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Implementing the Surgical Apgar Score in the trauma hip fracture patient population

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Abstract

Backgrounds:Trauma hip fractures in elderly patients are associated with a high postoperative morbidity and mortality, also premature death for a long-term period of many years. This high and long-term mortality among these patients can be explained not only by the fracture itself, but also due to patient's preoperative poor condition and comorbidities, the influence of the stressors such as surgery and type of anaesthesia on patient's condition, and the development of the major complications as cardiac failure, pulmonary embolism, pneumonia, deep venous thrombosis and acute renal failure in the postoperative period. Thus, the Surgical Apgar Score (SAS) could be a valuable clinicmetric tool that helps us objectively risk stratify patients immediately after the surgery, and enables those patients with the higher risk to have not only postoperative ICU care and good management during the hospital stay, but also after the hospital discharge as well.

Methods: The SAS was calculated retrospectively from the handwritten anaesthesia records on the 43 trauma hip fracture patients treated operatively in the University Hospital Center Zagreb over a 1-year period. The primary endpoints were the 30-days major postoperative complications and mortality, length of the ICU and hospital stay, and 6-months major complications development. Statistical analysis was applied to compare SAS with the patients' perioperative variables.

Results: The SAS score ≤4 in the trauma hip fracture patients was a significant predictor for the 30-days major surgical complications with 80% specificity (95% CI: 0.587-0.864,p=0.0111). However the surgical score was not significant in the prediction of the 30-days mortality (95% CI: 0.468-0.771, p=0.2238) and 6-months mortality (95% CI: 0.497-0.795, p=0.3997) as primary endpoints in the hip fracture surgery patients.

Conclusion: Validity of the SAS is that it reveals the riddle how intraoperative events affect postoperative outcomes. On behalf ability of computing the SAS score in the operative theatre immediate, reliable, real-time feedback information about patient's postoperative risk stratification is gained. Nevertheless, our study showed that every trauma hip fracture patients with the SAS≤4 should go postoperatively to the ICU and should be under intensive surveillance during the hospital stay as well after the hospital discharge too.

Keywords: Anaesthesia; hip fracture ;intensive care; Surgical Apgar Score; surgical outcome; trauma

Introduction

Hip fractures in elderly population are usually the consequence of the weightless trauma due to poor bone quality (1). Likewise they are the second capital cause of the hospitalization increasing the postoperative complications and mortality rate of these patients for a short-term (30-days) and mid-term (6-months) period as well (2,3). According to the studies the novel 10-point Surgical Apgar Score (SAS) has been considered as a good independent predictor of the major postoperative complications and mortality within a period of 30-days after surgery among many surgical subspecialities (4). It is an easy calculated, simple, objective, real-time parameter computed as a sum of the three vital intraoperative variables. The variables are estimated blood loss (EBL), lowest heart rate (HR) and lowest mean arterial pressure (MAP) driven from the intraoperative anesthesia records data calculated at the end of surgery (5). Hence, we conducted a preliminary retrospective research to perceive a utility and validation of the SAS in rating the surgical outcome, length of the ICU and hospital stay in a trauma vulnerable geriatric hip fracture patients.

Patients and Methods

Patient selection

All necessary data of the patients were collected from the medical records and University Hospital Centre Zagreb electronic medical database to analyse the SAS importance. Our research included patients older than 18 years submitted to the hip fracture surgery and admitted postoperatively to the ICU in the University Hospital Centre Zagreb between March 1, 2013, and May 31,2014. Beside already mentioned inclusion criteria, both sex, elective, expedited and emergent hip fracture surgery, general or spinal anaesthesia technique, and written informed consent were also eligible for inclusion in the study. Hip fracture patients with incomplete data were excluded. The 30-days and 6-months follow-up of the included patients was attained from the University Hospital Centre Zagreb electronic medical database and a private phone call to obtain a 6-months survival. The preliminary retrospective research protocol was approved by the Human Research Ethical Committee of the University Hospital Centre Zagreb

Calculation of the SAS

The SAS is computed as a sum of the 3 intraoperative variables collected during the surgery starting from incision-to-skin closure time to minimise the episode of the anaesthetics reaction during induction and intubation on the hypotension and lowering heart rate (6). The variables are EBL, lowest HR and lowest MAP obtained from the intraoperative handwritten anaesthesia records for the each patient included in the study (5). Each of these 3 variables according to the measured values were assigned particular scoring points after the SAS table (Figure 1).These 3 intraoperative variables points sum is a total SAS value of the particular patient for the specific operation (5).

Patient's preoperative characteristics and postoperative outcomes

Patient's preoperative variables were bundled in four groups by organ system. Pulmonary comorbidity was defined as pneumonia, mechanical ventilator dependency, and preexisting chronic obstrucive pulmonary disease. Cardiovascular comorbidity included earlier myocardial infarction, angina pectoris, congestive heart disease, coronary revascularization, peripheral vascular disease and anamnesis of stroke and transient ischaemic attack. Renal comorbidity included history of acute or chronic renal disease. Coagulation comorbidity comprised hereditary and acquired coagulation disorder, as well as the use of anticoagulation agents such as warfarin, acetylsalicylic acid and clopidogrel. Other preoperative variables were age, gender, American Society of Anaesthesiologists(ASA) phyiscal status (from 1 to 4), length of operative delay (7). The preoperative patient's laboratory data consisted of haemoglobin, thrombocyte, and prothrombin time level.

The primary endpoints were occurence of major postoperative complications and death within the follow-up period of 30-days after the hip fracture surgery, length of the ICU and hospital stay. The major complications were defined as the development of the following: postoperative bleeding that required transfusion of 4 units or more of packed red blood cells within 72 hours, cardiac arrest, myocardial infarction, deep venous thrombosis, pulmonary embolism, stroke or transient ischaemic attack, unplanned intubation, mechanical ventilation for 48 hours or more,pneumonia, sepsis, septic shock, and acute renal failure (8,9). Since we are without National Surgical Quality Improvement Program we have defined major postoperative complications according to other researches with the National Surgical Quality Improvement Program and reviewing the medical records. Complications were assessed by review of handwritten medical records, laboratory data, radiology records and electonic medical database by two independent researchers and verified by cross-examination. Six months postoperative mortality rate was obtained by a phone call to the patient or his family member.

Statistical analysis

We performed a univariate analysis examining the relationship between each preoperative and intraoperative variables in the database and the outcomes of the major complication or death. We analysed categorical variables using Pearson Chi-square test. Kruskal-Wallis test was performed to assess continuous data normality and due to its results, appropriate non-parametric tests have been used. Mann-Whitney test was used to compare the SAS with preoperative and intraoperative variables. Spearman rank correlation coefficients were used to correlate SAS with all other continuous variables. Receiver operating characteristics curve for the SAS value ≤4 and 30-days major complications. Binary logistic regression model has been made to assess prediction to group within 30 days postoperative major complications. Model included 4 predictor variables (ASA score, SAS score, age and gender) and major postoperative complications group as a binary dependent variable (0=without major complications and 1=with complication). P value below 0.05 was regarded significant. Statistical software MedCalc for Windows, version 13.0 was used for all analyses (MedCalc Statistical Software version 13.0 (MedCalc Software bvba, Ostend, Belgium; http://www.medcalc.org; 2014)

Results

Our study included 43 cases, 8 men and 35 women. Baseline demographic and clinical characteristics of the cases are listed in the Table 1 and 2. Major complications within the 30-days occurred in 8 cases, hospital mortality in 1 case, 30-days mortality in 5 cases, and major complications within 6-months in 4 cases (Table 1). The median of operative delay was 3 days(25%-75% interquratile range (IQR) 2-6)(Table 2). Mean surgical score was 5.53 (± 1.79 SD), and the SAS median was 6 (IQR 4-7) (Table 2). When we examined the relationship between the surgical score and 30-days major complications we obtained the SAS cut-off value 4 according to the area under the receiver operating characteristic curve (ROC AUC). The SAS value ≤4 was a significant predictor for the 30-days major surgical complications with 80% specificity (ROC AUC 0.743, SE 0.0957, 95% CI: 0.587-0.864,p=0.0111) (Figure 2). However the surgical score was not significant in the prediction of the 30-days mortality (ROC AUC 0.629, SE 0.106, 95% CI: 0.468-0.771, p=0.2238) and 6-months mortality (ROC AUC 0.657,SE 0.186, 95% CI: 0.497-0.795, p=0.3997) as primary endpoints in the hip fracture surgery patients. According to our research other parameter must be relevant predictor for the 30-days and 6-months mortality primary endpoints. When we compared variables of cases with the SAS ≤4 (N=12) and the SAS ≥5 (N=31) with Pearsons Chi-Square Test, significant difference ($p<0.05$) was found in the following variables: intraoperative EBL (p=0.016, df= 3), intraoperative vasoactive support with noradrenaline or ephedrine bolus doses (p=0.022, df= 1), and 30-days major complications(p=0.016, df=1) (Table 3). The SAS ≤4 group had greater intraoperative EBL. In this group 5 cases lost >1000 ml blood, 4 cases between 601-1000ml, 3 cases between 101-600ml versus the SAS ≥5 group where 3 cases lost >1000 ml blood, 5 cases 601-1000ml, 14 cases 101-600ml, and 9 cases ≤100 ml (Table 3). In the SAS≤4 group vasoactive support was applied in 4 cases versus the SAS≥5 group in 2 cases (Table 3). The 30-days major complications happened in the SAS≤4 group in 5 cases compared to the SAS ≥5 group in 3 cases (Table 3). When the SAS was compared with patients' variables and postoperative outcomes using nonparametric Mann-Whitney test where appropriate, the significant correlation was found between the SAS and the lowest HR(p=0.007) (Table 2). Spearman rank correlation coefficients were used to correlate the SAS value with patients' preoperative and intraoperative variables, length of the ICU and hospital stay. The significant negative correlation was observed with the intraoperative EBL (the lower intraoperative bleeding, higher SAS, p<0.001) and the lowest HR(lower HR, higher SAS, p<0.001) (Table 4). Interestingly, this test observed that duration of surgery was also in negative correlation wiht the SAS (longer duration of surgery, lower SAS, p=0.014) (Table 4). We also wanted to asses with binary logistic regresion model whether intraoperative SAS was better predictor for the 30-days major complications than the following patients' predictor variables ASA physical status, age and gender (Table 5). Binary logistic regression model was statisticaly significant (X2 test=9,82, df=4, P=0,043) and explained 33,1% of dependent variable variance. SAS score ≤4 was only predictor variable that significantly influence on belonging in major 30-days postoperative complications group: OR=14,24 (95% CI: 1,84-110,32) controlled for all other variables in the model (Table 5). Moreover, the length of operative delay was significantly associated with the 6-months major complications when Mann-Whitney test was applied (p=0.015). Those 4 patients who developed 6-months major complications had median length of operative delay for 7 days (IQR 6.25-7). It is relevant to emphasize that these patients did not develop 30-days major complications.

Discussion

So far many studies have observed value of this 10-point intra- and postoperative surgical outcome score in many surgical subspecialities. Although this score has been validated in selected orthopaedic procedures (10,11,12,13,14) we also wanted to observe the utility of the SAS in the trauma hip fracture surgery patients. Hip fracture surgery repairs are operations of different magnitude. Together with poor preoperative medical condition of these patients, many comorbidities, and reduced cardiopulmonary reserves, preoperative variables like age and ASA physical status sometimes are not enough to prognose early and late postoperative patient's course and the need for the ICU surveillance. Our study demonstrated that the SAS ≤4 was the only significant predictor for the 30-days major complications development when compared with the patient's gender, age and ASA physical status. The cases with the SAS≤4 had 14.4 times greater odds than the cases with the SAS≥5 for developing 30-days major complications. Our result is almost consistent with other studies in which these poor-scoring patients were 16 times more likely to develop major complications (5,8). This is very important because the median postoperative hospital stay in our study was 10 days. In addition,our research also observed that the operative delay was asscociated with the 6-months major complications development. Cases who developed 6-months major complications had operative delay approximately for 7 days. Reasons for such a long operative delay were the preoperative poor medical patient's condition and time to optimize it, additional diagnostic test requirements, availability of the ICU postoperative surveillance. However, every clinician should be aware that operative delay of more than 48 hours, especially for low-risk and younger patients, is associated with increased short-term (30-days) and mid term(1-year) mortality, as well as with prolonged hospital stay of these patients (15,16,17). Yet the mortality rate for this fragile geriatric population approaches expected mortality approximately 6-months postoperatively according to the research (18). So the hip fracture patients with the SAS≤4 and the operative delay of more than 48 hours every clinician should recognise as red alarm warning for not only the postoperative intensive hospital care but also the postoperative 6-months surveillance to prevent worse outcome.

This surgical score is also a reliable intraoperative patient guiding tool for all the members of the surgical team. There was no difference in the MAP values between the SAS≤4 and SAS≥5 groups probably due to applied vasoactive bolus doses support intraoperatively to avoid current hypotension. This refers to a good intraoperative blood pressure control. But the mentioned SAS groups significantly varied by the intraoperative HR and blood loss. In our study the lower HR and estimated blood loss were associated with higher SAS values and the better primary patient's outcome. The SAS value would be higher by avoding higher HR, hypotension and applying surgical techingue to minimize the bleeding. Hence, we also observed that maintaining intraoperative stability of the vital signs and controlling the bleeding are relevant predictors of the patient's final outcome (19,20).
Our study has several limitations. First, the SAS was tested only in the small size trauma hip fracture patients while it's importance and implementation in the postoperative surgical outcome risk grading in other trauma patients is still not recognized. In addition retrospective research can have lots of falsity and underreporting data. Second, tha SAS variables were gained from the handwritten anaesthesia records which are not reliable as electronic versions. Also, blood loss estimation could be questionable. Yet, the studies have shown that the SAS blood loss estimation categories match the observer's blood loss volume accurately, and obtain more reliability if estimation is made by the anaesthesiologist (21,22). Therefore, in comparison with the obstretic Apgar score the SAS variables are nothing less reliant quantified than the obstretic Apgar score parameters (23). Moreover, another limitation of our research was that all-casue mortality was the primary endpoint, without specific secondary endpoints such as cardiovascular, neurologic, or infectious events. That is

because recent studies have shown that this secondary endpoints can not accurately predict mortality therefore are not recommended for the studies which aim is to decrease mortality (24,25,26). Another weakness of the score is that it can not be used to compare physicians or institutions because it greatly depends on the patient's preoperative condition and yet not established in our country risk-adjustment National Surgical Quality Improvement Program model. In spite of the limitations, we think that a future prospective research about the SAS utility in the all trauma procedures on a large sample size is necessary.

Conclusion

To conclude,intraoperative patient's course has an impact on the postoperative outcome. Thereby implementation of this simple surgical outcome score in everyday routine practise for the trauma hip fracture patients gives us objective, immediate, feed-back information about patient's clinical condition at the end of the procedure. However, our study showed that every hip fracture patient with the SAS≤4 sholud postoeppratively have ICU surveillance. Likewise enables us to stratify patients with the higher than average odds for 30-days major complications. It is also a tool which facilitates good interdisciplinary operative and postoperative communication between the team members, and routes us to apply suitable and quality postoperative care management for the individual patient in every aspect.

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Abbreviations: American Society of Anaesthesiologists (ASA); Surgical Apgar Score (SAS);Estimated blood loss (EBL); Heart rate (HR); Mean arterial pressure (MAP)

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Figure 1. Calculating the 10-point Surgical Apgar Score[1]

	Surgical Apgar Score Points				
	0 points	**1 point**	**2 point**	**3 points**	**4 points**
Estimated blood loss (ml)	**> 1000**	**601-1000**	**101-600**	**≤100**	**—**
Lowest mean arterial pressure (mmHg)	**< 40**	**40-54**	**55-69**	**≥ 70**	**—**
Lowest heart rate (beats/min)	**> 85**	**76-85**	**66-75**	**56-65**	**≤ 55***

[1]The Surgical Apgar score is computed at the end of the operation from the anaesthesia records as the sum of the 3 intraoperative variables: estimated blood loss, lowest mean arterial pressure, and lowest heart rate.
*Ooccurence of pathologic bradyarrhythmia including sinus arrest, atrioventricular block or dissociation, junctional or ventricular escape rhythms, and asystole, also receives 0 points for lowest heart rate.

Table 1. Baseline perioperative characteristics of hip fracture patients

		N	%
Gender	Male	8	18,6%
	Female	35	81,4%
ASA class	2	3	7,0%
	3	35	81,4%
	4	5	11,6%
Pulmonary disease[1]	No	28	65,1%
	Yes	15	34,9%
Cardiovascular disease[2]	No	13	30,2%
	Yes	30	69,8%
Renal disease[3]	Ne	37	86,0%
	Da	6	14,0%
Coagulation disorders[4]	No	35	81,4%
	Yes	8	18,6%
Estimated blood lossI ml	>1000 ml	8	18,6%
	601-1000 ml	9	20,9%
	101-600 ml	17	39,5%
	<=100 ml	9	20,9%
Type of operation	Dynamic hip screw	18	41,9%
	Hemiarthroplasty	19	44,2%
	Total hip replacement	1	2,3%
	Osteosythesis sec AO	5	11,6%
Operative diagnosis	Pertrochanteric fracture	19	44,2%
	Femoral neck fracture	20	46,5%
	Subtrochanteric fracture	4	9,3%
Anaesthesia technique	General	27	62,8%
	Spinal	16	37,2%
Surgery urgency	Elective	0	,0%
	Expedited	40	93,0%
	Urgent	3	7,0%
Vasoactive support	No	37	86,0%
	Yes	6	14,0%
Major complications, 30-days	No	35	81,4%
	Yes	8	18,6%
Hospital mortality	No	42	97,7%
	Yes	1	2,3%
30-days mortality	No	38	88,4%
	Yes	5	11,6%
Major complications, 6-months	No	39	90,7%
	Yes	4	9,3%

[1] Pulmonary comorbidity was defined as pneumonia, mechanical ventilator dependency, and preexisting chronic obstrucive pulmonary disease. [2]Cardiovascular comorbidity included earlier myocardial infarction, angina pectoris, congestive heart disease, coronary revascularization, peripheral vascular disease and anamnesis of stroke and transient ischaemic attack.[3] Renal comorbidity included history of acute or chronic renal disease. [4]Coagulation comorbidity comprised hereditary and acquired coagulation disorder, as well as the use of anticoagulation agents such as warfarin, acetylsalicylic acid and clopidogrel.

Table 2. Perioperative hip fracture patients' characteristics expressed as mean ± SD and median (25%-75% IQR) after applying t-test.

	Mean ± SD	Percentiles Median (IQR)	p value*
Age, years	80.30±10.09	82 (75-87)	0.498
ASA class	3.05±0.43	3 (3-3)	
Preoperative haemoglobin, g/L	121.51±19.61	122 (111-132)	0.203
Preoperative platelet count, x 10^9 L	235.79±94.19	221 (182-265)	0.607
Preoperative prothrombin time	0.95±0.24	1.02 (0.9-1.11)	0.533
Operative delay, days	3.84±2.51	3 (2-6)	0.336
Lowest MAP, mmHG	65.13±15.85	66 (53-76)	0.101
Lowest HR, beats/min	72.56±16.49	70 (65-85)	0.007
SAS value	5.53±1.79	6 (4-7)	
Operative duration, min	104.76±61.19	90 (70-120)	0.055
Postoperative haemoglobin, g7L	109.23±16.72	109 (98-123)	0.151
ICU length of stay, days	4±5.66	2 (2-3)	0.315
Hospital length of stay, days	11.74±9.27	10 (8-13)	0.495

*The p values were obtained after applying Mann-Whitney test to compare SAS value with perioperative variables. P value <0.05 was considered significant.

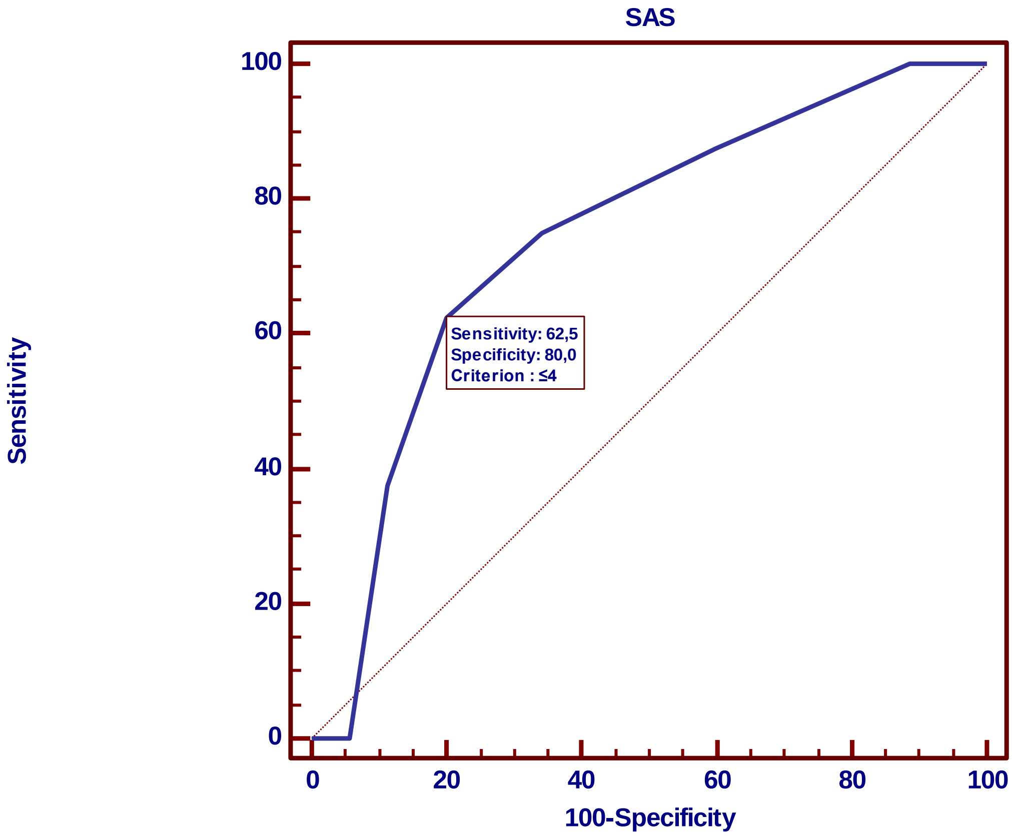

Figure 2. Receiver operating characteristics curve for the SAS value ≤4 and 30-days major complications. The SAS value ≤4 was a significant predictor for the 30-days major surgical complications with 80% specificity. ROC AUC 0.743, SE 0.0957, 95% CI: 0.587-0.864,p=0.0111 for Area =0.5.

Table 3. After the SAS cut-off value <=4 patients were dived in two SAS groups and their perioperative variables were compared applying Pearson Chi-Square Test.* P value <0.05 was considered significant.

		SAS: groups				p value
		<=4		>4		
		N	%	N	%	
Gender	Male	3	25.0%	5	16.1%	0.503
	Female	9	75.0%	26	83.9%	
ASA class	2	0	0.0%	3	9.7%	0.465
	3	11	91.7%	24	77.4%	
	4	1	8.3%	4	12.9%	
Pulmonary disease	No	9	75,0%	19	61.3%	0.398
	Yes	3	25,0%	12	38.7%	
Cardiovascular disease	No	4	33.3%	9	29,0%	0.783
	Yes	8	66.7%	22	71,0%	
Renal disease	No	9	75,0%	28	90.3%	0.193
	Yes	3	25,0%	3	9.7%	
Coagulation disorders	No	11	91.7%	24	77.4%	0.282
	Yes	1	8.3%	7	22.6%	
Estimated blood loss, ml	>1000 ml	5	41.7%	3	9.7%	0.016
	601-1000 ml	4	33.3%	5	16.1%	
	101-600 ml	3	25,0%	14	45.2%	
	<=100 ml	0	0,0%	9	29,0%	
Type of operation	Dynamic hip screw	3	25,0%	15	48.4%	0.451
	Hemiarthroplasty	7	58.3%	12	38.7%	
	Total hip replacement	0	0,0%	1	3.2%	
	Osteosythesis sec AO	2	16.7%	3	9.7%	
Operative diagnosis	Pertrochanteric fracture	3	25,0%	16	51.6%	0.054
	Femoral neck fracture	6	50,0%	14	45.2%	
	Subtrochanteric fracture	3	25,0%	1	3.2%	
Anaesthesia technique	General	8	66.7%	19	61.3%	0.744
	Spinal	4	33.3%	12	38.7%	
Operative urgency	Elective	0	0,0%	0	0,0%	0.121
	Expedited	10	83.3%	30	96.8%	
	Urgent	2	16.7%	1	3.2%	
Vasoactive support	No	8	66.7%	29	93.5%	0.022
	Yes	4	33.3%	2	6.5%	
Major complications, 30-days	No	7	58.3%	28	90.3%	0.016
	Yes	5	41.7%	3	9.7%	
Hospital mortality	No	11	91.7%	31	100,0%	0.104
	Yes	1	8.3%	0	0,0%	
30-days mortality	Ne	10	83.3%	28	90.3%	0.521
	Da	2	16.7%	3	9.7%	
Major complications, 6-months	No	10	83.3%	29	93.5%	0.301
	Yes	2	16.7%	2	6.5%	

Table 4. Correlation of the SAS and perioperative patients variables using Spearman Correlation Coefficient. P (2-tailed) value <0.05 was considered significant.

Variables	rho*	p value (2-tailed)
Age, years	-0.002	0.992
ASA class	-0.037	0.814
Preoperative haemoglobin, g/L	0.111	0.477
Preoperative platelet count, x 10^9 L	-0.051	0.746
Preoperative prothrombin time	0.171	0.274
Operative delay, days	-0.076	0.627
Estimated blood loss, ml	0.600	<0.001
Lowest mean arterial pressure, mmHG	0.256	0.098
Lowest heart rate, beats/min	-0.509	<0.001
Postoperative haemoglobin, g/L	0.230	0.138
Operative duration, min	-0.375	0.014
ICU length of stay, days	0.030	0.849
Hospital length of stay, days	-0.057	0.719

*rho is Correlation Coefficient. – sign mens negative correlation, no sign means positive correlation.

Table 5. Binary logistic regression model which included 4 predictor variables (ASA score, SAS score,age and gender) has been made to assess prediction to group with 30 days postop major complications as a binary dependent variable (0=without major complications and 1=with complicationa). Regression model was statisticaly significant (X2 test=9,82, df=4, P=0,043) and explained 33,1% of dependent variable variance. SAS score <=4 was only predictor variable that significantly influence on belonging in major compicatins group: OR=14,24 (95% CI: 1,84-110,32) controlled for all other variables in the model.

	B	**S.E.**	**Wald**	**df**	**OR**	**95% CI**		**P**
						Lower	**Upper**	
ASA score	-1,50	1,24	1,47	1	0,22	0,02	2,52	0,226
SAS score <=4	2,66	1,04	6,47	1	14,24	1,84	110,32	0,011
Age (years)	-0,05	0,05	1,00	1	0,95	0,86	1,05	0,317
Female gender	1,37	1,35	1,03	1	3,93	0,28	55,29	0,311