İstanbul Med J 2024; 25(1): 56-62
DOI: 10.4274/imj.galenos.2024.61430

Evaluation of Perioperative Scores Specific to Orthopedic Surgery Related to Intensive Care Admission and Mortality: CCI, ARISCAT and SAPS3 as Valuable Perioperative Orthopedic Risk Scores

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ABSTRACT

Introduction: Estimating intensive care admission of orthopedic patients is challenging because of patient variance and multiple comorbidities, primarily in geriatrics, and not yet standardized for the planned and qualified utility of hospital services. This study aimed to reveal the perioperative risk scores of orthopedic patients followed postoperatively in intensive care to investigate the efficacy of these scores in predicting intensive care admission and mortality.

Methods: Patients transferred from the orthopedic ward to the intensive care unit (ICU) at any time during their postoperative follow-up from 2022 to 2023 were investigated. Primarily searched scores were the Surgical Apgar, Wells for pulmonary embolism, Charlson Comorbidity Index, ARISCAT for Postoperative Pulmonary Complications preoperatively, and Simplified Acute Physiology III, Sequential Organ Failure Assessment (SOFA), quick-SOFA, and Acute Physiology and Chronic Health Evaluation postoperatively. These scores were evaluated in relation to total intensive care and hospital stay with mortality.

Results: The majority of the study population was found to be ASA-2 (45%). Ninety-eight percent of the patients were admitted to the ICU within three postoperative days, with the indication of planned postoperative follow-up mainly after proximal femoral nailing (24%). Among preoperative scores, wells had a significant positive correlation with ICU readmission and length of ICU stay (r=0.32, p=0.001). 62.7% of the patients had severe Charlson Comorbidity Risk Index. Up to postoperative scores, SAPS3 had a significant positive correlation with total ICU and hospital stay, with a significant difference in mortality (p=<0.001).

Conclusion: Among preoperative risk scores, the Charlson comorbidity index and ARISCAT scores could be valuable in predicting the need for postoperative intensive care for orthopedic surgery. Evaluating the daily postoperative SAPS3 score of these patients at the orthopedic ward could help organize patient care services and guide early critical care consultation.

Keywords: Surgical Apgar Score, Simplified Acute Physiology Score 3, Wells score, Charlson Comorbidity Index, intensive care, orthopedic surgery

Introduction

The scope of orthopedic surgeries may include musculoskeletal disorders of young people with concomitant syndromes, geriatric patients requiring major surgery, or trauma patients of all ages and comorbidities. Not surprisingly, these patients may need planned or unplanned intensive care unit (ICU) follow-up because of possible comorbidities or postoperative surgical complications (1). Evaluating the ICU needs of these patients will significantly improve qualified patient management, efficient use of hospital resources, and earlier intervention, resulting in improved morbidity and mortality. To predict the postoperative condition of a patient, there are risk scores perioperatively used but not explicitly studied for orthopedic patients.

Preoperative assessment scores allow for foreseeing the postoperative scenario and expectations regarding the mortality and morbidity of each patient. Many scores have been proposed for this mission, even those specialized to specific surgery types (2). However, probably because of the diversity of patient characteristics and the broad scope of surgeries, a specific scoring system designed for orthopedics and traumatology has not been identified (3). In addition, studies have focused on preoperative indicators in hip surgery because of high mortality rates. However, probably because the population of these surgeries was mainly geriatric, the commonly used preoperative scores, such as the Physiological and Operative Severity Score for enumeration of mortality and morbidity, were found to overestimate mortality (4,5). Therefore, this study was

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Cite this article as: Çalışkan B, Boyacı N, Gök MA, Beşir Z. Evaluation of Perioperative Scores Specific to Orthopedic Surgery Related to Intensive Care Admission and Mortality: CCI, ARISCAT and SAPS3 as Valuable Perioperative Orthopedic Risk Scores. İstanbul Med J 2024; 25(1): 56-62.

Received: 15.12.2023
Accepted: 05.02.2024

designed with a focus on all orthopedic patients needing ICU at any time during their surgical care and to search for the most likely perioperative assessment tool by investigating relevant scores that have not been searched in orthopedics. Therefore, we based our selection of data and scores on possible ICU indications, perioperative unwanted effects, and problems mostly specific to orthopedic surgery in clinical practice. Because most geriatric population has many comorbidities, as the literature implies, it is an ongoing challenge in orthopedics. We searched the Charlson Comorbidity Risk Index (CCI) and the ASA (4,6). Because cardiac and pulmonary complications are higher in association with long bone fractures, clinical frailty, and polypharmacy with comorbidities, the Wells score for pulmonary embolism and ARISCAT score for postoperative pulmonary complications were searched (6-8). To add a practical tool to assess intraoperative variables, especially blood loss, the Surgical Apgar Score (SAS) was selected (9). Because we sought a perioperative assessment for the risk of ICU need and mortality, we included postoperative quick Sequential Organ Failure Assessment (SOFA), SOFA, Acute Physiology and Chronic Health Evaluation II (APACHE II), and SAPS3 scores on the day of ICU admission to enlighten a predictive assessment tool to be used daily in the ward (10-12). All of which are to maintain orthopedic-based qualified care to prevent ICU need or lower mortality by early diagnosis and intervention.

Methods

This retrospective study was approved by University of Health Sciences Turkey, Haseki Training and Research Hospital Institutional Ethics Committee (approval number: 112-2023, date: 07.06.2023), and all research and analysis were conducted according to the Helsinki Declaration because it was an investigation based on medical records within the hospital informative system, exempted from informed consent. Of 1,192 patients who received orthopedic surgery (emergent or elective) at University of Health Sciences Turkey, Haseki Training and Research Hospital Institutional Orthopedics and Traumatology Department between January 2022-June 2023, 109 patients were transferred to the ICU at any time during their hospital stays. The inclusion criteria were ASA 1-4 patients aged over 18, and if they were readmitted, we evaluated the first ICU admission. The exclusion criteria were patients with incomplete data, patients who were admitted to surgery while in intensive care and transferred back to the ICU, those who developed an intensive care-acquired infection after being admitted to the ICU, or those with a complication unrelated to surgery after ICU admission.

We reviewed the medical records to calculate the selected scores and demographic data. To calculate ASA, SAS, CCI, Wells, and ARISCAT, we used preoperative medical anamnesis, preoperative anesthesia evaluation, laboratory analysis performed at most one day preoperatively, and intraoperative anesthesia forms were re-examined as the source of information. Afterward, medical records highlighted in the ICU consultation and laboratory analysis on the day of ICU admission were used to calculate SAPS3, qSOFA, SOFA, and APACHE II scores. Each medical record was evaluated from hospitalization until discharge, including in-hospital mortality.

Primary Outcome

The primary outcome was to reveal the study scores of the patients perioperatively transmitted to the ICU with the evaluation of their effect on the length of ICU and hospital stay.

Secondary Outcome

The secondary outcome was to demonstrate the relationship between the study scores and in-hospital mortality among patients perioperatively admitted to the ICU from the orthopedic ward.

Statistical Analysis

All analyses were performed using SPSS 15.0 for Windows. Descriptive statistics are given as mean, standard deviation, minimum, and maximum for categorical and numerical variables. Ratios in independent groups were compared using the chi-square test. Two independent group comparisons of numerical variables were performed using the Student's t-test when the normal distribution condition was met and with the Mann-Whitney U test when not. Spearman correlation analysis analyzed the relationships between numerical variables because the parametric test condition was not met. The alpha significance level was set as $p<0.05$. A receiver operating characteristic curve was determined for each prognostic score, and the best sensitivity and specificity for mortality were estimated as the cut-off points.

Results

Demographic data of the study population: The mean age of the patients was found to be 70 years, similarly distributed by gender. 12.8% of the population did not have any comorbidities, and if so, hypertension and diabetes mellitus were the leading diseases among them (Table 1). Notably, the distribution of ASA classifications was

Table 1. Demographic values of the study population

Age	**70.1±16.1 (18-95)**
ASA n (%)	
1	12 (11.0)
2	49 (45.0)
3	44 (40.4)
4	4 (3.7)
Gender n (%)	
Male	53 (48.6)
Female	56 (51.4)
BMI*	26.5±4.8 (18-40)
Comorbidity n (%)	
Hypertension	60 (55.0)
Diabetes mellitus	49 (45.0)
Coronary heart disease	39 (35.8)
Chronic obstructive pulmonary disease	21 (19.3)
Congestive heart failure	18 (16.5)
Chronic kidney disease	15 (13.8)
Arrhythmias	8 (7.3)
Dementia	9 (8.3)
Psychoneurological diseases	6 (5.5)
Cancer	5 (4.6)

*Mean ± SD (minimum-maximum), ASA: American Society of Anesthesiolog, BMI: Body mass index

discovered to be mainly ASA-2. Nine postoperative patients who were excluded because they were exitus before ICU at the surgical ward were found to be ASA-4.

Data related to anesthesia and surgery: Most patients who had received proximal nailing surgery needed ICU postoperatively (Table 2).

Data related to ICU and hospital stay with mortality: Patients were mostly taken into the ICU within 72 h postoperatively with the indication of planned postoperative follow-up because of patient comorbidities or major surgery (Table 3). The average hospital stay lasts 15.9±13.5 days, and the 30-day mortality was 17.4% among these patients, all concluded at their hospital stay.

Primary Outcomes

Surgical Apgar Score: Most patients (71.3%) was found to have moderate (5-7) scores. In addition, only 19 patients admitted to the ICU had low SASs (Table 4). There was no significant correlation between ICU readmission, length of ICU stay,and hospital stay (p=0.09, 0.95, 0.17) (Table 5).

Wells score for pulmonary embolism and ARISCAT score for postoperative pulmonary complications: 82.6% of patients had Wells scores of an unlikely pulmonary embolism, and only three patients had an ICU indication because of clinically suspected pulmonary embolism (Table 4). However, higher scores had a significant positive correlation with the length of ICU stay (Table 5). Meanwhile, 46 patients had moderate to high ARISCAT scores without significant correlation with the length of ICU stay (Table 5).

Charlson Comorbidity Index: 62.7% of the patients had severe CCI (Table 4). There was no significant correlation between the length of ICU stay and hospital stay.

Table 2. Data related to anesthesia and surgery

The type of anesthesia n (%)	
General anesthesia	51 (46.8)
Combined spinal-epidural	5 (4.6)
Spinal	46 (42.1)
Peripheral nerve block	1 (0.9)
Sedo-analgesia	1 (0.9)
Epidural and general	4 (3.7)
Surgery (n, %)	
Proximal femoral nailing	29 (26.6)
Hip prostheses	28 (25.7)
Vertebra, instrumentation-laminectomy	11 (10)
Amputation	16 (14.6)
Fracture surgery, lower extremity (intramedullary nailing, osteosynthesis)	12 (11)
Others (debridman, external fixation)	11 (10)
Tumor	2 (1.8)
Surgery time*	178.5±132.6/44-630 (122.5)
Preoperative Hb*	10.7±2.3/6-17 (10.3)
Postoperative Hb*	9.5±2.0/5.5-14.6 (9.3)
Preoperative creatinine*	1.17±0.88/0.33-4.33 (0.94)
Postoperative creatinine*	1.15±1.04/0.16-6.08 (0.89)
Preoperative SpO_2*	93.4±4.1/80-100 (94)
Vasoactive drug need n (%)	40 (36.7)
Intraoperative blood loss *	363.9±582/0-2900 (135) mL
Preoperative heart rate*	89.8±18.2/50-133 (86.5)
Perioperative lowest systol*	94.3±20.6/48-140 (95)

*Mean ± standard deviation/minimum-maximum (median)

Table 3. Data related to ICU and hospital stay with mortality

Time of ICU admission (day)	
Preoperative	5 (4.6)
Postoperative 72 h	99 (90.8)
Postoperative more than 3 days	5 (4.6)
ICU indication n (%)	
PACU	68 (62.4)
Respiratory insufficiency	29 (26.6)
Pulmonary embolism	3 (2.8)
Heamodynamic insufficiency	24 (22.1)
Proved infection at ICU admission n (%)	
Culture negative	69 (63.3)
Culture positive	40 (36.7)
Total blood transfusion *	1.6±1.9/0-9 (1)
Total ICU stay*	3.6±4.1/1-20 (2)
Total hospital stay*	15.9±13.5/4-109 (11)
Mortality (30 days) n (%)	19 (17.4)

*Mean ± SD/minimum-maximum (median)

Table 4. Preoperative and postoperative scores

Surgical Apgar Score*	**6.1±1.6/2-10 (6)**
Low (8-10), n (%)	19 (17.6)
Moderate (5-7), n (%)	77 (71.3)
High (0-4), n (%)	12 (11.1)
Wells score	2.3±2.2/0-9 (1.5)
Unlikely (<5 point), n (%)	90 (82.6)
Likely (>4 point), n (%)	19 (17.4)
Charlson Comorbidity Index*	5.0±2.6/0-13 (5)
Mild (1-2), n (%)	13 (12.7)
Moderate (3-4), n (%)	25 (24.5)
Severe (>5), n (%)	64 (62.7)
ARISCAT score *	42.0±15.4/8-78 (42)
Low (<26), n (%)	19 (17.4)
Medium (26-44), n (%)	44 (40.4)
High (>44), n (%)	46 (42.2)
Quick SOFA*	1.0±1.0/0-3 (1)
0-1 no infection	77 (70.6)
2-3 possible infection	32 (29.4)
SOFA*	4.4±3.2/0-18 (4)
APACHE II*	15.4±8.1/0-41 (13)
SAPS3*	57.2±13.7/32-98 (56)

*Mean ± SD/minimum-maximum (median), SOFA: Sequential Organ Failure Assessment, APACHE II: Acute Physiology and Chronic Health Evaluation II

Quick SOFA, SOFA, APACHE, SAPS3: Most patients in the orthopedic ward were not found to have sepsis due to low q-SOFA scores by negative culture results from the first samples taken at admission to the ICU (Table 3, 4). SOFA, APACHE, and SAPS3 scores at the same time interval had a significant positive correlation with the length of ICU stay, and SAPS3 also had a significant positive correlation with total hospital stay (Table 5).

Secondary Outcomes

Preoperative scores: SAS, Wells, and ARISCAT were found to be unrelated to mortality because lower scores or higher risks were not apparently distributed to the patients who ended up exitus as expected. Severe CCI was correlated with mortality as % 63.2 of the exitus patients (Table 6).

Postoperative scores: SAPS3 had a higher range between exitus and healthy discharge. For SAPS3, the receiver operating characteristic (ROC) curve area was 0.864 (95% CI: 0.78-0.94) with a 61.5 cut-off point (sensitivity: 73%; specificity: 75) (Figure 1). For APACHE II and SOFA, the ROC curve areas were 0.799 (95% CI: 0.67-0.92) with a 15.5 cut-off point (sensitivity: 73%; specificity: 71%) and 0.738 (95% CI: 0.61-0.86) with a cut-off point 4.5 (sensitivity: 63%; specificity: 63) (Figure 1).

Table 5. Relationship of Scores length of ICU stays and length of hospital stays

	ICU stay		Total hospital stay	
	r	p	r	p
Surgical Apgar Score	-0.005	0.95	-0.13	0.17
Wells score for pulmonary embolism	0.32	0.001	0.16	0.09
Charlson Comorbidity Index	0.04	0.61	-0.071	0.46
ARISCAT score	0.11	0.23	0.01	0.91
Quick SOFA at ICU admission	0.55	<0.001	0.21	0.03
SOFA score at ICU admission	0.45	<0.001	0.18	0.05
APACHE score at ICU admission	0.45	<0.001	0.09	0.3
SAPS 3	0.48	<0.001	0.21	0.03

SOFA: Sequential Organ Failure Assessment, APACHE II: Acute Physiology and Chronic Health Evaluation II, ICU: Intensive care unit

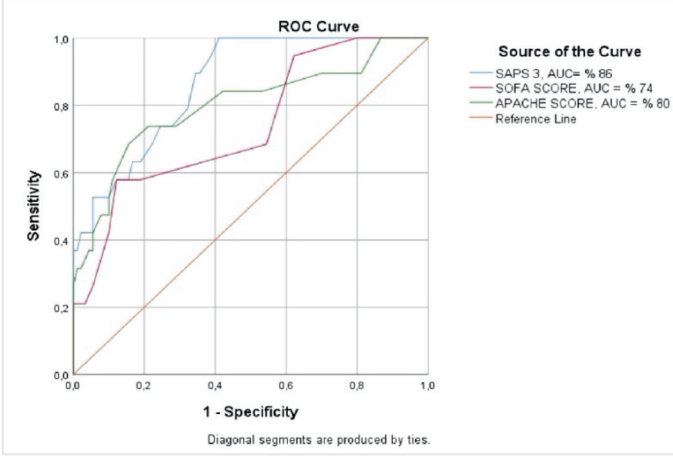

Figure 1. SAPS3, APACHE 2, and SOFA scores and mortality
SOFA: Sequential Organ Failure Assessment, APACHE II: Acute Physiology and Chronic Health Evaluation II, ROC: Receiver operating characteristic

Table 6. Scores and mortality (exitus and healthy discharge)

	Exitus	Healthy discharge	p
Surgical Apgar Score*	6.6±1.7/3-9 (7)	6.0±1.5/2-10 (6)	0.18**
Low (8-10), n (%)	6 (31.6)	13 (14.6)	0.19
Moderate (5-7), n (%)	11 (57.9)	66 (74.2)	
High (0-4), n (%)	2 (10.5)	10 (11.2)	
Wells score	3.7±2.9/0-9 (3)	2.0±1.9/0-9 (1.5)	0.01**
Unlikely (<5 point), n (%)	11 (57.9)	79 (87.8)	0.005
Likely (>4 point), n (%)	8 (42.1)	11 (12.2)	
Charlson Comorbidity Index*	5.0±1.7/2-9 (5)	5.0±2.8/0-13 (5)	0.86**
Mild (1-2), n (%)	2 (10,5)	11 (13.3)	1.0**
Moderate (3-4), n (%)	5 (26,3)	20 (24.1)	
Severe (>5), n (%)	12 (63,2)	52 (62.7)	
ARISCAT score*	44.3±12/22-65 (43)	41.5±16.1/8-78 (42)	0.47
Low (<26), n (%)	1 (5.3)	18 (20)	0.30**
Medium (26-44), n (%)	9 (47.4)	35 (38.9)	
High (>44), n (%)	9 (47.4)	37 (41.1)	
Quick SOFA*	1.9±1.0/0-3 (2)	0,8±0.89/0-3 (1)	<0.001**
0-1 no infection	8 (42.1)	69 (76.7)	0.003**
2-3 possible infection	11 (57.9)	21 (23.3)	
SOFA*	7.2±4.4/2-18 (7)	3.8±2.5/0-10 (4)	0.001**
APACHE II*	24.0±10.6/9-41 (21)	13.6±6.1/0-34 (13)	<0.001**
SAPS3*	73.2±13.0/56-98 (75)	53.9±11.3/32-79 (54)	<0.001

*Mean ± standard deviation/minimum-maximum (median), **Mann-Whitney U testi, SOFA: Sequential Organ Failure Assessment, APACHE II: Acute Physiology and Chronic Health Evaluation II

Discussion

Our retrospective observational analysis revealed that some perioperative scores were significantly higher in 109 patients perioperatively admitted to the ICU among a total of 1192 orthopedic surgeries and may be useful for generalizing the prediction of the ICU need, length of hospital stays, and mortality in routine clinical practice. Our research suggests that CCI could be a better option for the identification and allocation of ICU resources for orthopedic patients with regard to ASA, Wells, ARISCAT, and SAS scores. Moreover, the higher correlation of SAPS3 compared with SOFA and APACHE scores in the length of ICU and hospital stays seemed promising to navigate the perioperative health care needs of orthopedic patients. In addition, SAPS3 scores, with their higher specificity and distinct cut-off point, may be a more accurate tool for predicting mortality than others for orthopedic patients. Accordingly, among the many preoperative and postoperative prognostic scores that can be used in the care of orthopedic patients, especially for planned proximal femoral nailing and partial prostheses, CCI and SAPS3 scores seem to be more relevant.

Although postoperative critical care has been reported to be required mainly after spine surgeries, in our institution, patients in the ICU had mostly geriatric lower extremity fractures (13). This could be due to the perception of our anesthesiology and reanimation department about the utility of postoperative critical care based chiefly on patient comorbidities. This is the reason for this study to investigate CCI, especially for orthopedic surgery. Under our understanding of ICU needs, patients are primarily admitted postoperatively with the ICU indication (62.4%) as planned post-anesthesia care, and 95% have comorbidities with moderate to severe CCI (87.2%).

Interestingly, however, most of our patients were ASA-2, and only four were ASA-4. Although previous literature implies its reliability related to hospital stay and mortality, these studies were restricted to arthroplasties, and no study reflecting its usefulness in the general orthopedic population has not yet been published (14). Therefore, we assumed that the physical status classification of orthopedic patients could not be as valid as that in other surgical populations because it would be subjective to evaluate a disabled geriatric patient with a physical activity score.

The second most frequent ICU indication for postoperative orthopedic patients was respiratory insufficiency, with only a few being diagnosed with pulmonary emboli. This is not surprising with trauma patients, especially long bone fractures in orthopedics, because of the known complexity of managing a prothrombotic state after trauma and immobility due to extremity injury along with the risk of bleeding due to anticoagulants and surgery (7). Therefore, a risk assessment tool for deep vein thrombosis may guide further preoperative examination and predict the need for postoperative respiratory support in the ICU (15). In our study, as its utility in trauma and orthopedic patients is a valid tool, we evaluated the Wells score, and most postoperative patients admitted to the ICU were found to have a low risk for embolism (7,15,16). However, we also searched for a novel tool recently used for non-thoracic surgery but not for orthopedic surgery (8,17,18). Notably, ARISCAT scores within our study were found to be high, as expected because these patients were admitted to the ICU because of respiratory insufficiency. Thus, the ARISCAT score seems correlateded than Wells scores in postoperative orthopedic patients because of our results and promising further research.

Moreover, other than preoperative evaluation, intraoperative assessment with SAS has been shown to predict postoperative ICU admission because its relationship with postoperative complications and mortality is well-described (9,19). However, its correlation with ICU admission has been revealed in previous studies of abdominal surgeries (9). For orthopedic surgery, research is limited to its relation to increased complications after arthroplasties and spine surgeries (20,21). SAS scores of our patients were relatively moderate, and only 11% of ICU-admitted patients had low scores. The reason was obvious when we observed that the data of mean intraoperative blood loss, heart rate, and lowest systole or even amount of blood transfusion of our patients were not significant, possibly due to tourniquet and tranexamic acid use in orthopedic surgery (Table 2) (22). Consequently, SAS may not be a valid tool for orthopedic surgery to assess ICU admission and mortality.

Association of Critical Illness Scores (APACHE, SOFA) are crucial for critical care because they are accepted as indicators of ICU and total hospital stay, especially mortality (11,12). Furthermore, another mortality estimation score, SAPS3, has demonstrated its utility as a predictor of postoperative ICU admission (10). Therefore, our study searched these scores on the day of ICU admission at the surgical ward to analyze and compare if they could be used as an indicator before ICU admission and revealed that SAPS3 could be the score of choice for orthopedic surgery with its higher sensitivity and specificity than the others and it could help to organize hospital searches with its strong correlation to length of ICU and hospital stay.

Study Limitations

Our data represent a single-center observation of an orthopedic center of the same type of surgery with the same anesthesiologist deciding the need for critical postoperative care. In a center in which oncologic surgeries are the majority or having a PACU for only 24-h follow-up, ICU indications would be different from ours. Therefore, our study could guide the creation of an orthopedic-based risk assessment score, but it still needs to be investigated in a multi-centered design. Because most geriatric patients with comorbidities need ICU, additional comorbidity measures could be valuable to evaluate. However, we preferred the accustomed CCI, and future research comparing comorbidity- and frailty-based scores, such as age-adjusted CCI or clinical frailty scale, would clarify the most appropriate comorbidity index for orthopedic patients (14).

Although the association between perioperative myocardial injury and cardiovascular outcomes appeared in our study with hemodynamic insufficiency (19.3%) after orthopedic surgery, we could not analyze the troponin levels of each patient because of missing data in our retrospective analysis (23). In addition, it would be wise to add the type of surgery that

was shown to be related to increased mortality or ICU admission to create a risk assessment tool. As we demonstrated in our study, hip fractures and amputations could be compatible with previous literature as they were shown to be related to increased mortality (24,25). In addition, based on our results, most compatible scores, such as CCI and SAPS3, should be accompanied by a cognitive assessment of patients, which were shown to be mostly at older age to complete a specified risk assessment for orthopedic surgery because delirium is a major contributor to mortality, length of hospital stay, and critical care (26).

Conclusion

Standardized risk stratification designed especially for orthopedic surgery is essential to improve the organization of hospital care services through proper prediction of ICU needs, length of hospital stay, and mortality. A combination of scores proven significant in intensive care admitted postoperative orthopedic patients, as revealed in this study, CCI, ARISCAT, and SAPS3, could be used and provide incipiency for further research.

Ethics Committee Approval: This retrospective study was approved by University of Health Sciences Turkey, Haseki Training and Research Hospital Institutional Ethics Committee (approval number: 112-2023, date: 07.06.2023).

Informed Consent: Retrospective study.

Authorship Contributions: Surgical and Medical Practices - B.Ç., N.B., M.A.G., Z.B.; Concept - B.Ç.; Design - B.Ç.; Data Collection or Processing - N.B., M.A.G., Z.B.; Analysis or Interpretation - B.Ç.; Literature Search - B.Ç.; Writing - B.Ç.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

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