resuscitation, conservative fluid management after the shock period, early mobilization, low tidal volume, and avoidance of excessive sedation, which can prevent early organ damage in the course of critical illness, may help the clinician to prevent long-term hospitalization (20-25). The present study also found that the usage rate of vasoactive drug was higher in the prolonged ICU-LOS group. However, vasoactive drug use was not associated with prolonged ICU-LOS. A similar study reported that vasoactive drug use and prolonged ICU-LOS were not associated (6). This is probably because patients who need vasopressors are in the more severe patient group and are more likely to die early after ICU admission.

In the present study, APACHE II, SAPS III, and other disease severity scores were higher in the prolonged ICU-LOS group, but they were not associated with prolonged ICU-LOS. Contrary to our results, a multicenter study, which was conducted with APACHE II, examined ICU-LOS for 10 months in 5,881 patients and found that patients with short ICU-LOS had high APACHE II scores (26). Another study found that patients with very high disease severity (APACHE II ≥30) had a short ICU-LOS because they died early in the ICU (18). Patients with low disease severity have relatively short ICU-LOS and are then discharged from the ICU, probably because they only need intensive care for a short time. By contrast, patients with very high disease severity have a shorter ICU-LOS because mortality develops in the early period. Considering the studies on SAPS III, which is another disease severity score, a study evaluated the SAPS III scores of the patients during admission to the ICU and found that patients with high SAPS III scores had a longer ICU-LOS (6). In another study, patients with a higher SAPS III scores stayed in the postoperative ICU for 3 more days (27). This situation can be explained by the high chronic disease burden of most of the patients with high SAPS III scores (6).

The present study also found that the increase in BMI and development of pressure sores were associated with prolonged ICU-LOS. Similar studies have reported that obesity increases ICU time, which is consistent with our results (28,29). In a meta-analysis including 23 studies, a trend was found to increase ICU-LOS in patients who were obese (29). In another meta-analysis study including 14 studies, obesity was associated with increased ICU-LOS and MV time (28). Nursing care of patients who are obese is more difficult than those with normal weight because of the large body weight and large body surface area. Difficult position changes in these patients may cause pressure sores and skin lacerations. Disruption of the protective skin barrier may prolong ICU-LOS in patients who are obese by increasing complications such as infection or bleeding (30,31).

Another finding of this study was that AKI development was associated with prolonged ICU-LOS of patients with critical illness. Our results are compatible with the literature. Previous studies have shown that AKI development is associated with prolonged ICU-LOS and increased morbidity, hospital costs, and worse outcomes in patients with critical illness (32,33). Impairment of pulmonary dynamics due to hypervolemia, which is common with decreased pulmonary compliance in patients with AKI, may increase respiratory workload and prolong MV time (34). In the present study, another parameter related to prolonged ICU-LOS was TPN. Similarly, a previous study showed that TPN use prolonged ICU-LOS (35). TPN was associated with infectious complications due to hyperalimentation and hyperglycemia, which may explain its association with prolonged ICU-LOS (36,37).

Study Limitations

In addition to its strengths, such as minimized data loss since the study data were obtained by the CDSS with electronic queries and all ICU processes were followed in our clinic, this study has some limitations. First, its single-center design prevents generalization of the results despite the diversity in the patient population. Second, given its retrospective nature, confounding factors may affect the results and increase bias risk. Third, data on long-term survival and functional outcomes of the patients could not be obtained. Fourth, since data on IV fluids and diuretic treatments given before the ICU follow-up could not be obtained, the weights measured in the ICU and urine volume of patients may have affected the BMI and AKI data. Fifth, comorbidities may have been underestimated because of deficiencies in patient's statement during anamnesis. Finally, the lack of a common consensus for the need for prolonged intensive care and various definitions in previous studies that accepted it as 10, 14, and 21 days may lead to differences in results, where we determined the need for prolonged intensive care as ≥14 days.

CONCLUSION

Patients who had prolonged ICU-LOS occupied 66.3% of MV days and 59.7% of total hospitalization days. The rate of prolonged ICU-LOS was higher in patients diagnosed with sepsis and pulmonary diseases. An increase in BMI, TPN use, AKI, and pressure ulcer development was associated with prolonged ICU. The increase in mechanical power increased the probability of prolonged ICU in patients who needed MV. Patient age, APACHE II score, and use

of vasoactive agents were not associated with prolonged ICU-LOS. A full understanding of the factors associated with prolonged ICU-LOS will be achieved through prospective studies that will generalize well-designed results and randomize patients with prolonged ICU-LOS at the center of the study.

ETHICS

Ethics Committee Approval: The study were approved by the Bakırköy Dr. Sadi Konuk Training and Research Hospital of Local Ethics Committee (protocol code: 2021/405-decision number: 2021-16).

Informed Consent: Retrospective study.

Authorship Contributions

Surgical and Medical Practices: M.S.S., S.A., Concept: M.S.S., S.A., Design: M.S.S., S.A., Data Collection or Processing: M.S.S., S.A., Analysis or Interpretation: M.S.S., Literature Search: M.S.S., S.A., Writing: M.S.S., S.A.

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