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The Cardiothoracic Surgeon (2023) 31:13
https://doi.org/10.1186/s43057-023-00104-y

The Cardiothoracic Surgeon

RESEARCH Open Access

Surgical Apgar Score can help predict postoperative cardiopulmonary complication and reoperation in lung cancer resection

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Abstract

Background Bleeding due to lung resection increases the risk of cardiopulmonary complications and hospital stay. Surgical massive bleeding is associated with a high rate of mortality. In this study, our aim is to determine the effectiveness of Surgical Apgar Score in predicting complications and reoperation in the short term. Peroperative data of 405 patients aged 18–82 who underwent lung resection (pneumonectomy, lobectomy, wedge) and were operated consecutively were recorded.

Results Pulmonary complication developed in 38 (9.4%) of the patients, cardiac complication in 104 (25.7%), acute kidney failure in 8 (1.9%), and cerebrovascular accident in 1 (0.2%). Reoperation was performed in 24 (5.9%) patients due to bleeding. The Surgical Apgar Score was found to predict postoperative complications well for a value of <6 (area under the curve = 0.745, 95%CI 0.710–0.7770, $p<0.001$). When Surgical Apgar Score were evaluated together with receiver operating characteristic, the ability of Surgical Apgar Score to predict reoperation was found to be statistically significant (area under the curve = 0.777, 95%CI 0.671–0.883, $p<0.001$. Accordingly, age, resection type, blood loss, heart rate, SAS score, intraoperative blood transfusion, and postoperative blood transfusion were independent risk factors affecting the development of complications. It was determined that the only independent risk factor affecting the development of mortality was postoperative blood transfusion. It was determined that the independent risk factors affecting ICU development were resection type, blood loss, SAS score, and postoperative blood transfusion.

Conclusion In our study, the Surgical Apgar Scoring System was found to be sufficient in predicting cardiac and respiratory complications. Patients with a low postoperative Surgical Apgar Score should be followed carefully in terms of postoperative complications and reoperation. Surgical Apgar Score can be a useful scoring method in predicting the prognosis of patients who underwent lung cancer resection in the postoperative period.

Keywords Lung resection, Hemorrhage, Surgical Apgar Score, Complication, Reoperation

Background

The incidence of cardiopulmonary complications (CPC) after lung resection varies between 20-30%. The development of complications is characterized by prolonged hospital stay, increased hospital cost and increased incidence of mortality [1]. Intraoperative bleeding increases the risk of CPC and hospital stay. Surgical massive bleeding is associated with a high mortality rate [2, 3]. In a retrospective study examining the perioperative side effects of 62,571 patients who had undergone thoracic surgery,

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the two most important events were found to be surgery-related death and massive bleeding [2].

Conditions such as lung resection type, duration of surgery, age, and hypertension (HT) affect the degree of intraoperative blood loss (IBL). IBL plays a decisive role in the short and long term prognosis of patients. It is the most common and fatal reason for switching from thoracotomy or video-assisted thoracoscopic surgery (VATS) approach to open thoracotomy in lung resections [3–5]. However, no study was found in the literature in which IBL was classified and evaluated with the Surgical Apgar Score (SAS) score in lung resection.

Unlike other scoring systems, SAS is a simple, objective scoring system in which three intraoperatively measured parameters are evaluated out of 10 points [6]. When calculating, the lowest intraoperative heart rate, the lowest mean arterial blood pressure, and total blood loss are taken into account. It is used in many surgical fields such as general, vascular, orthopedics, and neurosurgery (Table 1).

Our aim in this study is to determine the effectiveness of the SAS score in predicting short-term complications, reoperation, and length of stay in the intensive care unit (ICU). In addition, as a secondary aim, it was aimed to investigate the independent risk factors for ICU stay, reoperation, and complications.

Methods

This retrospective study was carried out at Chest Diseases and Thoracic Surgery Training and Research Hospital between June 2018 and February 2020. Peroperative data of 405 patients aged 18–82 who underwent lung resection (pneumonectomy, lobectomy, wedge) were recorded.

Preoperative management

Management of patients using anticoagulant therapy was arranged before surgery; anticoagulants such as warfarin 3 days before the procedure and acetylsalicylic acid and clopidogrel 7 days before the procedure were discontinued. For patients undergoing coronary procedures (e.g., angioplasty, stenting), their cardiologist was contacted before discontinuing anticoagulant therapy and their treatment planned according to the nature of the planned surgery (elective or emergency). Enoxaparin sodium was routinely started at a dose of 30 to 40 mg/day subcutaneously for prophylaxis before the planned surgery, unless the procedure was short and/or the patient was young [5, 6]. If lung resection was planned, enoxaparin sodium was started regardless of the patient's age.

İntraoperative management

A common general anesthesia protocol was used for all patients. Antibiotic prophylaxis was administered preoperatively. Propofol 2–3 mg/kg and fentanyl 2 μg/kg were used for induction in all surgical procedures. As a muscle relaxant, 0.5 mg/kg intravenous (iv) rocuronium bromide was administered. A double-lumen endobronchial tube was placed on the right or left as appropriate and its position was confirmed by fiberoptic bronchoscopy (FBS). Anesthesia was maintained with 50% oxygen, 50% air, and 2% sevoflurane. Remifentanil iv infusion was continued through out the operation. The surgical procedure was determined according to current guidelines for pneumonectomy and lobectomy according to the patient's condition, respiratory function tests, and location of the lesion. Resections were performed with VATS and thoracotomy.

Postoperative management

Postoperative pain control was achieved mainly with intercostal block and IV patient-controlled analgesia. The same analgesic protocol was applied with all patients. The patients' pain levels were assessed using a visual pain scale ranging from 0 to 10, and care was taken to keep the patients' pain level below 4. Postoperative SAS score of the patients were calculated. Complications and death conditions of the patients within 30 days postoperatively were recorded. Complications as pulmonary (pneumonia, acute respiratory failure, pulmonary embolism, prolonged air leak, need for mechanical ventilation), cardiac (arrhythmia, acute myocardial infarction, angina), other (cerebrovascular accident (CVA), acute renal failure (ARF), liver dysfunction) classified.

Bleeding status was followed up with peroperative arterial blood gas and hemogram tests. The amount of blood in the aspirator, sponge and compresses was recorded at periodic intervals. Intraoperative 7 g/dl hemoglobin or

Table 1 Variables for the Surgical Apgar Score

	Number of points				
	0	1	2	3	4
Blood loss (g)	> 1000	601–1000	101–600	≤ 100	–
Lowest mean arterial pressure (mmHg)	< 40	40–54	55–69	≥ 70	–
Lowest heart rate (beats per min)	> 85	76–85	66–75	56–65	≤ 55

20% hematocrit, postoperative erythrocyte suspension (ES) replacement was performed to values less than 8 g/dl. In case of bleeding, ES and fresh frozen plasma (FFP) options were preferred. At the end of the operation, the patients who underwent pneumonectomy and lobectomy were transferred to the surgical intensive care unit. Surgery was performed 4–6 weeks after neoadjuvant therapy, as neoadjuvant chemotherapy and radiotherapy may pose a risk of postoperative bleeding. Drainage and hemodynamic parameters were routinely monitored by intensive care specialists, intensive care nurses and thoracic surgery assistants. Patients who continued to drain 100 mL for 8 h or 200 mL for 2–4 h were included in the revision. Considering the amount of residual hematoma in the X-ray, the patient's hemodynamic parameters, and the hemorrhagic drainage volume per hour, the thoracic surgery clinical council decided to re-operate and which surgical method would be used.

Statıstıcal analysıs

Patient demographics and collected data were entered into IBM® SPSS® (the Statistical Package for the Social Sciences) Statistics version 23. Variables were characterized using mean, maximum, and minimum values, while percentage values were used for qualitative variables. Normal distributions were determined by Kolmogorov–Smirnov analysis. Normal distributions were reported as mean ± SD. Logistic regression analyzes were performed separately using certain variables that may affect complications, mortality, ICU stay, and reoperation due to bleeding. The Hosmer and Lemeshow Test was used in each logistic regression analysis. The p value for each comparison was greater than 0.05. Therefore, the tests were considered to be calibrated. The reliability of peroperative bleeding scores in predicting reoperation, postoperative general complications, and postoperative respiratory and cardiac complications was examined with the receiver operating characteristic (ROC) curve and the area under the curve (AUC) was evaluated. In addition, the data were entered into MedCalc ® Version 12.2.1.0 and the best cut-off values were determined for the predictiveness of reoperation. While determining the best threshold values, the best sensitivity and specificity values were taken into consideration. In order to examine the relationship between intraoperative pulse, blood pressure, and bleeding amount in the Apgar Scale with general complications, cardiac and pulmonary complications, patients were grouped as those with and without complications. Pearson's chi-square test was used for comparative analysis of qualitative variables; however, Fisher's exact test was used if the sample size was small (≤ 5). Normal distributions were recorded as mean. The independent sample *t* test (i.e., ındependent sample *t* test) was used in this study. The reliability of peroperative bleeding scores in predicting reoperation, postoperative general complications, and postoperative respiratory and cardiac complications was examined with the receiver operating characteristic (ROC) curve and the area under the curve (AUC) was evaluated. In addition, the data were entered into MedCalc ® Version 12.2.1.0 and the best cut-off values were determined for the predictiveness of reoperation. While determining the best threshold values, the best sensitivity and specificity values were taken into consideration. p value of < 0.05 was considered statistically significant.

Results

Of the patients, 311 (76.8%) were male and 94 (23.2%) were female. Demographic, preoperative clinical, intraoperative bleeding score scores and postoperative conditions of patients with a mean age of 57.7 (min = 17, max = 94 years) are shown in Table 2.

The relationship between heart rate, blood pressure and amount of intraoperative blood loss and general complications, respiratory complications and cardiac complications is given in Table 3. The amount of intraoperative blood loss was found to be statistically higher in patients who developed postoperative general complications, respiratory, and cardiac complications compared to patients who did not ($p < 0.001$ for all comparisons). Intraoperative MAP was found to be statistically lower in patients who developed postoperative general complications, respiratory and cardiac complications compared to patients who did not ($p < 0.001$, $p = 0.001$ and $p < 0.001$, respectively). Intraoperative heart rate was found to be statistically higher in patients with postoperative general and cardiac complications than those without ($p = 0.04$ and $p = 0.01$, respectively). Intraoperative heart rate was higher in patients who developed postoperative respiratory complications than in patients who did not, but this difference was not statistically significant ($p = 0.09$). The mean use of peroperative red cell suspension was 1.7 ± 1 unit(u) in pneumonectomy and 1.2 ± 0.6u in lobectomies ($p = 0.01$). Intraoperative 1.62 ± 0.89 u ES was given to patients with postoperative complications, and 1.23 ± 0.6u ES to patients who did not develop ($p = 0.01$).

Intraoperative mean 1.5 ± 0.82u of ES was given to patients with reoperation, while 1.3 ± 0.74u of ES was given to patients who did not ($p = 0.011$). The mean intraoperative blood loss was 607 ± 460 ml in pneumonectomies, 330 ± 288 ml in lobectomies, and 170 ± 161 ml in wedges ($p = 0.01$). While the mean blood loss was 398 ± 351 ml in patients who underwent thoracotomy, it was 263 ± 241 ml in patients who underwent VATS ($p = 0.01$). 1.4 u of ES was applied to those who underwent thoracotomy, 1.08 u of ES was applied to those

Table 2 Demographic, preoperative clinical, and postoperative status of the patients

Variable	Data
Age, year ± SD	57.7 ± 13.3
Gender, *n* (%)	
Male	311 (76.8%)
Woman	94 (23.2%)
Diagnosis, *n* (%)	
Lung cancer	294 (72.6%)
Bening Lung mass	111 (27.4%)
Disease localization, *n* (%)	
Right	237 (59.0%)
Left	168 (41.0%)
BMI, kg/m^2 ± SD	25.6 ± 4.7
EF value, *n* (%)	
< 60	60 (14.8%)
≥ 60	345 (85.2%)
HT presence	149 (36.8%)
COPD presence	79 (19.5%)
Neoadjuvan, *n* (%)	25 (6.2%)
Resection type, *n* (%)	
Pneumonectomy	71 (17.5%)
Lobectomy	293 (72.3%)
Wedge resection	41 (10.1%)
Type of operation, *n* (%)	
Thoracotomy	318 (78.5%)
VATS	87 (21.5%)
Operation time, hours ± SD	3.9 ± 0.7
Intraoperative blood loss, ml ± SD	369 ± 335.0
Intraoperative MAP, mmHg ± SD	66.1 ± 11.8
Intraoperative heart rate, *n*/min ± SD	67.6 ± 11.3
Intraoperative Apgar Score, *n* ± SD	6.5 ± 1.5
Postoperative APACHE II, unit ± SD	8.1 ± 3.3
Postoperative SOFA, unit ± SD	0.79 ± 1.56
Reoperation, *n* (%)	24 (5.9%)
Postoperative complications, n (%)	151 (37.2%)
Mortality, n (%)	5 (1.2%)

COPD Chronic obstructive pulmonary disease, *EF* Ejection fraction, *BMI* Body mass index, *VATS* Video-assisted thoracic surgery, *MAP* Mean arterial pressure, *HT* Hypertension, *APACHE* Acute Physiological And Chronic Health Evaluation, *SOFA* Sequental Organ Failure Assessment Score

who underwent VATS. The length of stay in the intensive care unit was 1.2 ± 1.03 days for bleedings < 100 ml, 1.6 ± 1.1 days for bleedings of 100–600 ml, and 1.8 ± 0.8 days for bleeding > 1000 ml.

Logistic regression analysis for complication development is given in Table 4. Accordingly, age, resection type, blood loss, heart rate, SAS score, intraoperative blood transfusion and postoperative blood transfusion were independent risk factors affecting the development of complications. Logistic regression analysis for mortality improvement is given in Table 5. It was determined that the only independent risk factor affecting the development of mortality was postoperative blood transfusion. Logistic regression analysis for staying in ICU for more than 1 day is given in Table 6. It was determined that the independent risk factors affecting ICU development were resection type, blood loss, SAS score and postoperative blood transfusion. The logistic regression analysis for the reoperation is given in Table 7. Accordingly, SAS score ($p = 0.007$) and postoperative blood transfusion ($p < 0.001$) were observed as independent risk factors affecting reoperation.Nagelkerke R square for reoperation; 0.532 for complication, 0.548 for complication, 0.153 for mortality, 0.458 for postoperative ICU stay.

Reoperation was required due to bleeding in 24 (5.9%) of the postoperative patients. When SAS was evaluated together with ROC, the ability of the SAS score to predict reoperation was also found to be statistically significant (Table 8). According to the cut-off values determined for the SAS system, which was found to be significantly predictive for reoperation, the patients were grouped as those with high and low scores. While the rate of reoperation was 19.4% in patients with a low (≤ 5) SAS Score ($n = 86$), this rate was 2.1% ($n = 11$) in patients with a high (> 5) SAS Apgar ($n = 319$). (AUC = 0.777, 95%CI 0.671–0.883, $p < 0.001$). Postoperative complications were seen in 151 (37.2%) patients and postoperative mortality occurred in 5 patients (1.2%). Pulmonary complication (PC) in 38 patients (9.4%), cardiac complication (CC) in 104 patients (25.7%), ARF in 8 patients. (1,9%), 1 (0.2%) had CVA. When the intraoperative bleeding scores were evaluated together with the ROC, it was seen that the SAS scoring system was effective enough for postoperative complications. The SAS system was found to predict postoperative complications well (AUC = 0.745, 95%CI 0.710–0.7770, $p < 0.001$) (Fig. 1).

The SAS system was found to be a good predictor of postoperative respiratory complications (AUC = 0.704, 95%CI 0.617–0.792, $p < 0.001$). When intraoperative SAS was evaluated together with ROC. The SAS scoring system was effective enough for postoperative cardiac complications. The SAS system was found to be a good predictor of postoperative cardiac complications (AUC = 0.738, 95%CI 0.664–0.780, $p < 0.001$).

Discussion

In this study, we aimed to determine the effectiveness of the SAS score in predicting short-term complications, reoperations and prolonged intensive care stays. In our study, it was seen that the SAS score system was sufficient to predict cardiac and respiratory complications and rethoracotomy.

Table 3 Relationship between heart rate, blood pressure, and amount of intraoperative blood loss with general complications, respiratory complications, and cardiac complications

	Amount of intraoperative blood loss, ml ± SD	***p* value**	**Intraoperative MAP, mmHg ± SD**	***P* value**	**Intraoperative heart rate, rate /min**	***P* value**
Postoperative general complication, *n* (%)		**< 0.001**		**< 0.001**		
None (*n* = 292)	316.2 ± 330.3		67.0 ± 10.4		66.0 ± 10.3	**0.102**
Yes (*n* = 113)	481 ± 328.1		61 ± 11.5		68.9 ± 12.1	
Postoperative respiratory complications *n* (%)						
None (*n* = 367)	379.0 ± 495	**< 0.001**	66.6 ± 11.7	**0.013**	**67.2** ± 11.1	0.133
Yes (*n* = 38)	547.1 ± 157.0		61 ± 12.0		70.1 ± 13.0	
Postoperative cardiac complications *n* (%)						
None (*n* = 301)	323.9 ± 279	**< 0.001**	67.5 ± 11.5	**< 0.001**	**66.8** ± 10.7	**0.049**
Yes (*n* = 104)	473.9 ± 322.5		62.1 ± 11.6		69.3 ± 12.9	

SD Standart deviasyon, *MAP* Mean arterial pressure

Table 4 Logistic regression analysis for complication development

Variable	**Odds ratio**	**95% CI**	***P***
Age (per year)	1.048	1.016–1.080	0.003
Gender (female/male)	1.018	0.454–2.281	0.965
Resection type (wedge/lobectomy/pneumonectomy)	18.592	3.378–102.315	< 0.001
Operation type (thoracotomy/VATS)	1.023	0.434–2.410	0.958
Blood loss (per 100 ml)	1.002	1.001–1.004	0.006
Mean arterial pressure (per unit)	1.029	0.990–1.070	0.141
Heart rate (per unit)	0.926	0.879–0.975	0.003
SAS score (for each unit)	0.343	0.208–0.567	< 0.001
Intraoperative blood transfusion	2.866	1.068–7.696	0.03
Postoperative blood transfusion	59.048	20.442–170.558	< 0.001

Table 6 Logistic regression analysis for more than one day stay in ICU

Variable	**Odds ratio**	**95% CI**	***P***
Age (per year)	1.023	0.998–1.049	0.07
Gender (female/male)	1.298	0.623–2.703	0.486
Resection type (wedge/lobectomy/pneumonectomy)	2.288	1.138–4.597	0.02
Operation type (thoracotomy/VATS)	0.627	0.254–1.546	0.311
Blood loss (per 100 ml)	1.001	1.000–1.002	0.04
Mean arterial pressure (per unit)	1.027	0.992–1.063	0.137
Heart rate (per unit)	0.961	0.919–1.005	0.08
SAS score (for each unit)	0.577	0.379–0.879	0.01
Intraoperative blood transfusion	0.558	0.236–1.318	0.184
Postoperative blood transfusion	4.990	2.588–9.619	< 0.001

Table 5 Logistic regression analysis for mortality improvement

Variable	**Odds ratio**	**95% CI**	***P***
Age (per year)	1.023	0.945–1.108	0.572
Gender (female/male)	1.002	0.999–1.008	0.996
Resection type (wedge/lobectomy/pneumonectomy)	5.014	0.484–51.974	0.177
Operation type (thoracotomy/VATS)	3.981	0.272–58.292	0.313
Blood loss (per 100 ml)	1.000	0.996–1.005	0.846
Mean arterial pressure (per unit)	0.958	0.838–1.096	0.533
Heart rate (per unit)	1.100	0.937–1.291	0.244
SAS score (for each unit)	1.846	0.396–8.599	0.435
Intraoperative blood transfusion	1.331	0.087–20.342	0.837
Postoperative blood transfusion	7.053	0.845–58.866	0.04

Table 7 Logistic regression analysis for reoperation

Variable	**Odds ratio**	**95% CI**	***P***
Age (per year)	1.002	0.971–1.033	0.923
Gender (female/male)	.287	0.077–1.068	0.063
Resection type(wedge/lobectomy/pneumonectomy)	1.213	0.655–2.245	0.540
Operation type (thoracotomy/VATS)	0.248	0.997–1.001	0.133
Blood loss (per 100 ml)	0.999	0.997–1.001	0.315
Mean arterial pressure (per unit)	1.039	0.982–1.098	0.182
Heart rate (per unit)	1.024	0.956–1.096	0.498
SAS score (for each unit)	0.414	0.379–0.879	0.007
Intraoperative blood transfusion	0.975	0.269–3.530	0.969
Postoperative blood transfusion	4.185	2.588–9.619	< 0.001

Table 8 Evaluation of the predictor of SAS score in terms of postoperative general complications, respiratory complications and cardiac complications by ROC analysis

Complication type	AUC	95%CI	Cut-off	Sensitivity (%)	Specificity (%)
General complication	0.745	0.710–0.777	6	72.6	68.2
Cardiac complication	0.738	0.644–0.780	6	70.1	66.4
Respiratory complication	0.704	0.617–0.792	6	80.7	59.6
Reoperation	0.777	0.671–0.883	6	79.7	60.6

Hemorrhage is a major surgical complication. Although the mortality rate in surgical procedures is 0.1% in general, this rate can be 5–8% in vascular surgeries and up to 20% in excessive bleeding [7–9]. It is caused by technical reasons in the range of approximately 75–90% in the intraoperative period and in the early period in thoracic surgery [5]. Intraoperative bleeding may force the transition from VATS method to thoracotomy within the operation. Blood transfusions administered to the patient after bleeding may initiate a series of events that result in infection, immune suppression, transfusion-related acute lung injury, systemic inflammatory systemic response syndrome, multiple organ failure, and ultimately death, especially in the postoperative period [10–14]. Blood transfusion is an independent factor for increased mortality, morbidity and hospital cost [4]. Li et al. In a retrospective study in which the perioperative side effects of 62,571 patients who had undergone thoracic surgery were examined, the side effect rate was 0.2%; defined the two most important side effects associated with surgery as death and massive bleeding [2].

SAS has been the subject of many studies since it was defined by Gawande et al. in 2007 [11, 12]. SAS is a simple scoring system calculated over 10 points and can be calculated at any stage of surgery. SAS does not consider factors such as clinical evaluation, biochemical outcome, acute or chronic illness of the patient. Nair et al., in their retrospective comprehensive study, stated that the use of SAS can help identify patients at risk and help achieve the highest possible SAS in surgical patients [13]. Patients with low scores are more likely to encounter a life-threatening event within 30 days postoperatively. In our study, it was seen that SAS was sufficiently effective in predicting postoperative complications and reoperation at values of 6 and below. Age, resection type, blood loss, heart rate, SAS score, intraoperative blood transfusion, and postoperative blood transfusion were independent risk factors affecting the development of complications in the logistic regression analysis for the development of complications. The most important reason for this situation is that the SAS contains the physiological data of the patient regarding the mean heart rate and mean blood pressure value. In our study, a strong correlation was found between high mean intraoperative heart rate and low mean arterial pressure and cardiopulmonary complications. This result is compatible with the literatüre [13, 14]. Heart rate is accepted as an indicator of physical condition according to traditional knowledge. Studies have shown that deterioration in heart rate may be a precursor to mortality in coronary artery disease and heart failure, as well as cause clinical worsening of pulmonary hypertension [15]. Ducha et al. showed that there is a relationship between deterioration in heart rate and postoperative cardiac complications in their study in patients undergoing lung resection [15, 16]. In addition, Fu et al. showed that increased preoperative heart rate was correlated with an increased cardiopulmonary risk after lung resection [17]. In our study, it was observed that the mean blood pressure value in patients with complications was lower than those without complications (61.5 mmHg versus 68 mmHg). It has been shown that the incidence of postoperative ARF and MI increases at values of 55 mmHg and below intraoperatively in patients who underwent noncardiac surgery [18].

Thomas et al. found that the patients who received blood transfusion in patients who underwent pneumonectomy may experience increased postoperative 30-day mortality, respiratory failure and infection in proportion to the applied blood product package, compared to patients who did not receive pneumonectomy [19]. In our study, an average of 1.7 units in patients who developed postoperative CPC. An average of 1.1 units of ES was given in the patient group that did not develop while ES was given. The mean amount of intraoperative blood transfusion was greater in patients with CPC than in those who did not.

Bleeding > 318 in lobectomies, over 69 years of age, female gender, cancer types other than adenocarcinoma were listed as adverse factors for 5-year survival [16]. Li et al. showed that patients with a diagnosis of lung cancer and undergoing VATS, with an estimated intraoperative blood loss of $\geq$100, had more postoperative CPC and a

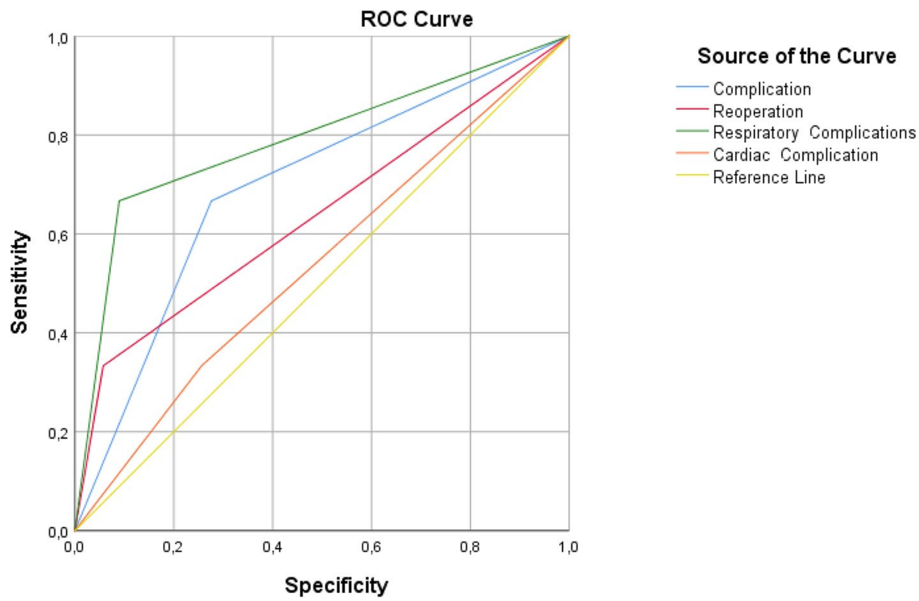

Fig. 1 Evaluation of SAS score in terms of ability to predict complication, respiratory complication, cardiac complication, and repoperation with ROC analysis

longer hospital stay than patients with < 100 ml [20]. In our study, the average intraoperative blood loss was 496 ml in the group with postoperative complications, while it was 291 ml in the group that did not develop. Nakamura et al. found a mean blood loss of 445 ml in lobectomies, 908 ml in pneumonectomies, and 88 ml in wedge resections. In our study, the mean intraoperative bleeding was observed as 607 ml in pneumonectomies, 330 ml in lobectomies. This result indicates lower bleeding amounts compared to the literature results [16]. In our study, a strong correlation was found between the mean amount of blood loss and cardiopulmonary complications and reoperation. In addition, it was determined that the only independent risk factor affecting the development of mortality was postoperative blood transfusion. It was determined that the independent risk factors affecting the prolonged hospital stay in the intensive care unit were resection type, blood loss, SAS score, and postoperative blood transfusion.

Many scoring systems such as the European Society Objective Score (ESOS), Cardiopulmonary risk index, Physiologic and Operative Severity Score for the Numeration of Mortality and Morbidity (POSSUM) and Estimation of Physiologic Ability and Surgical Stress (E-PASS) in the prediction of complications after thoracic surgery has developed. SAS is used to predict mortality and complications in many surgical departments. The SAS scoring system has weaknesses as well as strengths. It powerfully photographs values such as the bleeding status, pulse and blood pressure of the peroperative patient. The missing points are that it does not include criteria such as the age of the patients, their diseases, the type of intervention, the diagnosis, and the drugs used by the patient.

Limitations

This study was conducted in a single center and with a limited number of patients. Multicenter studies with more patients will be supportive in terms of the reliability of the scores.

Conclusions

The development of complications is characterized by prolonged hospital stay, increased hospital cost and increased incidence of mortality. In our study, the SAS scoring system was found to be sufficient to predict cardiac and respiratory complications. It was also found to be useful in predicting postoperative reoperations. Patients with a low postoperative SAS score (< 6) should be followed carefully in terms of postoperative complications and reoperation. In the logistic regression analysis, it was seen that the development of postoperative complications and prolonged intensive care stays longer than 2 days were associated with a low SAS score. Heart rate and SAS score were independent risk factors affecting the development of complications in the logistic regression analysis for the development of complications. SAS can be a useful scoring method in predicting the prognosis of patients who underwent lung cancer resection postoperatively. Anticipating complications and the risk of reoperation at the end of the surgery can help prevent the morbidity and mortality that patients may encounter. Peroperative close follow-up of the patients and multidisciplinary approach of the relevant clinical branches will prevent morbidity and mortality due to bleeding.

Abbreviations

AUC	Area under the curve
ROC	Receiver operating characteristic
MAP	Mean arterial pressure
AMI	Acute myocardial infarction
SAS	Surgical Apgar Score
CPC	Cardiopulmonary complication
HT	Hypertension
IBL	Intraoperative blood loss
VATS	Video-assisted thoracic surgery
ARF	Acute kidney failure
PC	Pulmonary complication
CC	Cardiac complication
ES	Erythrocyte suspension

Acknowledgements
None

Authors' contributions
YÖ and MVD extracted the data, which were analyzed by YÖ. All authors were involved in development of the methodological approach. YÖ wrote the article, which was reviewed and revised by all authors. All authors have read and approved the manuscript.

Funding
Not applicable.

Availability of data and materials
Available on request.

Declarations

Ethics approval and consent to participate
This study was approved by the Ethics Committee of Hospital. Confirmed number/date 181–2022. All patients signed a written consent form for the study. Patient data was anonymised, available on request.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

Received: 12 February 2023 Accepted: 17 June 2023
Published online: 11 July 2023

References

1. Ferguson MK, Durkin AE (2003) A comparison of three scoring systems for predicting complications after major lung resection. Eur J Cardiothorac Surg 23(1):35–42
2. Li Q, Zhang X, Xu M, Wu J (2019) A retrospective analysis of 62,571 cases of perioperative adverse events in thoracic surgery at a tertiary care teaching hospital in a developing country. J Cardiothorac Surg 14(1):98
3. Liu L, Mei J, He J, Demmy TL, Gao S, Li S, He J et al (2019) International ınterest group on bleeding during VATS lung surgery. International expert consensus on the management of bleeding during VATS lung surgery. Ann Transl Med 7(23):712
4. Blank RS, Hucklenbruch C, Gurka KK, Scalzo DC, Wang XQ, Jones DR, Tanner SR, Jaeger JM (2011) Intraoperative factors and the risk of respiratory complications after pneumonectomy. Ann Thorac Surg 92(4):1188–1194
5. Erdoğu V, Selin Onay M, Çiftçi A, Yasemin Emetli E et al (2021) Comparing the outcomes of video-assisted thoracoscopic surgery and rethoracotomy in the management of postoperative hemorrhage. Curr Thorac Surg 6(2):051–057
6. Haddow JB, Adwan H, Clark SE et al (2014) Use of the surgical Apgar score to guide postoperative care. Ann R Coll Surg Engl 96(5):352–358
7. Marietta M, Facchini L, Pedrazzi P, Busani S, Torelli G (2006) Pathophysiology of bleeding in surgery. Transplant Proc 38(3):812–814
8. Karkouti K, Wijeysundera DN, Yau TM et al (2004) The independent association of massive blood loss with mortality in cardiac surgery. Transfusion 44:1453
9. Fernandes EO, Teixeira C, Silva LC (2011) Thoracic surgery: risk factors for postoperative complications of lung resection. Rev Assoc Med Bras (1992) 57(3):292–8
10. Jakobsen CJ. Transfusion strategy: impact of haemodynamics and the challenge of haemodilution. J Blood Transfus. 2014;2014:627141. https://doi.org/10.1155/2014/627141
11. Pearson ACS, Subramanian A, Schroeder DR, Findlay JY (2017) Adapting the surgical apgar score for perioperative outcome prediction in liver transplantation: a retrospective study. Transplant Direct 3(11):e221
12. Yusufali T, M. Awori, K. Ojuka and V. Wekesa. "Surgical Apgar Score predicts postoperative complications in traumatic brain injury." Ann Afr Surg. (2016):13; 15–19
13. Nair A, Bharuka A, Rayani BK (2018) The reliability of surgical apgar score in predicting immediate and late postoperative morbidity and mortality: a narrative review. Rambam Maimonides Med J. 9(1):e0004. https://doi.org/10.5041/RMMJ.10316
14. Kotera A (2018) The Surgical Apgar Score can help predict postoperative complications in femoral neck fracture patients: a 6-year retrospective cohort study. JA Clin Rep 4(1):67
15. Ha D, Choi H, Zell K, Raymond DP et al (2015) Association of impaired heart rate recovery with cardiopulmonary complications after lung cancer resection surgery. J Thorac Cardiovasc Surg 149(4):1168–73.e3
16. Nakamura H, Saji H, Kurimoto N, Shinmyo T, Tagaya R (2015) Impact of intraoperative blood loss on long-term survival after lung cancer resection. Ann Thorac Cardiovasc Surg 21(1):18–23
17. Fu D, Wu C, Li X, Chen J (2018) Elevated preoperative heart rate associated with increased risk of cardiopulmonary complications after resection for lung cancer. BMC Anesthesiol 18(1):94 (Published 2018 Jul 25)
18. Brady K, Hogue CW (2013) Intraoperative hypotension and patient outcome: does "one size fit all?" Anesthesiology 119(3):495–497
19. Thomas P, Michelet P, Barlesi F, Thirion X, Doddoli C, Giudicelli R, Fuentes P (2007) Impact of blood transfusions on outcome after pneumonectomy for thoracic malignancies. Eur Respir J 29(3):565–570
20. Li S, Zhou K, Lai Y, Shen C, Wu Y, Che G (2018) Estimated intraoperative blood loss correlates with postoperative cardiopulmonary complications and length of stay in patients undergoing video-assisted thoracoscopic lung cancer lobectomy: a retrospective cohort study. BMC Surg 18(1):29