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RESEARCH ARTICLE

Predictors and Influential Factors of Prolonged Stay in the Postoperative Surgical Intensive Care Unit

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ABSTRACT

Objective: Prolonged stays in the surgical intensive care unit (SICU) lead to increased costs of care, mortality, and delays in elective operations. This study investigates the factors and predictors of prolonged stays in the SICU.

Materials and Methods: Patients who were followed up in the SICU after the operation between June 2021 and June 2022 were evaluated retrospectively. Patients were classified into a non-prolonged group (<7 days) and a prolonged group (≥7 days) according to the duration of stay in the SICU. The patient's clinical characteristics, comorbidities, anesthesia type, anesthesia- and surgery-related complications were compared between the groups.

Results: The study included 516 patients. Emergency surgery was performed on 37.2% of the patients (n=192). The emergency surgery, intracranial surgery, and surgery duration were significantly higher in the prolonged group (p<0.001, p=0.008, and p<0.001). In addition, the need for mechanical ventilation (Mv), renal replacement therapy (RRT), and sepsis on admission to the SICU was found to be significantly higher (p<0.001 for all). The mean hemoglobin and median albumin levels of patients in the prolonged group upon admission to the SICU were significantly lower (p=0.004 and p<0.001, respectively). At the same time, median GCS scores at admission to SICU were significantly lower, and APACHE-II scores were significantly higher in the prolonged group (p<0.001).

Conclusion: Emergency surgery, intracranial surgery, surgery lasting more than 2 hours, sepsis on admission, MV and RRT requirements, and low hemoglobin and albumin levels are risk factors for prolonged stay. GCS (<11.5) and APACHE-II (>12.5) scores help predict prolonged stay.

Keywords: Length of stay, predictor, prolonged stay, risk factor, surgical intensive care

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INTRODUCTION

The intensive care unit (ICU) is one of the most specialized and costly hospital units, with its advanced monitoring equipment and qualified healthcare team. Prolonged stays in the ICU are associated with an increase in morbidity and mortality and impose significant costs on patients, their families, and the country's economy.[1,2] The length of the ICU stay is also one indicator of intensive care efficiency. As a result of rapid population growth and increased life expectancy, the demand for ICU beds is increasing. Identifying patients at risk of long-term stay may aid critical care management. Determining the factors affecting prolonged stay in surgical intensive care units (SICU) is also essential in planning elective operations that require postoperative beds.

Prolonged stay in SICU in the postoperative period can be influenced by factors such as preoperative patient characteristics, comorbidities, need for urgent surgery, preoperative preparations, unexpected events related to anesthesia and surgery, and type of anesthesia.[3,4] To predict prognosis in ICU patients, scoring systems such as the physical status of the American Society of Anesthesiologists (ASA), Acute Physiology and Chronic Health Assessment-II (APACHE-II), Multiple Organ Dysfunction Score (MODS), Sequential Organ Failure Evaluation (SOFA), and Simplified Acute Physiology Score (SAPS II) are used.[5–7] These scores, while not specific to patients followed in the postoperative period, were developed to predict mortality in patients in the ICU for medical and surgical reasons. They play a crucial role in the field of

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critical care and anesthesiology. However, there needs to be more consensus in the literature regarding prolonged ICU stays, with studies considering 14 or 30-day prolonged stays in medical or mixed ICUs.[5,8] More studies are needed on prolonged stays in the SICU in the postoperative period. In these studies, patients in the SICU of certain branches were included, and three days or more were considered prolonged.[9,10] Patients in the postoperative period are admitted to the SICU for close observation. The 3-day period would not reflect extended hospitalization due to the occupancy of beds in our hospital's ward and the impossibility of discharging patients to the ward. For this reason, in the current study, seven days or more were considered prolonged stays.

This study aims to determine the predictors and influential factors of prolonged stay in patients followed in the postoperative period in the SICU of a tertiary hospital.

MATERIALS and METHODS

This retrospective observational study was started after the approval of the Kanuni Sultan Süleyman Training and Research Hospital Clinical Trials Review Board and Ethics Committee (KAEK/2023.08.108, 09.08.2023). The principles of the Declaration of Helsinki conducted the study. All patients were reached in the SICU in the postoperative period at the Kanuni Sultan Süleyman Training and Research Hospital between June 2021 and June 2022. Patient data were accessed from the hospital information system and patient follow-up files.

In our hospital, assistant and specialist physicians of the Anesthesiology and Reanimation Clinic provide 24/7 follow-up and treatment in the ICU, which has 50 beds. Postoperative patients are followed in the 8-bed SICU. Inclusion criteria are as follows: (1) age ≥18 years; (2) emergency or elective surgical operation; (3) stay in SICU for at least 24 hours. Exclusion criteria included: (1) performing cardiopulmonary resuscitation in the emergency department or operating theater; (2) readmission to SICU; and (3) missing data. This descriptive study did not determine the sample size. All patients followed in the postoperative SICU during the one year between the relevant dates were evaluated.

The patient's demographic data, comorbidities, functional status <4 METS or >4 METS) ASA status, type of operation (emergency or scheduled), operation area and duration, surgery and anesthesia-related complications, type of anesthesia, postoperative analgesic regimen, and intraoperative blood transfusion requirements were recorded. Additionally, sepsis on admission to the SICU, the need for mechanical ventilation (Mv) and renal replacement therapy (RRT) in the SICU, hemoglobin and albumin levels on admission, Glasgow coma scale (GCS) and Acute Physiology and Chronic Health Assessment-II (APACHE-II) scores on admission and 28-day mortality were evaluated.

Statistical Analysis

The data were analyzed using the SPSS Inc., Chicago, USA (SPSS v26.0) program. The suitability of the variables for normal distribution was evaluated using the Shapiro-Wilks test and histogram. Descriptive statistics were expressed as the number of patients, percentage mean±standard deviation, median, and interquartile range (Q1-Q3). In analyzing quantitative variables between two independent groups, the independent sample t-test was used for normally distributed data, and the Mann-Whitney U test was used for non-normally distributed data. Pearson chi-square test and Fisher's exact test were used to evaluate qualitative data. Multivariate logistic regression analysis was applied to factors affecting prolonged stay. Receiver operating characteristics (ROC) curve analysis was performed to determine the predictive power of biomarkers and scores that differed significantly between groups for prolonged stay. The statistical significance limit was accepted as $p<0.05$.

RESULTS

The study included 516 patients who were followed in the SICU between June 2021 and June 2022 (Fig. 1). It was determined that 15.5% of the patients were followed in the SICU for seven days or more (group prolonged, n=80). The median age of the entire population was 66 (51–77) years, and 58.1% (n=300) were women. Demographic data (age, gender, BMI) were similar between groups. While 56.8% (n=293) of the entire population was in ASA III status, ASA status was similar between groups (p=0.512). Elective surgery was performed on 62.8% of the patients (n=324). The prolonged group's emergency operation rate was significantly higher (p<0.001). Abdominal and pelvic area operations were performed on 49.8% of the entire population (n=257). Intracranial operations were significantly higher in the prolonged group (27.5% vs. 13.3%, p=0.008). Surgery time was significantly higher in patients in the prolonged group (p<0.001). Malignancy and trauma surgery did not significantly affect prolonged SICU stay (p=0.528 and p=0.355, respectively). Intraoperative blood transfusion was performed in 28.9% of the population (n=149). Blood transfusion requirements were similar between groups. General anesthesia was applied to 71.1% (n=367) of the entire population, and intrave-

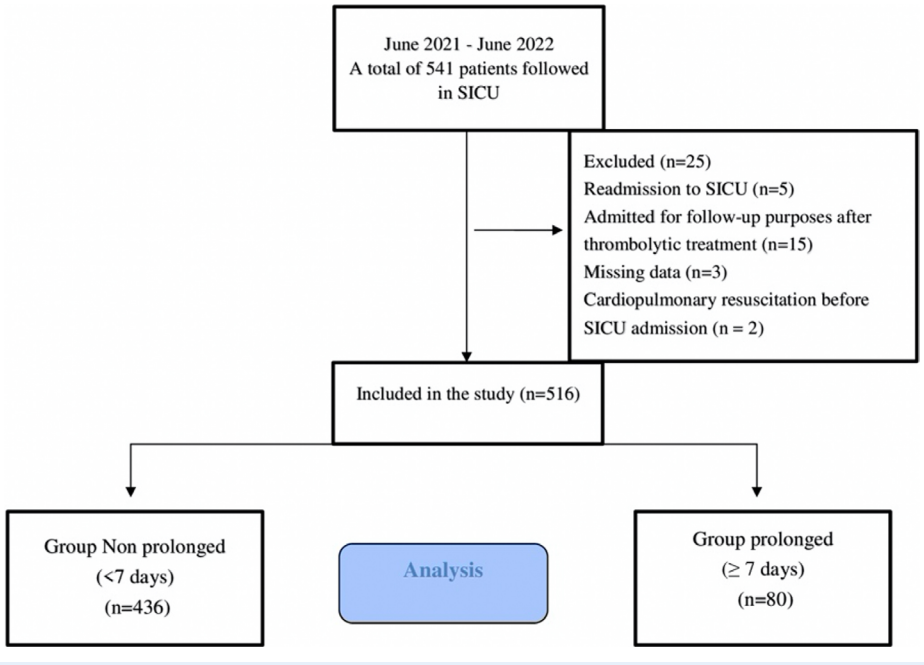

Figure 1. Flow chart of the study

SICU: Surgical intensive care units

nous analgesics (paracetamol, diclofenac sodium, tramadol hydrochloride) were preferred for postoperative analgesia in 79.8% (n=412). The groups' anesthesia types and postoperative analgesic requirements were similar (p=0.346 and p=0.172, respectively). The most common surgical complications in the entire population were postoperative bleeding (2.5%, n=13) and subcutaneous emphysema due to laparoscopic surgery (1.4%, n=7). The most frequently observed anesthesia-related complications were bronchospasm and hypoxemia (4.7%, n=24), hemodynamic instability (0.8%, n=4), and massive transfusion reaction (0.8%, n=4). There was no difference between the groups regarding surgery-related complications and anesthesia-related adverse events (p=0.911 and p=0.127, respectively). In the prolonged group, the need for Mv and RRT and the presence of sepsis on admission to the SICU were significantly higher (p<0.001 for all). The patients' mean hemoglobin and median albumin levels in the prolonged group upon admission to the SICU were significantly lower (p=0.004 and p<0.001, respectively). In the prolonged group, median GCS scores at admission to SICU were significantly lower, and APACHE-II scores were significantly higher (p<0.001). 28-day mortality was found to be 6.8% (n=35) in the entire population (Table 1).

At least one comorbid disease was present in 80% of the population (n=413). The most common comorbid diseases were hypertension (45.3%), coronary artery disease/heart failure (24%) and diabetes mellitus (23.3%). No significant difference was detected between the groups regarding comorbid diseases (Table 2).

In multivariate logistic regression analysis of factors and predictors affecting prolonged stay, emergency surgery, intracranial surgery, operation time, MV requirement in SICU, GCS, and APACHE-II scores were found to be independent risk factors for prolonged hospitalization (p<0.001, p<0.001, p<0.001, p<0.001, p<0.001 and p=0.014, respectively) (Table 3).

In the ROC curve analysis of markers and scores showing significant differences between groups, the cut-off value of hemoglobin ≤10.1 mg/dL, the area under the curve (AUC)=0.601 (0.532–0.670), the cut-off value of albumin ≤3.11 mg/dL, AUC=0.654 (0.587–0.722), the cut-off value of GCS was ≤11.5, AUC=0.631 (0.561–0.701), and the cut-off value of APACHE-II was ≥12.5 and AUC=0.719 (0.653–0.784) (Table 4).

DISCUSSION

In this study conducted in the SICU of a tertiary hospital, emergency surgery, intracranial surgery, >2 hours of the operation duration, sepsis on admission, need for MV and RRT, low hemoglobin and albumin levels on admission, low GCS and high APACHE-II scores were found to be associated with

Table 1. Clinical characteristics of patients

	Overall (n=516)		Group non prolonged (<7 days) (n=436)		Group prolonged (≥7 days) (n=80)		p
	n	%	n	%	n	%	
Age (years)	66 (51–77)		65 (50–77)		66 (56–77)		0.538
Sex							0.064
Female	300	58.1	261	59.9	39	48.8	
Male	216	41.9	175	40.1	41	51.3	
BMI (kg/m^2)	25.7 (23.4–28.7)		25.7 (23.5–28.9)		25.6 (23.1–27.7)		0.523
ASA status							0.512
I	30	5.8	28	6.4	2	2.5	
II	185	35.9	153	35.1	32	40	
III	293	56.8	248	56.9	45	56.3	
IV	8	1.6	7	1.6	1	1.3	
Surgical type							**<0.001**
Emergency	192	37.2	134	30.7	58	72.5	
Scheduled	324	62.8	302	69.3	22	27.5	
Laparoscopic surgery	124	24	104	23.9	20	25	0.825
Operation area							**0.008**
Abdomen and pelvis	257	49.8	219	50.2	38	47.5	
Bone fractures	129	25	115	26.4	14	17.5	
Intracranial*	80	15.5	58	13.3	22	27.5	
Neuraxial	36	7	31	7.1	5	6.3	
Face and neck	6	1.2	6	1.4	0	0	
Eye	5	1	5	1.1	0	0	
Thorax	1	0.2	0	0	1	1.3	
Surgery duration							**<0.001**
<2 hour	182	35.3	170	39	12	15	
≥2 hour	334	64.7	266	61	68	85	
Malignancy surgery	144	27.9	124	28.4	20	25	0.528
Trauma surgery	131	25.4	114	26.1	17	21.3	0.355
Intraoperative blood tx	149	28.9	121	27.8	28	35	0.189
Anesthesia type							0.346
General	367	71.1	306	70.2	61	76.3	
Spinal	142	27.5	123	28.2	19	23.8	
Sedoanalgesia	7	1.4	0	0	7	1.6	
Postoperative analgesia							0.172
IV analgesia	412	79.8	342	78.4	70	87.5	
PNB+IV analgesia	68	13.2	61	14	7	10.3	
Epidural	36	7	33	7.6	3	3.8	
Functional class							0.654
<4 MET	337	65.3	283	64.9	54	67.5	
≥4 MET	179	34.7	153	35.1	26	32.5	

Table 1. Cont.

	Overall (n=516)		Group non prolonged (<7 days) (n=436)		Group prolonged (≥7 days) (n=80)		p
	n	%	n	%	n	%	
Surgical complication							0.911
Postoperative hemorrhage	13	2.5	10	2.3	3	3.8	
Subcutaneous emphysema	7	1.4	7	1.6	0	0	
Pneumothorax	2	0.5	1	0.5	1	1.1	
Ureter injury	2	0.4	0	0	2	0.4	
Trachea/Recurrent nerve injury	2	0.4	1	0.2	1	1.1	
Bowel injury	1	0.2	1	0.2	0	0	
Diaphragmatic damage	1	0.2	0	0	1	1.1	
Anesthesia complication							0.127
Bronchospasm & hypoxemia	24	4.7	20	4.5	4	5	
Hemodynamic instability	4	0.8	4	0.9	0	0	
Massive transfusion reaction	4	0.8	2	0.5	2	2.5	
Cardiopulmonary arrest	2	0.4	0	0	2	2.5	
Sepsis on admission	57	11	30	6.9	27	33.8	**<0.001**
Mechanical ventilation	153	29.7	95	21.8	58	72.5	**<0.001**
RRT	13	2.5	3	0.7	10	12.5	**<0.001**
Hemoglobin (g/dL)	11.1±2.1		11.2± 2.1		10.5± 2.2		**0.004**
Albumin (g/dL)	3.18 (2.73–3.67)		3.25 (2.84–3.70)		2.92 (2.45–3.35)		**<0.001**
Length of stay in SICU	2 (1–4)		2 (1–2)		11.5 (7–16)		–
GCS	15 (10–15)		15 (12–15)		12 (3–15)		**<0.001**
APACHE-II	11 (8–16)		10 (7–14)		17.5 (11–23)		**<0.001**
Mortality (28-day)	36 (7)		10 (2.3)		26 (32.5)		**<0.001**

*: Intracranial surgery was significantly higher in the prolonged group. Data are expressed as number of patients, percentage and median (interquartile range= Q1-Q3). BMI: Body mass index; ASA: American Society of Anesthesiologists; IV: Intravenous, PNB: Peripheral nerve block; MET: Metabolic equivalent; RRT: Renal replasman therapy; GCS: Glasgow coma scale; APACHE-II: Acute physiology and chronic health assessment-II

prolonged stay. However, the prolonged stay did not affect ASA status, anesthesia type, postoperative analgesic regimens, surgery, and anesthesia-related complications.

The widespread use of advanced life support and hemodynamic support systems in ICUs has prolonged survival and length of stay in critical patient groups. Although various studies have investigated factors affecting prolonged stay in ICUs, generally, all patient groups have been included in the studies.[3,5,8,11,12] However, there has yet to be a consensus on prolonged stay. Alkali et al.[11] reported that the rate of prolonged stay was 40.3% in their study, in which they considered stays of 14 days or more in the medical ICU as extended stay. Köse et al.[12] stated that the prolonged stay rate was 11.3%. The authors included all ICU patients in their study and allowed prolonged stay >28 days. Kongsayreepong et al.[9] stated that the rate of prolonged stay in SICU in the postoperative period was 20.1%. The authors accepted a prolonged stay as three days or more. The current study defined extended SICU stay as seven days or more. Transfer may not be possible due to the service beds being full or the patient's relatives not being in the hospital. For this reason, a 3-day period would not reflect a prolonged hospitalization. In our study, we found a prolonged stay rate of 15.5%. We think patient characteristics and care standards followed in SICU may affect the prolonged stay rate.

Different opinions have been reported regarding the effect of demographic characteristics on prolonged stays. Zampieri et al.[13] reported that advanced age is a risk factor for prolonged stays in the ICU. Cevik and Geyik.[8] stated that the prolonged group was significantly older, and there was no

Table 2. Comorbid diseases

Comorbidity	Overall (n=516)		Group non prolonged (<7 day) (n=436)		Group prolonged (≥7 day) (n=80)		p
	n	%	n	%	n	%	
Hypertension	234	45.3	203	46.6	31	38.8	0.197
CAD/HF	126	24.4	111	25.5	15	18.8	0.199
Diabetes mellitus	120	23.3	103	23.6	17	21.3	0.644
Malignancy	83	16.1	67	15.4	16	20	0.300
Asthma/COPD	53	10.3	47	10.8	6	7.5	0.374
Hypo/hyperthyroidism	42	8.1	39	8.9	3	3.8	0.118
Cerebrovascular disease	37	7.2	33	7.6	4	5	0.413
Alzheimer/Parkinson	32	6.2	25	5.7	7	8.8	0.304

Values are expressed as number of patients and percentage. CAD/HF: Coronary artery disease/heart failure; COPD: Chronic obstructive pulmonary disease

Table 3. Multivariate logistic regression analysis of prolonged SICU stay

Variables	Adjusted odds ratio (95% CI)	p
Emergency surgery	0.256 (0.130–0.506)	**<0.001**
Intracranial surgery	0.160 (0.070–0.365)	**<0.001**
Surgery duration	0.375 (0.163–0.862)	**<0.001**
Sepsis on admission	0.444 (0.195–1.012)	0.053
Mechanical ventilation	0.042 (0.015–0.116)	**<0.001**
RRT	0.138 (0.021–0.922)	0.441
Hemoglobin	0.885 (0.754–1.039)	0.135
Albumin	0.592 (0.332–1.056)	0.076
GCS	1.339 (1.192–1.503)	**<0.001**
APACHE-II	1.071 (1.014–1.131)	**0.014**

SICU: Surgical intensive care units; CI: Confidence interval; RRT: Renal replasman therapy; GCS: Glasgow coma scale; APACHE-II: Acute physiology and chronic health assessment-II

Table 4. Prolonged stay prediction performance of markers and scores

	Cut-off	Sensitivity	Specificity	AUC (95% CI)
Hemoglobin	10.1	0.488	0.702	0.601 (0.532–0.670)
Albumin	3.11	0.675	0.594	0.654 (0.587–0.722)
GCS	11.5	0.475	0.784	0.631 (0.561–0.701)
APACHE-II	12.5	0.713	0.679	0.719 (0.653–0.784)

AUC: Area under curve; CI: Confidence interval; GCS: Glasgow coma scale; APACHE-II: Acute physiology and chronic health assessment-II

difference in gender. Arabi et al.[14] reported no difference in age and gender between patient groups who stayed in the ICU for less than or more than seven days. Kongsayreepong et al.[9] stated that age did not significantly affect the prolonged stay in the SICU, but BMI was significantly lower in the prolonged group. In our study, although the average age of the patients in the prolonged group was high and their BMI was low, no significant difference was found.

It has been reported that low functional capacity and comorbid diseases are risk factors for prolonged stays in the ICU.[15] ASA status, the preoperative evaluation of the American Society of Anesthesiologists' physical status, determines prognosis.[16] In our study, around 60% of the population had partial ASA III-IV status, and 80% had at least one comorbid disease. However, ASA status, comorbid diseases, and functional capacity did not affect prolonged SICU stay.

We found that emergency surgery, intracranial operations, and operations lasting 2 hours or more were independent risk factors for prolonged stay in the SICU after surgery. These factors should be carefully considered when planning and managing postoperative care. Notably, we found that various surgical complications and anesthesia-related undesirable conditions, while present in the patients, were not among the factors affecting the stay of 7 days or more. Laparoscopic surgery, trauma or malignancy surgery, an-

esthesia type, and postoperative analgesia management did not show a significant effect on prolonged stay. This could be attributed to the successful treatment of various complications detected in patients in the SICU or the loss of patients within the first seven days.

Infections in the ICU have been associated with prolonged stay and mortality.[17] It has been reported that infected patients stay in the ICU 3 times longer than uninfected patients.[18] Another study stated that sepsis at admission to SICU increased the probability of a prolonged stay by 4.8 times.[9] In our study, sepsis was detected in 11% of the patients upon admission to the SICU, and it was significantly higher in the prolonged group. Early and aggressive treatment of sepsis in patients followed in the postoperative period is effective in preventing prolonged stay and mortality.

Acute or chronic renal failure is frequently observed in patients in the ICU, and dialysis treatments are applied. Although studies report that RRTs extend the length of stay in the ICU, there are also studies stating that they do not affect the duration in the ICU.[19,20] In our study, the rate of continuous RRT was significantly higher in the prolonged group (12.5% vs. 0.3%).

Albumin has significant physiological effects on the body. A preoperative low serum albumin level is an essential biomarker in determining the need for an ICU in geriatric patients.[21] Hypoalbuminemia has also been reported to be associated with increased mortality rates and prolonged stays in the ICU.[22] In our study, albumin levels were significantly lower in the prolonged group. Preoperative nutritional support and optimization of serum albumin levels will reduce the rate of prolonged stay in SICU, especially in geriatric patients.

It has been reported that a decrease in hemoglobin levels is associated with a prolonged stay in postoperative patients.[21] A hematocrit level of 34% and above effectively reduces the stay in the SICU to less than three days.[9] In the current study, although hemoglobin levels were significantly lower in the prolonged group, they were not an independent risk factor for prolonged stay. In addition, although blood transfusion reactions were seen at a higher rate in the prolonged group, no significant difference was detected. Preventing the decrease in hemoglobin levels, especially in geriatric patients with high ASA status, may help avoid complications related to impaired tissue oxygenation and blood transfusion.

It has been stated that invasive and non-invasive Mv applications in the ICU are associated with prolonged lengths of stay.[8,13,14,23] This situation initiates sedation for mechanical ventilation, prolongs the weaning process, and causes Mv-related complications and infections. Tracheostomy, or tracheostomy, is one of the most frequently performed procedures in the ICU due to prolonged mechanical ventilation, failure in weaning, and upper airway obstruction.[24] Although it has been reported that tracheostomy/tracheotomy is associated with a prolonged stay in the ICU, it has also been reported that early tracheostomy may shorten the length of stay in the ICU.[25] In our study, Mv requirement was determined to be an independent risk factor for prolonged stay. The weaning process, mechanical ventilation-related complications, and infections are associated with a prolonged stay. Since the length of stay was determined to be seven days or more in our study, the effect of tracheostomy applications on the length of stay was not evaluated.

GCS and APACHE-II scores are used to determine prognosis and predict mortality in critically ill patients followed up in the ICU.[17] Low GCS and high APACHE-II scores on admission to the ICU are associated with mortality. It has been reported that patients with a high APACHE-II score (APACHE-II score ≥30) have a short stay in the ICU due to early mortality.[26,27] Kıray et al.[28] stated that although the APACHE-II score was high in the prolonged group, there was no significant difference, and GCS scores were significantly lower. In our study, GCS and APACHE-II scores were independent predictors of prolonged length of stay. It can predict prolonged length of stay in patients followed in the SICU in the postoperative period.

Study Limitations

The study, while comprehensive, has some limitations. Its main limitation is that it is retrospective and single-centered. Another limitation is that cardiac surgery patients were not included in the study.

CONCLUSION

In conclusion, the study underscores the significant impact of prolonged stay in SICU. This not only creates an economic burden on the healthcare system but also increases mortality rates. The findings are particularly relevant for patients scheduled for elective surgery, as their operations may be postponed. The study identifies several factors associated with prolonged stay, including emergency surgery, intracranial surgery, operation time over 2 hours, sepsis on admission to SICU, Mv and RRT requirements, low hemoglobin, albumin levels, and low GCS and high APACHE-II scores on admission to SICU.

Disclosures

Ethics Committee Approval: The study was approved by the Kanuni Sultan Süleyman Training and Research Hospital Clinical Research Ethics Committee (No: 2023.08.108, Date: 09/08/2023).

Authorship Contributions: Concept: K.A., R.A.A.; Design: K.A., R.A.A.; Supervision: K.A., A.S.Ş.; Funding: K.A.; Data Collection or Processing: K.A., A.S.Ş.; Analysis or Interpretation: K.A., R.A.A.; Literature Search: K.A., A.S.Ş.; Writing: K.A.; Critical review: K.A., A.S.Ş.

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