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RESEARCH

# The Use of Surgical Apgar Score as a Predictor of Postoperative ICU Admission

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## ABSTRAK

Background: Postoperative Intensive Care Unit (ICU) care can improve outcomes in high-risk surgical patients. The Surgical Apgar Score (SAS) was developed to predict postoperative morbidity and mortality; however, its ability to predict ICU admission remains unclear
Objective: To evaluate the utility of the SAS as a predictor of postoperative ICU admission.
Methods: This prospective cohort study included 314 surgical patients at Dr. Sardjito General Hospital between June and July 2025. Data on demographics, preoperative status, intraoperative variables (including the SAS), ICU admission, and postoperative mortality were analyzed using both bivariate and multivariate methods.
Results: Lower SAS scores were significantly associated with an increased risk of postoperative ICU admission in multivariate analysis, particularly in SAS categories 0–2 (OR 326.45; p = 0.016) and 5–6 (OR 47.39; p = 0.037). The ROC curve of SAS for predicting postoperative ICU admission yielded an AUC of 0.701 (p = 0.001; 95% CI: 0.62–0.78) with a cut-off value of 6.5. Neurosurgical and vascular thoracic procedures, cardiovascular comorbidities, intraoperative vasopressor use, and surgical duration greater than 2 hours were also strong predictors of postoperative ICU admission. The postoperative mortality rate was 3.5%, mainly associated with surgical duration exceeding 6 hours (predictive factor) and other types of surgery (protective factor). The SAS, with clinical factors such as procedure type, comorbidities, and surgical duration, may help guide the decision for postoperative ICU admission
Conclusion: The SAS is a useful tool for predicting postoperative ICU requirements. Surgical duration of more than 6 hours and other types of surgery were the most consistent and significant predictors of mortality.

**Keywords**: Surgical apgar score, ICU admission, mortality, perioperative

## INTRODUCTION

Access to surgical procedures has been steadily increasing worldwide, with an estimated 187 to 200 million operations performed annually. However, within 30 days after surgery, nearly 10% of patients experience adverse events, and approximately 1 million deaths occur each year.[1] To support perioperative clinical decision-making, various risk stratification systems have been developed. Models that integrate both preoperative and intraoperative variables have demonstrated greater accuracy in predicting risk. Notably, evidence indicates that intraoperative factors significantly influence postoperative outcomes.[2]

Admission to the Intensive Care Unit (ICU) after surgery may improve outcomes in high-risk patients. However, unnecessary or unplanned ICU admissions are associated with increased mortality and higher healthcare costs.[3] In resource-limited settings, ICU admission should be carefully prioritized. Patients requiring immediate life-saving interventions are classified as Priority 1, whereas those requiring primarily close monitoring fall into Priority 3.[4] This underscores the need for an objective, simple, and cost-effective tool to identify high-risk patients most likely to benefit from postoperative ICU care.

One such tool is the Surgical Apgar Score (SAS), which is based on three intraoperative parameters: estimated blood loss, lowest mean arterial pressure (MAP), and lowest heart rate during surgery.[2] The SAS is broadly applicable across diverse surgical procedures, whether elective or emergency, regardless of anesthesia type or baseline patient characteristics.5 Given its established correlation with postoperative complications and mortality, the SAS may also serve as a practical instrument for predicting the need for postoperative ICU admission.[3] Therefore, this study aimed to evaluate the predictive value of SAS for postoperative ICU admission.

## METHODS

This study employed a prospective cohort design to evaluate SAS as a predictor of postoperative ICU admission among surgical patients at Dr. Sardjito General Hospital. Subjects were enrolled consecutively over a defined study period to assess the relationship between SAS values and clinical outcomes. The study was conducted at Dr. Sardjito General Hospital, Yogyakarta, after obtaining ethical approval from the Research Ethics Committee of the Faculty of Medicine, Public Health, and Nursing, Universitas Gadjah Mada, as well as institutional permission from the hospital.

A consecutive sampling method was used. Patients who presented consecutively and met the eligibility criteria were included until the required sample size was reached (n = 314). Inclusion criteria: patients aged ≥18 years, scheduled for surgery, and receiving general anesthesia, regional anesthesia, or peripheral nerve block. Exclusion criteria: patients scheduled for cardiac surgery or catheterization, diagnostic procedures (non-incisional or excisional), one-day care (ODC) surgery, or those admitted to the ICU or high care unit (HCU) prior to surgery. Dropout criteria: patients or family members who withdrew consent and patients with incomplete data.

The study variables were categorized into three groups: Independent variables (the Surgical Apgar Score (SAS), consisting of estimated blood loss (EBL), lowest mean arterial pressure (MAP), and lowest heart rate). Dependent variables (postoperative ICU admission and postoperative mortality). Confounding variables (age, sex, comorbidities (obesity, hypertension, pulmonary disease, cardiovascular disease, diabetes mellitus, renal failure, sepsis, cerebrovascular disease, malignancy), ASA physical status, type of surgery, type of anesthesia, duration of surgery, intraoperative vasopressor use, and intraoperative blood transfusion [packed red cells, PRC]).

All variables were defined operationally and measured based on medical records, anesthesia records, and case report forms. The SAS was classified into five categories: 0–2, 3–4, 5–6, 7–8, and 9–10. ICU admission was defined as postoperative care in the ICU, whether planned or unplanned. Postoperative mortality was defined as death occurring during the

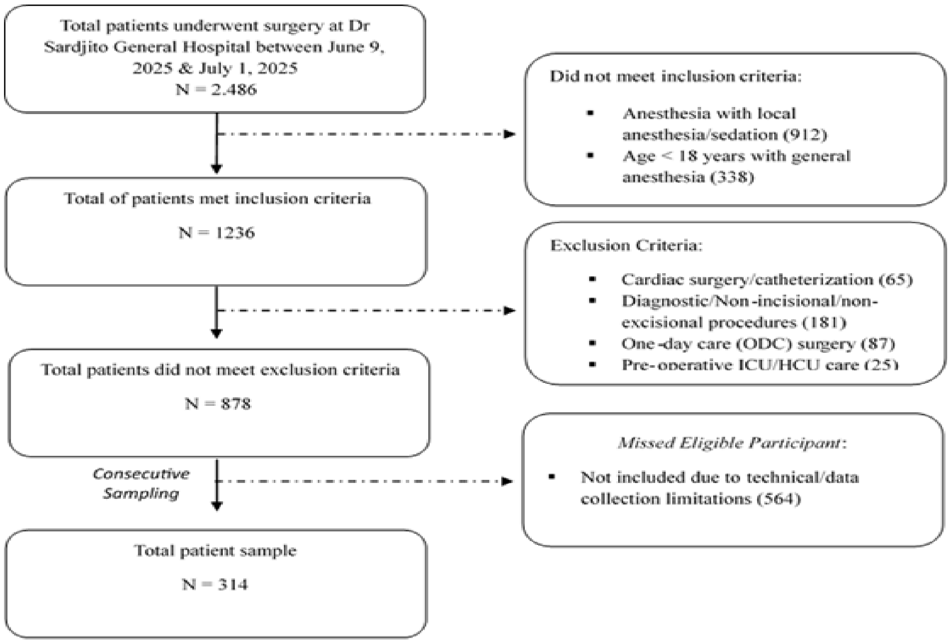


**Figure 1. Flow Diagram of Patient Selection**

postoperative hospital stay. Both independent and confounding variables were analyzed in relation to the dependent outcomes. Bivariate and multivariate logistic regression analyses were performed to identify predictor factors for the primary outcome (ICU admission) and the secondary outcome (postoperative mortality). Results were expressed as odds ratios (ORs) with corresponding 95% confidence intervals (CIs). Statistical significance was set at $p < 0.05$.

## RESULT

Characteristics of Study Subjects

A total of 314 patients undergoing surgical procedures were included in this study. The baseline characteristics are summarized in Table 1. The majority of patients were younger than 60 years (78%) and female (64%). Most surgeries were elective (92.4%), with digestive and orthopedic procedures being the most frequent, each accounting for 21.3% of cases. The mean body mass index (BMI) was 23.27 ± 4.47 kg/m$^2$, with 9.2% of patients classified as obese. The most prevalent comorbidities were malignancy (29.6%) and hypertension (28.7%). In terms of physical status, most patients were classified as ASA II (75.8%), and general anesthesia (84.1%) was the most commonly used anesthetic technique. The mean estimated intraoperative blood loss was 388.8 ± 583.5 mL. The mean lowest MAP was 67.3 ± 9.3 mmHg, and the mean lowest heart rate was 69.7 ± 12.2 beats per minute. Most patients had a Surgical Apgar Score (SAS) in the 7–8 category (45.9%) or the 5–6 category (35.7%), while only a small proportion were classified as 9–10 (9.9%), 3–4 (6.7%), or 0–2 (1.9%).

Intraoperative vasopressor use was documented in 4.5% of patients, and 26.8% received a blood transfusion. Surgical duration was most frequently between 0–2 hours (48.1%) and 2–6 hours (46.2%). A total of 48 patients (15.3%) were admitted to the ICU postoperatively. The overall mortality rate during the study period was 3.5%.

Postoperative ICU Admission

Of the 314 patients, 48 (15.3%) required postoperative ICU care, comprising 46 planned admissions and 2 unplanned admissions. Both unplanned ICU admissions occurred in patients with low SAS values (scores of 1 and 4).

Bivariate analysis of SAS and postoperative ICU admission (Table 2) demonstrated that lower SAS scores were significantly associated with an

**Table 1a. Characteristics of Study Subjects**

| Characteristics | | Mean | Standard Deviation | Total Number of Patients (% of total patients) |
|---|---|---|---|---|
| Age | ≥60 years | | | 69 (22) |
| | <60 years | | | 245 (78) |
| Gender | Male | | | 113 (36) |
| | Female | | | 201 (64) |
| Type of Surgery | Emergency | | | 24 (7.6) |
| | Elective | | | 290 (92.4) |
| Category of Surgery | Digestive surgery | | | 67 (21.3) |
| | Oral surgery | | | 4 (1.3) |
| | Oncology surgery | | | 48 (15.3) |
| | Orthopedic surgery | | | 67 (21.3) |
| | Plastic surgery | | | 17 (5.4) |
| | Neurosurgery | | | Neurosurgery |
| | Thoracic & vascular surgery | | | 11 (3.5) |
| | Urology surgery | | | 7 (2.2) |
| | Ophthalmology | | | 1 (0.3) |
| | Obstetrics & gynecology | | | 50 (15.9) |
| | Otolaryngology | | | 18 (5.7) |
| BMI (kg/m2) | | 23.27 | 4.47 | |
| Obesity | Yes | | | 29 (9.2) |
| | No | | | 285 (90.8) |
| Hypertension | Yes | | | 90 (28.7) |
| | No | | | 224 (71.3) |
| Pulmonary disease | Yes | | | 20 (6.4) |
| | No | | | 294 (93.6) |
| Cardiovascular disease | Yes | | | 19 (6.1) |
| | No | | | 295 (93.9) |
| Diabetes melitus | Yes | | | 23 (7.3) |
| | No | | | 291 (92.7) |
| Kidney Failure | Yes | | | 4 (1.3) |
| | No | | | 310 (98.7) |
| Sepsis | Yes | | | 4 (1.3) |
| | No | | | 310 (98.7) |
| Cerebrovaskular disease | Yes | | | 20 (6,4) |
| | No | | | 294 (93.6) |
| Cancer | Yes | | | 93 (29.6) |
| | No | | | 221 (70.4) |
| ASA Physical Status | I | | | 33 (10.5) |
| | II | | | 238 (75.8) |
| | III | | | 39 (12.4) |
| | IV | | | 4 (1.3) |

**Table 1b. Characteristics of Study Subjects**

| Characteristics | | Mean | Standard Deviation | Total Number of Patients (% of total patients) |
|---|---|---|---|---|
| Anesthesia Plan | General Anesthesia | | | 264 (84.1) |
| | Regional Anesthesia | | | 46 (14.6) |
| | Peripheral nerve block | | | 4 (1.3) |
| Estimated Bleeding Volume (ml) | | 388.81 | 583.46 | |
| Lowest MAP (mmHg) | | 67.27 | 9.32 | |
| Lowest Pulse (beats/min) | | 69.71 | 12.24 | |
| SAS | 0-2 | | | 6 (1.9) |
| | 3-4 | | | 21 (6.7) |
| | 5-6 | | | 112 (35.7) |
| | 7-8 | | | 144 (45.9) |
| | 9-10 | | | 31 (9.9) |
| Vasopressor | Yes | | | 14 (4.5) |
| | No | | | 300 (95.5) |
| Transfusion | Yes | | | 84 (26.8) |
| | No | | | 230 (73.2) |
| Operative Duration | 0-2 hours | | | 151 (48.1) |
| | 2-6 hours | | | 145 (46.2) |
| | >6 hours | | | 18 (5.7) |
| ICU Admission | Yes | | | 48 (15.3) |
| | No | | | 266 (84.7) |
| Mortality | yes | | | 11 (3.5) |
| | No | | | 303 (96.5) |

increased likelihood of requiring intensive care. Patients with an SAS of 0–2 had a 60-fold higher risk of ICU admission compared to those with an SAS of 9–10 (OR = 60.0). Similarly, elevated risks were observed in patients with SAS scores of 3–4 (OR = 12.0) and 5–6 (OR = 8.18). A statistically significant association was found for SAS categories 0–6 ($p < 0.05$), whereas an SAS of 7–8 was not significantly associated with postoperative ICU admission.

Receiver operating characteristic (ROC) curve analysis for postoperative ICU admission (Table 3, Figure 2) identified an optimal SAS cut-off value of 6.5 using the Youden Index method. This threshold yielded a sensitivity of 60.5% and a specificity of 70.8% for predicting the need

**Table 2. Bivariate Analysis of Surgical Apgar Score (SAS) and Postoperative ICU Admission**

| | | Admission | No | p | OR | CI 95% |
|---|---|---|---|---|---|---|
| SAS | 0-2 | 4 (66.67%) | 2 (33.33%) | 0.002* | 60.00 | 4.38-821.97 |
| | 3-4 | 6 (28.57%) | 15 (71.42%) | 0.027* | 12,00 | 1.32-108.94 |
| | 5-6 | 24 (21.42%) | 88 (78.57%) | 0.044* | 8.18 | 1.06-63.10 |
| | 7-8 | 13 (9.03%) | 131 (90.97%) | 0.302 | 2.98 | 0.37-23.65 |
| | 9-10 | 1 (3.23%) | 30 (96.77%) | | Ref | |

***) p<0,05**

**Table 3. ROC Analysis for Postoperative ICU Admission**

| Cut off | Sensitivity | 1 - Specificity | Youden index |
|---|---|---|---|
| 0.0000 | 1.000 | 1.000 | 0.000 |
| 1.5000 | 1.000 | 0.958 | 0.042 |
| 2.5000 | 0.992 | 0.917 | 0.076 |
| 3.5000 | 0.977 | 0.896 | 0.082 |
| 4.5000 | 0.936 | 0.792 | 0.144 |
| 5.5000 | 0.820 | 0.521 | 0.299 |
| 6.5000 | 0.605 | 0.292 | 0.314 |
| 7.5000 | 0.327 | 0.146 | 0.181 |
| 8.5000 | 0.113 | 0.021 | 0.092 |
| 9.5000 | 0.015 | 0.000 | 0.015 |
| 11.0000 | 0.000 | 0.000 | 0.000 |

for intensive care. The area under the curve (AUC) was 0.701 (p = 0.001; 95% CI: 0.62–0.78), indicating acceptable discriminatory ability.

Figure 2. ROC analysis of ICU admissions. Bivariate analysis of confounding variables for postoperative ICU admission (Table 4) demonstrated significant associations ($p < 0.05$) with type of surgery, hypertension, cardiovascular disease, diabetes mellitus, cerebrovascular disease, ASA physical status, type of anesthesia, vasopressor use, blood transfusion, and duration of surgery. In contrast, age, sex, obesity, pulmonary disease, cancer, and renal failure were not significantly associated with ICU admission.

Multivariate logistic regression analysis was subsequently performed using variables with $p < 0.25$ in the bivariate analysis, excluding blood transfusion due to collinearity with the SAS score. The multivariate analysis (Table 5) revealed that several factors were independently associated with postoperative ICU admission ($p < 0.05$). These included SAS scores of 0–2 and 5–6, neurosurgical and thoracic–vascular procedures, comorbid cardiovascular disease, intraoperative vasopressor use, and surgical duration of 2–6 hours and >6 hours. In contrast, age ≥60 years, type of surgery (elective vs. emergency), most other comorbidities, ASA physical status, and type of anesthesia were not

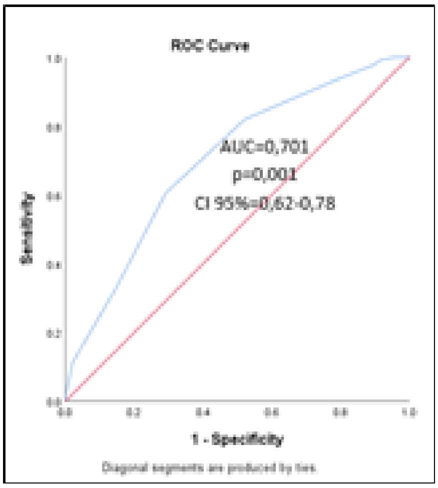


**Figure 2. ROC Analysis of ICU Admissions**

**Table 4. Bivariate Analysis of Confounding Variables for Postoperative ICU Admission**

| | | Admission | No | p | OR | CI 95% |
|---|---|---|---|---|---|---|
| Age | ≥60 years | 14 (29.2%) | 55 (20.7%) | 0.191 | 1.58 | 0.79-3.15 |
| | <60 years | 34 (70.8%) | 211 (79.3%) | | Ref | |
| Gender | Male | 19 (39.6%) | 94 (35.3%) | 0.573 | 1,19 | 0.64-2.25 |
| | Female | 29 (60.4%) | 172 (64.7%) | | Ref | |
| Type of Surgery | Emergency | 13 (27.1%) | 11 (4.1%) | <0,001*$ | 8.61 | 3.58-20.70 |
| | Elective | 35 (72.9%) | 255 (95.9%) | | Ref | |
| Surgical Category | Digestive Surgery | 7 (14.6%) | 60 (22.6%) | | Ref | |
| | Neurosyurgery& Thoracic/ vascular | 26 (54.2%) | 9 (3.4%) | <0.001* | 24.76 | 8.33-73.62 |
| | Others | 15 (31.3%) | 197 (74.1%) | 0.375 | 0,65 | 0.25-1.67 |
| Obesity | Yes | 4 (8.3%) | 25 (9.4%) | 1.000$ | 0,87 | 0.29-2.64 |
| | No | 44 (91.7%) | 241 (90.6%) | | ref | |
| Hypertension | Yes | 21 (43.8%) | 69 (25.9%) | 0.012* | 2.22 | 1.18-4.18 |
| | No | 27 (56.3%) | 197 (74.1%) | | Ref | |
| Pulmonary Disease | Yes | 5 (10.4%) | 15 (5.6%) | 0.206$ | 1.95 | 0.67-5.63 |
| | No | 43 (89.6%) | 251 (94.4%) | | Ref | |
| Cardiovascular Disease | Yes | 7 (14.6%) | 12 (4.5%) | 0.015*$ | 3.61 | 1.34-9.71 |
| | No | 41 (85,4%) | 254 (95,5%) | | Ref | |
| Diabetes mellitus | Yes | 9 (18.8%) | 14 (5.3%) | 0.003*$ | 4.15 | 1.68-10.25 |
| | No | 39 (81.3%) | 252 (94.7%) | | Ref | |
| Gagal ginjal | Yes | 0 (0%) | 4 (1.5%) | 1.000$ | - | - |
| | No | 48 (100%) | 262 (98.5%) | | Ref | |
| Sepsis | Yes | 4 (8.3%) | 0 (0%) | <0,001*$ | - | - |
| | No | 44 (91.7%) | 266 (100%) | | Ref | |
| Cerebrovaskular desease | Yes | 12 (25%) | 8 (3%) | <0,001*$ | 10.75 | 4.12-28.08 |
| | No | 36 (75%) | 258 (97%) | | Ref | |
| Cancer | Yes | 17 (35.4%) | 76 (28.6%) | 0.339 | 1.37 | 0.72-2.62 |
| | No | 31 (64.6%) | 190 (71.4%) | | Ref | |
| ASA Physical Status | I | 1 (2.1%) | 32 (12%) | | Ref | |
| | II | 25 (52,1%) | 213 (80.1%) | 0.202 | 3.76 | 0.49-28.68 |
| | III | 18 (37.5%) | 21 (7.9%) | 0.002* | 27.43 | 3.40-221.21 |
| | IV | 4 (8,3%) | 0 (0%) | 0.999 | - | - |
| Anesthesia Plan | General Anesthesia | 46 (95.8%) | 218 (82%) | | Ref | |
| | Regional Anesthesia | 2 (4.2%) | 44 (16.5%) | 0.038* | 0.22 | 0.05-0.92 |
| | Pheripheral nerve block | 0 (0%) | 4 (1.5%) | 0,999 | 0 | 0-∞ |
| Vasopressor | Yes | 10 (20.8%) | 4 (1.5%) | <0.001*$ | 17.24 | 5.15-57.71 |
| | No | 38 (79.2%) | 262 (98.5%) | | Ref | |
| Transfusion | Yes | 34 (70.8%) | 50 (18.8%) | <0.001* | 10.49 | 5.24-21.01 |
| | No | 14 (29.2%) | 216 (81.2%) | | Ref | |
| Duration of surgery | 0-2 hours | 4 (8.3%) | 147 (55.3%) | | Ref | |
| | 2-6 hours | 31 (64.6%) | 114 (42.9%) | <0.001* | 999 | 3.43-29.12 |
| | >6 hours | 13 (27.1%) | 5 (1.9%) | <0.001* | 95.55 | 22.82-400.03 |

**Table 5. Multivariate Analysis of Predictive Factors for Postoperative ICU Admissio**

| | p | OR<br>Lower | 95% C.I<br>Upper | |
|---|---|---|---|---|
| SAS | | | | |
| 0-2 | 0.016 | 326.448 | 2.933 | 36337.889 |
| 3-4 | 0.131 | 25.056 | 0.383 | 1638.853 |
| 5-6 | 0.037 | 47.387 | 1.256 | 1787.167 |
| 7-8 | 0.090 | 22,392 | 0,614 | 817.021 |
| 9-10 | | Ref | | |
| Age (≥60 years) | 0.977 | 0.979 | 0.227 | 4.217 |
| Type of Surgery(Emergency) | 0.407 | 0.411 | 0,050 | 3.365 |
| Surgical Category | | | | |
| Digestive Surgery | | Ref | | |
| Neurosurgery & Thoracic-Vascular Surgery | 0.001 | 34.788 | 4.187 | 289.053 |
| Others | 0.972 | 1.030 | 0.201 | 5.267 |
| Hypertension | 0.770 | 0.818 | 0.212 | 3.156 |
| Pulmonary Disease | 0.703 | 0,602 | 0,044 | 8.151 |
| Cardiovascular Disease | 0.014 | 11.803 | 1.636 | 85,129 |
| Diabetes mellitus | 0.669 | 1.462 | 0.256 | 8.351 |
| Sepsis | 0.999 | 123708131.908 | 0.000 | . |
| Cerebrovaskular desease | 0.913 | 1.124 | 0.139 | 9.116 |
| ASA physical status | | | | |
| I | | Ref | | |
| II | 0.832 | 0.757 | 0.058 | 9.920 |
| III | 0.241 | 5.041 | 0.338 | 75.103 |
| IV | 0.999 | 289349750.935 | 0.000 | . |
| Anesthesia Plan | | | | |
| General Anesthesia | | Ref | | |
| Pheripheral nerve block | 0.532 | 0.556 | 0.088 | 3.512 |
| Regional Anesthesia | 0.999 | 0,000 | 0.000 | . |
| Vasopressor | 0.000 | 59.359 | 6.805 | 517.802 |
| Duration of surgery | | | | |
| 0-2 hours | | Ref | | |
| 2-6 hours | 0.002 | 16.526 | 2.847 | 95.919 |
| >6 hours | 0.000 | 228.844 | 22.057 | 2374.298 |

significantly associated with postoperative ICU admission (p > 0.05).

Postoperative Mortality

Postoperative mortality is presented in Table 6. Among the 314 patients, 11 (3.5%) died during the postoperative period. Of these, 8 patients (72.7%) had been admitted to the ICU, whereas 3 patients (27.3%) were not admitted. The SAS scores of patients who died ranged from 1 to 7,

**Table 6. Characteristics of Patients Who Died After Surgery**

| NO | Postoperative ICU Admission | SAS Score | Final Care Location | Day of Death (Posoperative) | Cause of Death |
|---|---|---|---|---|---|
| 1 | Yes | 1 | ICU | 1 | Septic shock |
| 2 | Yes | 5 | ICU | 6 | Septic shock |
| 3 | Yes | 5 | Ward | 16 | *Cerebrovascular Disease* (*End Stage*) |
| 4 | Yes | 5 | ICU | 8 | ARDS |
| 5 | Yes | 6 | Ward | 9 | **Refractory hyperkalemia** |
| 6 | Yes | 6 | Ward | 7 | *Cardiac Arrest* |
| 7 | Yes | 6 | ICU | 3 | Pneumonia |
| 8 | Yes | 7 | ICU | 9 | Septic shock |
| 9 | No | 5 | HCU | 6 | Septic shock |
| 10 | No | 7 | Ward | 11 | Hypovolemic Shock |
| 11 | No | 7 | HCU | 16 | Septic shock |

**Table 7a. Bivariate Analysis of Predictive Factors for Postoperative Mortality**

| | | Death | Survival | p | OR | CI 95% |
|---|---|---|---|---|---|---|
| SAS | 0-2 | 1 (9.1%) | 5 (1.7%) | 0.152$ | 9.40 | 083-107.05 |
| | 3-4 | 0 (0%) | 21 (6,9%) | 1.000$ | | |
| | 5-6 | 7 (63.6%) | 105 (34.7%) | 0.110$ | 3.13 | 0.79-12.40 |
| | 7-8 | 3 (27.3%) | 141 (46.5%) | | Ref | |
| | 9-10 | 0 (0%) | 31 (10.2%) | 1.000$ | | |
| Age | ≥60 years | 5 (45.5%) | 64 (21.1%) | 0.056 | 3,11 | 0.92-10.52 |
| | <60 years | 6 (54.5%) | 239 (78,9%) | | Ref | |
| Gender | Male | 4 (36.4%) | 109 (36%) | 1.000$ | 1,02 | 0.29-3.55 |
| | Female | 7 (63.6%) | 194 (64%) | | Ref | |
| Type of Surgery | Emergency | 5 (45.5%) | 19 (6,3%) | 0.001*$ | 12,46 | 3,48-44,55 |
| | Elective | 6 (54.5%) | 284 (93,7%) | | Ref | |
| Surgical Category | Digestive Surgery | 4 (36.4%) | 63 (20.8%) | | Ref | |
| | Neurosurgery&Thoracic Vascular | 5 (45.5%) | 30 (9.9%) | 0.031* | 6.67 | 1.19-37.25 |
| | Others Surgery | 2 (18,2%) | 210 (69.3%) | 0.001* | 17.5 | 3.25-94.26 |
| Obesity | Yes | 1 (9,1%) | 28 (9.2%) | 1.000$ | 0.98 | 0.12-7.96 |
| | No | 10 (90.9%) | 275 (90.8%) | | Ref | |
| Hipertension | Yes | 4 (36.4%) | 86 (28.4%) | 0.518$ | 1,44 | 0,41-5,05 |
| | No | 7 (63,6%) | 217 (71,6%) | | Ref | |
| Pulmonary Disease | Yes | 2 (18.2%) | 18 (5.9%) | 0.150$ | 3.52 | 0.71-17.51 |
| | No | 9 (81.8%) | 285 (94.1%) | | Ref | |
| Cardiovascular Disease | Yes | 2 (18.2%) | 17 (5.6%) | 0.138$ | 3,74 | 0.75-18.67 |
| | No | 9 (81.8%) | 286 (94,4%) | | Ref | |
| Diabetes mellitus | Yes | 6 (54.5%) | 17 (5.6%) | 0,001*$ | 20,19 | 5.59-72.88 |
| | No | 5 (45.5%) | 286 (94.4%) | | Ref | |
| Renal failure | Yes | 0 (0%) | 4 (1.3%) | 1,000$ | - | - |
| | No | 11 (100%) | 299 (98,7%) | | Ref | |

**Table 7. Bivariate Analysis of Predictive Factors for Postoperative Mortality**

| | | Death | Survival | p | OR | CI 95% |
|---|---|---|---|---|---|---|
| Sepsis | Yes | 1 (9.1%) | 3 (1%) | 0,134$ | 10,00 | 0.95-104.77 |
| | No | 10 (90,9%) | 300 (99%) | | Ref | |
| *Cerebrovaskular disease* | Yes | 2 (18.2%) | 18 (5.9%) | 0.150$ | 3.52 | 0.71-17.51 |
| | No | 9 (81.8%) | 285 (94.1%) | | Ref | |
| Cancer | Yes | 4 (36.4%) | 89 (29.4%) | 0.738$ | 1.37 | 0.39-4.81 |
| | No | 7 (63.6%) | 214 (70.6%) | | Ref | |
| ASA physical status | I | 0 (0%) | 33 (10.9%) | 1,000$ | - | - |
| | II | 3 (27.3%) | 235 (77.6%) | | Ref | |
| | III | 7 (63.6%) | 32 (10.6%) | 0.001* | 17.14 | 4.22-69.63 |
| | IV | 1 (9.1%) | 3 (1%) | 0.012* | 26.11 | 2.07-328.95 |
| Anesthesia Plan | General Anesthesia | 11 (100%) | 253 (83.5%) | | Ref | |
| | Regional Anesthesia | 0 (0%) | 46 (15.2%) | 0.379$ | - | - |
| | Pheripheral nerve block | 0 (0%) | 4 (1.3%) | 1.000$ | - | - |
| Vasopressor | Yes | 1 (9.1%) | 13 (4.3%) | 0.400$ | 2.23 | 0.26-18.76 |
| | No | 10 (90.9%) | 290 (95.7%) | | Ref | |
| Transfusion | Yes | 8 (72.7%) | 76 (25.1%) | 0,002*$ | 7.96 | 2.06-30.79 |
| | No | 3 (27.3%) | 227 (74.9%) | | Ref | |
| Duration of Surgery | 0-2 hours | 3 (27.3%) | 148 (48.8%) | | Ref | |
| | 2-6 hours | 3 (27.3%) | 142 (46.9%) | 0.960 | 1.04 | 0.21-5.25 |
| | >6 hours | 5 (45.5%) | 13 (4.3%) | 0.001* | 18.97 | 4.07-88.47 |

with the largest proportion in the SAS 5–6 group (6 patients, 54.5%). The most frequent location of final care was the ICU (5 patients, 45.5%), followed by the ward (3 patients, 27.3%) and the HCU (3 patients, 27.3%). The median time to death was 9 days postoperatively (range: 1–16 days), with septic shock identified as the leading cause of death (5 patients, 45.5%).

The results of the bivariate analysis of mortality predictors (Table 7) showed that several variables were significantly associated with postoperative mortality ($p < 0.05$), namely emergency surgery, neurosurgical procedures, thoracic–vascular surgery, other types of operations, comorbid diabetes mellitus, ASA physical status III–IV, and surgical duration >6 hours.

In contrast, age, gender, obesity, hypertension, cancer, type of anesthesia, SAS score, and vasopressor use were not significantly associated with postoperative mortality. Variables with a p value <0.25 in the bivariate analysis were included in a multivariate logistic regression model, with the exception of the blood transfusion variable, which was excluded due to strong collinearity with the SAS score.

The multivariate analysis (Table 8) showed that an operative duration of >6 hours was an independent predictor of postoperative mortality (OR = 54.68; p = 0.034). In contrast, the category of "other" types of surgery was identified as a protective factor, demonstrating a statistically significant association with reduced mortality. In contrast, other variables, including SAS score, age ≥60 years, type of surgery (elective vs. emergency), ASA physical status, and comorbidities such as diabetes, pulmonary disease, cardiovascular disease, and sepsis, were not statistically significant predictors of postoperative mortality..

Table 8. Multivariate Analysis of Predictor Factors for Postoperative Mortality

| | p | OR Lower | 95% C.I Upper | |
|---|---|---|---|---|
| SAS | 1.000 | | | |
| 0-2 | 0.895 | 0.471 | 0.000 | 34203.540 |
| 3-4 | 0.997 | 0.000 | 0.000 | . |
| 5-6 | 0.954 | 0.932 | 0.084 | 10.312 |
| 9-10 | 0.997 | 0.000 | 0.000 | . |
| Age(≥60 years) | 0.547 | 2.310 | 0.151 | 35.280 |
| Type of Surgery (Emergency) | 0.507 | 2.939 | 0.122 | 70.942 |
| Surgery Category | | | | |
| Neurosurgery & thoracic vascular surgery | 0.987 | 0.969 | 0.022 | 43.043 |
| Other surgery | 0.050* | 0.052 | 0.003 | 0.996 |
| Pulmonary Disease | 0.214 | 9.644 | 0.271 | 343.426 |
| Cardiovascular Disease | 0.747 | 0.559 | 0.016 | 19.278 |
| Diabetes mellitus | 0.080 | 13.263 | 0.732 | 240.241 |
| Sepsis | 0.356 | 37.985 | 0.017 | 86445.004 |
| Cerebrovaskular disease | 0.121 | 0.013 | 0.000 | 3.135 |
| ASA physical status | 0.294 | | | |
| I | 0.998 | 0.000 | 0.000 | |
| III | 0.065 | 12.404 | 0.859 | 179.198 |
| IV | 0.475 | 54,677 | 0.001 | 3197067.883 |
| Duration of surgery | | | | |
| 2-6 hours | 0.519 | 0.333 | 0.012 | 9.398 |
| >6 hours | 0.034* | 54.677 | 1.351 | 2212.208 |

## DISCUSSION

This study demonstrates that a low Surgical Apgar Score (SAS ≤6) is a strong predictor of postoperative ICU admission. Patients with an SAS of 0–2 had up to a 326-fold higher risk of ICU admission compared to those with an SAS of 9–10. These findings are consistent with previous studies which showed that low SAS values are associated with hemodynamic instability and intraoperative bleeding, conditions that often necessitate intensive monitoring in the ICU.[3,6]

In addition to SAS, other significant factors included the type of surgery (neurosurgery, thoracic surgery, vascular surgery), cardiovascular comorbidities, intraoperative vasopressor use, and prolonged surgical duration. These results align with previous studies which reported that an SAS cut-off of <7 predicts ICU admission with an AUC of 0.89.[5,7] Futhermore, modified versions of SAS incorporating surgical duration have been proposed to improve predictive accuracy.[5,7]

The postoperative mortality rate in this study was 3.5%, comparable to rates reported by previous stuides.[5,8,9] While bivariate analysis suggested a trend toward increased mortality among patients with a low SAS, this association was not significant in the multivariate model, likely due to the limited sample size and the influence of stronger confounding variables.

Surgical duration >6 hours emerged as the only independent predictor of postoperative mortality (OR 54.68), consistent with priors findings which found that longer surgeries increased the risk of complications.[10] A meta-analysis further confirmed that each additional 30 minutes of operative time increased complication rates by 14%.[10] Other factors such as diabetes mellitus and higher ASA physical status also showed associations with mortality, consistent with previous report.[11,12]

In this study, the category of "other" surgical procedures (including orthopedic, urologic, plastic, oral, ophthalmologic, otolaryngologic, and obstetric-gynecologic surgeries) demonstrated a protective effect against postoperative mortality compared with digestive, neurosurgical, and thoracic-vascular surgeries. This finding is consistent with previous research, which reported that obstetric-gynecologic and orthopedic procedures were associated with lower mortality compared with abdominal surgery. [13] Perioperative mortality is influenced by several potential factors, including preoperative factors, intraoperative factors such as surgical approach and intrinsic procedural risks (specialty, procedure type, and procedural complexity), and postoperative factors.[14]

Overall, these findings reinforce the usefulness of SAS as a simple tool for predicting postoperative ICU requirements. However, surgical duration and other perioperative clinical factors remain critical determinants of postoperative mortality. Combining SAS with other risk variables may enhance predictive accuracy and assist in perioperative planning and resource allocation. This study has several limitations. First, the SAS can only be calculated after the completion of surgery, as its components are based on intraoperative parameters such as blood pressure, heart rate, and estimated blood loss. This may potentially delay clinical decision-making regarding postoperative ICU transfer. Second, although the SAS has been shown to be effective in predicting postoperative complications and mortality, several studies have reported that its discriminatory ability is only moderate, with a c-statistic of approximately 0.69 for predicting delayed ICU admission, and without an optimal cut-off value that balances sensitivity and specificity.[6]

Third, postoperative ICU admission decisions are also influenced by various other factors, including preoperative and intraoperative conditions such as comorbidities, ASA classification, and type of surgery. This was evident among patients with minimal bleeding and stable hemodynamics in the higher SAS groups (SAS 7–8 and SAS 9–10), where 29% still required postoperative ICU admission. Therefore, the SAS should not be used as the sole predictor but rather considered as part of a multivariate model in determining the need for intensive care.

## CONCLUSION

The Surgical Apgar Score (SAS) can be used to predict the need for postoperative ICU admission. Lower SAS values are significantly associated with an increased risk and a higher likelihood of postoperative ICU admission. An operative duration of >6 hours (predictor factor) and the category of "other" surgical procedures (protective factor) were the most consistent and significant predictors of mortality.

## RECOMMENDATIONS

The SAS is a simple, practical, and easily accessible tool that can assist medical teams in predicting ICU requirements and allocating resources more effectively. It also has potential to be integrated into perioperative risk assessment and clinical decision-making, particularly for patients with vulnerable health conditions. Future prospective studies with larger sample sizes are strongly recommended to strengthen the evidence base and support the development of standardized protocols for incorporating the SAS into perioperative care.

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