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Surgical Apgar Score (SAS): A Simple, Reliable Preoperative Prognosticator for Postoperative Complications of Surgery

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Abstract

Background: Preoperative risk assessment and perioperative factors may help identify patients at increased risk of postoperative complications and allow postoperative management strategies that improve patient outcomes.

Aim and objective: To be a be a reliable preoperative prognosticator for postoperative complications of surgery.

Method: A prospective observational study was conducted among eligible adult patients undergoing laparotomies at SJ MCH, Puri Hospital, and followed up for 3 months. We collected data on the patient's preoperative and intraoperative characteristics. Using the data generated, SAS was calculated, and patients were classified into 3 groups, namely: low (8–10), medium (5–7), and high (0–4). The primary outcomes were in-hospital major complications and mortality. Data was presented as proportions, mean (standard deviation), or median (interquartile range), as appropriate. We used inferential statistics to determine the association between the SAS and the primary outcomes, while the SAS discriminatory ability was determined from the receiver-operating curve (ROC) analysis.

Results: Of the 100 participants recruited, 68 (68%) were male, and the mean age was 40.6±15. Overall postoperative in-hospital major complications and mortality rates were 24% and 10%, respectively. The participants with a high SAS category had an 18-times risk (95% CI, 2–95, p = 0.012) of developing major complications, while those in the medium SAS category had a 3-times risk (95% CI, 1–15, p = 0.0452) of dying. SAS had a fair discriminatory ability for in-hospital major complications and mortality with an area under the curve of 1 and 1, respectively. The sensitivity and specificity of SAS≤6 for major complications were 60% and 8%, respectively, and for death, 54% and 81%, respectively.

Conclusion: SAS of≤6 is associated with an increased risk of major complications and/or mortality. SAS has a high specificity and an overall fair discriminatory ability to predict the risk of developing in-hospital major complications and/or death following laparotomy.

Keyword: Surgical Apgar Score, Preoperative, Postoperative Complications

Introduction

Globally, over seven million people develop postoperative complications annually [1], while postoperative deaths are the third leading contributor to global mortality, with 7.7% of the mortality occurring within 30 days of surgery [2]. Half of global mortality and complications occur in low- and middle-income countries (LMICs) [3], with 20% of patients undergoing surgery in Africa developing complications, while 10% of them die due to postoperative complications [4].

Accurate risk stratification before surgery has the potential to improve several aspects of overall patient care, including more accurate informed consent, improved selection of procedures, better estimates of the likelihood of early and safe discharge, and more appropriate targeting of postoperative critical care services [5–6]. (Fig. 1). Therefore, it is crucial to design reliable and simple tools to predict postoperative complications. Several studies have identified an association between the incidence of postoperative complications and factors such as the postoperative elevation of infammatory parameters [7]. However, in most countries, surgeons are legally obliged to inform patients of the potential risks of surgery, which reduces the value of postoperative measures [8]. The identification of patients most at risk of serious postoperative complications is essential to the decision-making process before surgery, highlighting the need to develop prediction tools based exclusively on factors identified preoperatively. Ideally, such tools should be based on simple, low-cost, rapid, and objective measures and be applicable to all patients and hospitals.

The Surgical Apgar Score (SAS) is a 10-point score that uses three intraoperative parameters: the lowest heart rate, the lowest mean arterial pressure (MAP), and the estimated blood loss (EBL) during the surgery to predict postoperative complications and death [9]. It is a simple and easy-to-use tool with a good discriminatory ability to differentiate between those at high and low risk of developing major complications or death within 30 days of surgery [10]. SAS has been validated in other countries [11], but its use in LMIC is low. This study will generate more evidence on thepredictive performance of SAS in patients undergoing abdominal surgery in LMICs and could increase its adoption in most LMICs. Therefore, this study aimed to determine the performance of SAS in predicting complications and mortality in patients undergoing laparotomy at SJ MCH, Puri, India.

Material and method

Study design

We conducted a prospective observational cohort study, and participants were followed up for 30 days. The study aimed to determine the accuracy of the surgical Apgar score for prediction of post-operative complication severity among patients who underwent emergency laparotomy at SJ MCH, Puri, India. We also aimed to describe the severity pattern of post-operative complications among patients who underwent emergency laparotomies and to evaluate the correlation between SAS and the severity of post-operative complications following emergency laparotomies.

Sample size estimation

We consecutively recruited 100 participants. Using the sample size formula for comparing two proportions, studies assessing the sensitivity and/or specificity of a single test tool [12] and based on findings from a study done in Kenya [13] and Turkey [14]. Due to the small target population, we used a new sample size estimation formula, S=(N)/(1+N/K), where N is the calculated sample size, K is the maximum population available, and a fnite correction factor, K = 200. We considered a 20% loss to follow up, and the final sample size of 100 was determined.

Study procedure

Prospective participants or their next of kin were given an introduction to the study by the research assistants. Prior to surgery, informed consent was obtained from participants who were hemodynamically stable and not experiencing discomfort. The research assistant then delivered an interviewer-guided questionnaire to these same participants. After the intervention was administered, participants who were in critical condition or who were experiencing extreme pain or discomfort were recruited with their agreement.

Study variables collected

Age and other sociodemographic information were gathered, as well as clinical information about the presence of co-morbidities, the type of operation (elective or emergency), the length of the procedure, the surgeon's training (surgical resident or specialist), and the intra-operative diagnosis (pathology or condition identified upon intraperitoneal access). Prior to, during, and following their laparotomies, every participant was evaluated to determine whether they required admission to the intensive care unit. We determined whether a patient required more than 24 hours of mechanical ventilation (advanced respiratory support) or needed pre- or postoperative care to support two or more failing organ systems, or if they met the criteria for Clavien class IV, which required readmission to the intensive care unit, in order to plan for ICU admission.

SAS variables

We collected intraoperative parameters of SAS, but no pre-operative parameters were collected. Heart rate and mean arterial Arterial Pressure (MAP) were obtained from the anesthesia case logs either electronically on the patient's monitor or from the patient's anesthesia chart after the operation (after skin incision closure). If MAP was not directly recorded, it was calculated from intraoperative recordings of systolic blood pressure (SBP) and diastolic blood pressure (DBP) using the equation: $MAP=[SBP+(2 \times DBP)]/3$. Estimated Blood Loss (EBL) was calculated after the summation of the amount estimated based on the gauze visual analogue (pictorial materials were available in theater) [15] by the surgeon and/or anesthetist/anesthesiologist, the amount of blood in the suction container, and blood spillage. The amount of blood in the suction container was determined at the end of surgery after estimation of the peritoneal contamination fluid (gastric, bowel, and other fluids) and normal saline used in lavage. Blood spillage on the theater floor was determined by visual estimation by the surgeon. The pictorial material showing different estimated amounts of blood absorbed by the gauze or mop was developed by getting the dry weight of the gauze or mop and then later impregnating it with several different known amounts of blood and getting their weight again. The difference was the estimated amount of blood (1 g of blood measured equals 1 ml). SAS (Table 1) was calculated by summing the point scores of the lowest heart rate, lowest MAP, and lowest EBL [16]. The SAS was used to stratify the participants into three categories: high score (SAS 0–4), medium score (SAS 5–7), and low score (SAS 8–10).

We recorded in-hospital postoperative major complications and mortality based on the patient's outcome in the operating room, recovery room, A&E unit, and during their admission in the general surgery ward and ICU. For ease of follow-up, telephone contacts of either the participant or next of kin were recorded in a separate form that was kept by the principal investigator or a research assistant designated by the principal investigator. We followed up with participants on postoperative days 1, 3, 5, and every other day until discharge, death, or the 30th postoperative day. During the follow-up visits, we reviewed clinical notes and recorded patient-reported symptoms to identify any post-operative complications or death.

Outcomes

The outcomes of our study were the development of major postoperative complications or death. Major-complication assessments were based on clinical definitions. These included:

Pneumonia: Chest radiographs with new or progressive and persistent infiltrates, consolidation, or cavitation, and at least one of the following:

1. Fever (>38 °C) with no other recognized cause
2. Leucopenia (<4000 white blood cells/mm3) or leukocytosis (>12,000 white blood cells/mm3)
3. New onset of purulent sputum or change in the character of sputum, increased respiratory secretions, or increased suctioning requirements
4. New-onset or worsening cough, dyspnea, or tachypnea, with rales or bronchial breath sounds.

Deep surgical site infection (deep)

AN infection within 30 days of surgery if the surgical implant is removed; this infection affects the deep soft tissues of the wound, such as the layers of muscle and fascia; at least one of the following conditions was present in the patient:

1. Purulent discharge coming from the deep cut.
2. A deep incision with at least one of the following symptoms was either spontaneously dehisced or was voluntarily opened by a surgeon or attending physician, and either culture-positive or no cultures were obtained. Fever (>38 °C); localized soreness or pain
3. An abscess or other infection-related sign involving the deep incision seen via a gross anatomical examination or imaging test

Surgical site infection (organ or space)

Any area of the body that was opened or moved during the surgical operation, whether it be deeper than the fascia or muscle layers, is susceptible to infection, and the patient must have at least one of the following conditions:

1. Purulent drainage from the drain that was inserted into the organ or space through a stab wound
2. Identification of an organism from an aseptically obtained fluid or tissue in the organ or space by a culture- or non-culture-based microbiologic testing method that was performed for the purpose of clinical diagnosis or treatment
3. An abscess or other indication of organ or space infection was found on direct examination, during reoperation, or by radiologic examination.
4. A surgeon's or attending physician's diagnosis of an organ or space surgical site infection.

Wound dehiscence

Superficial or deep wound breakdown.

Acute kidney injury

Increase in serum creatinine level 2.0 to 3.0-fold or serum creatinine level greater or equal to 4 mg/dl (≥354 μmol/l) with an acute increase of>0.5 mg/dl (>44 μmol/l) or the initiation of renal replacement therapy, or urine output<0.5 ml/kg/h for 12 h or anuria for 12 h. Stage 2 and 3 acute kidney injury as defined by the Acute Kidney Injury Working Group of KDIGO (kidney disease: Improving Global Outcomes) [17].

Cardiac arrest

The absence of circulatory signs (bradycardia with a heart rate of less than 60 beats per minute (bpm) with poor perfusion necessitating external cardiac compressions and assisted ventilation), unresponsiveness, and lack of respiratory effort confirm the cessation of cardiac mechanical activity.

Anastomotic leak

Bowel contents are being released through a wound, drain, or unusual orifice. Unplanned intubation: defined by the ACS-NSQIP database as the need for the implantation of an endotracheal tube due to the development of respiratory or cardiac failure, as demonstrated by

the emergence of severe respiratory distress, hypoxia, hypercarbia, or respiratory acidosis within 30 days following the procedure. Any intubation following an earlier intubation for surgical patients was regarded as an unplanned incubation.

Septic shock

Sepsis-induced persistent hypotension (systolic blood pressure<90 mmHg and diastolic<60 mmHg) despite adequate fuid resuscitation along with the presence of perfusion abnormalities that may include, but are not limited to, lactic acidosis, oliguria, or an acute alteration in mental status [18]. Postoperative complications that met the definition of Clavien class III complications (requiring surgical, endoscopic, or radiologic intervention) and class IV complications (requiring readmission to the intensive care unit [ICU] or being considered life-threatening) were categorized as major complications [19]. Multiple complications in a single patient were graded and recorded separately. Patients' outcomes (alive or dead, major complication or no major complication) were the point of reference against which SAS was compared.

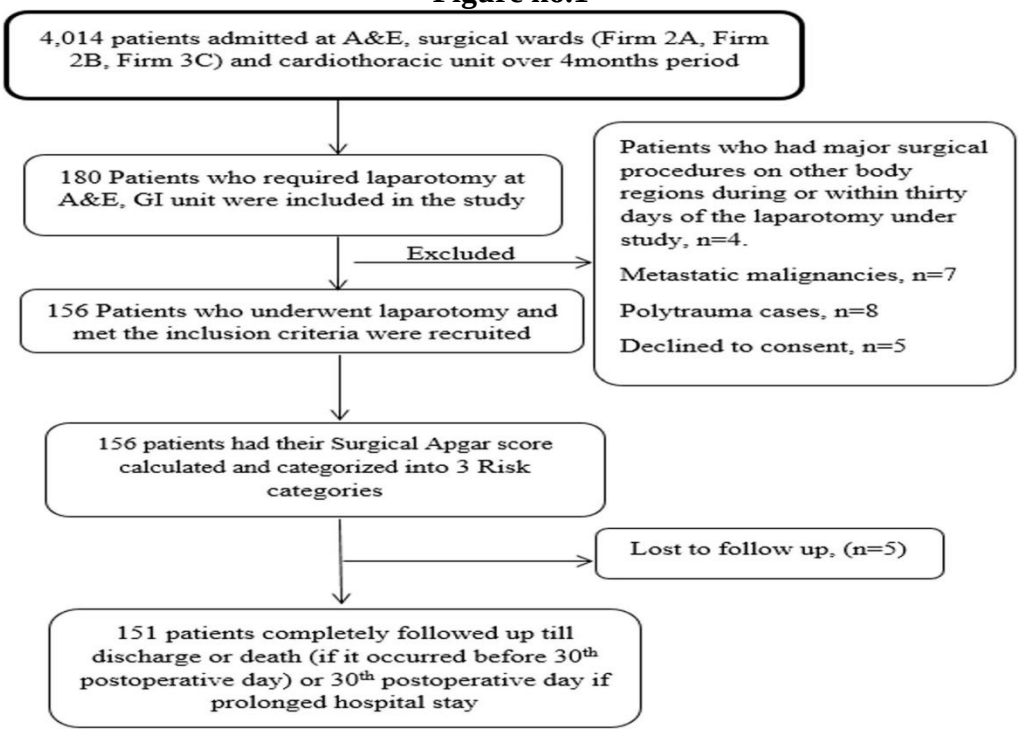
Postoperative mortality

Data on the deaths of participants post-operatively was generated from the medical certificate of death.

Analysis

Data was entered into EPI-DATA 4.2 and exported to SPSS version 23 for analysis. Baseline characteristics and continuous variables are summarized using means and standard deviations, or medians and interquartile ranges, for normally distributed and skewed data, respectively. Categorical variables were summarized using proportions and percentages, where appropriate. Tables, bar graphs, and pie charts, where appropriate, are used to present results. The 30-day post-operative survival rates were calculated using the Kaplan-Meier method. The chi-square test was used to determine the association between major complications and the independent variables (SAS categories (0–4, 5–7, 8–10), age, sex, nature of the operation, the cadre of the surgeon, needing ICU, intraoperative diagnosis, and duration of operation). In addition, Chi-square was used to determine the association between being alive or dead and the SAS. Variables with a cut-off p-value less than or equal to 0.20 at variance analysis and those clinically known to be associated with major complications were subjected to multivariate logistic regression adjusting for potential confounders. A p-value of 0.05 or less was considered statistically significant. To test the surgical Apgar score's discriminant operating characteristic (ROC) curves, they were generated. The patient's outcome (alive or dead, major complication, or no major complication) were the references against which SAS was compared. The point estimate on the ROC curves whose sensitivity and specificity had the maximal Youden's index ([Sensitivity+Specifcity]−1) was the optimal cut-off, and its corresponding sensitivity, specificity, and area under curve (AUC) were reported. The same was done for mortality.

Figure no.1



Observation and Results

Participant demographics

We recruited 105 participants into the cohort, but five were lost to follow-up (Fig. 1). One hundred participants were included in the final analysis. Of the 100 participants, 68 (68%) were male, and the mean age was 40.6±15 years. 13 (13%) had comorbidities, with hypertension being the most common at 40%.

Table 1: Surgical Apgar Score

Parameter	**0point**	**1 point**	**2 point**	**3 point**	**int**
imated blood loss (ml)	>1000	601–1000	101–600	≤100	
owest MAP (mmHg)	**<40**	**40-54**	**55-69**	**≥70**	
vest heart rate beats/min)	>85	**76-85**	**66-75**	**56-65**	

Table 2: Distribution of clinical indications among patients who underwent laparotomy

Clinical indication	Frequency	%
peritonitis	28	28
intestinal obstruction	26	26
ıtrabdominal malignancy	11	11
Abdominal trauma	10	10
appendicitis	7	7
Others	6	6
achalasia	4	4
Gastric outlet obstruction	3	3
lecystitis		
nia		

Regarding clinical characteristics, the majority of the participants underwent emergency laparotomies (70%). General surgery residents conducted most of the laparotomies, 69 (69%), with emergency laparotomies accounting for 95 (95%). The most common reported indication for laparotomies was peritonitis at 28 (28.%), followed by intestinal obstruction at 26 (26%) (table 3), while gastrointestinal perforation at 30 (30%) was the most reported intraoperative diagnosis. Other patient characteristics are summarized in Table 3. In terms of clinical outcomes, 24 (24%) of the participants developed major complications, with 13 (13%) having 3 or more major complications, and 9 (9%) participants died following surgery (Table 4). The median duration of developing postoperative cardiac arrest was 0.5 (IQR: 0–1), which was the shortest, while participants took a median duration of 6 days postoperatively to develop pneumonia (IQR, 4–10), wound dehiscence (IQR, 5–6), and anastomotic leak (IQR, 5–8). About 9 patients (9%) were re-operated, 7 of whom were due to anastomotic leaks.

Table 3: Participant's characteristics

iable	**quency**
(mean±SD)	±15
(M:F)	2
ence of comorbidity	
	ertension
cify comorbidities 3)	
	betes mellitus only
	ertension+diabetes
	r cirrhosis
ical characteristics	gory of operation
	rgency
	tive
re of primary geon	dent
	rgency
	tive

	:ialist	
	rgency	
	tive	
	rointestinal	
a-operative	ɔration	
nosis	obstruction	
	abdominal	
	gnancy	
	nmatory disorder	
	ers	
		80
ation of surgery (median utes/IQR)	) min	
	) min	

Post-surgery survival

Patients were followed up for 30 days after surgery. Figure 3 shows the Kaplan-Meir survival estimates during the period of follow-up. Survival at day 1 was 98.7% (IQR: 94.8–99.7%), 96.7% (92.2–98.6%) at day 3, 91.7% (84.6–95.6%) at day 7, 85.6% (76.6–91.4%) at day 14, 83.1% (73.5–89.4%) at day 21, and 81.4% (71.4–88.2%) at day 30.

Table No. 3: Outcomes in Patients Undergoing Laparotomy

iable		**quency**
occurrence of major plications		
ıber of major plications	major complications	
	more major complications	
tality	ivors	
	-survivors	
	ımonia	
	-operative day (median.)	
	ınd dehiscence	
	-operative day (median.)	
	ɔ or organ-space SSI	
vidual major plications	-operative day (median.)	
	ɔeration	
	-operative day (median.)	
	stomotic leak	
	-operative day (median.)	
	liac arrest	

	-operative day (median.)	
	:e kidney injury	
	-operative day (median.)	
	ic shock	
	ɔation	
	-operative day (median.)	
nission to the Intensive e Unit (ICU)	ned Admission to the ICU iitted to the ICU admitted to the ICU	

Surgical Apgar Score (SAS): Score Category Distribution, Components, and Diagnostic Accuracy

Table No. 5: Distribution of SAS Parameters

iable		**quency**
(median, IQR)		
risk categorization	risk (8–10) ium (5–7) ı risk (0–4)	
mated blood loss in mls (median, IQR)	)	20
	600	
	100	
	)0	
est heart rate in beats per minute dian, IQR)		10
	5	
	5	
	5	
est mean arterial pressure (median,)		0
	9	
	6	

In our study, 62 (62%) of the participants had a medium SAS (Table 5). Te median estimated blood loss was 120mls (Interquartile range (IQR), 75-110) while the median lowest heart rate was 82 bpm (IQR 60–80). The median lowest MAP was 70 mmHg, (IQR 60–80). SAS had fair discriminatory ability with the AUC for in-hospital major complications at 1 (95% CI, 0.68–0.87) while that of mortality at 1 (95% CI, 0.66–0.83). From the ROC curve analysis, SAS≤6

had the highest Youden's index of 0.42 hence the optimal cutof. A SAS≤6 had a sensitivity of 60% and specifcity of 80% for detecting complications for patients undergoing laparotomy. For mortality, a SAS≤6 had a sensitivity of 54% and specifcity of 87% (Youden's index of 0.42) for mortality in patients undergoing laparotomy.

Factors associated with major postoperative complications and mortality

Table no.6: Factors associated with major complications and mortality

		or complications		**tality**	
come variables		**de %CI)**	**RR alue**	**de %CI)**	**RR alue**
		-1)	01	0–1)	1
	score (n=13)				
category	ium score 8)	-40)	2		
	score 2)	.0–95)	**82**	-11)	7
(years)	r more				
	4	-9)	**2**	).3–8.6)	**2**
	e	-4)	**1**	-1)	**1**
	ale				
ıre of operation	tive				
	ergency	40)	**1**	42)	**25**
e of surgeon	ialist				
	dents	-22)	**2**	– 50)	**2**
ıtion of surgery	) min				
	) min	-2)		- 4)	**4**
	tinal obstruction				
operative nosis	erforation	-20)	01		
	nmatorydisorder	-7)	**2**		
	ers	-2)	**4**		
l ICU		3.0–35.0)	01	– 60)	01

Based on bivariate analysis (Table 6), the crude relative risk of participants developing major complications in the high SAS category was 16 (95% CI, (2.0–95), P=0.0082) compared to the low SAS category. Participants in the high SAS category were 3 times more likely to die compared to those in the medium SAS category (95% CI, (1–11), P=0.015). Emergency laparotomies were 9 times (CRR, 95% CI, 2–43.0), p<0.05) compared to the elective cases. Participants who required ICU admission were 10 times (95% CI (3.0–35.0), p<0.05) and 15 times (95% CI (5–60), p<0.001) as likely to develop complications and to sufer death,

respectively as those who did not require ICU admission. On multivariate analysis (Table 6), SAS was an independent risk factor for complications and mortality postoperatively. Patients in the high-SAS category had a high likelihood of developing major complication (ARR, 95% CI, (16 (2–95), p=0.0082), and dying (ARR, 95% CI, 3 (1–15), p=0.048) compared to those in the medium SAS category. Emergency laparotomies were associated with complications post operatively (AAR, 95% CI, 19 (1–350), p=0.044). In addition, the need for ICU admission was associated with post operative complications (ARR, 95% CI, 16.3 (2.8–94.6), p<0.05) and mortality (ARR, 95% CI, 10 (3–135), p<0.001). However, there was no statistical significance between cadre of primary surgeon and post operative complications and mortality.

Discussion

In our cohort study, we investigated the performance of SAS in predicting postoperative major complications and mortality among participants who had undergone laparotomies at SJ MCH, Puri. The observed in-hospital mortality rate in our study was 10.%. This is consistent with prior studies in resource-limited areas which reported a mortality rate ranging between 5.5% and 22.4% [4]. Compared to findings from a global survey [20], we had a higher mortality rate in our cohort. This may be attributed to the fact that we had mainly emergency cases who were not adequately optimized and majority had delays in making diagnosis and surgical intervention. In our study, the overall in-hospital complication rate was 24%. where the complication rate was 24% and 29%, respectively. In our setting, patients are delayed or misdiagnosed at other lower healthcare facilities which may cause their clinical deterioration preoperatively, intraoperatively, and post operatively. We found that the SAS had a fair discriminatory ability for in-hospital complications and mortality with an AUC. Our findings were in agreement with those from a study conducted in Rwanda which had an AUC of 0.79 for postoperative in-hospital mortality and 1 for major complications [21]. Similarly, in a multi country pilot study, the AUC of SAS was 0.70 and 0.77 for prediction of any complication and mortality, respectively [22] while among 1,441 patients undergoing general and vascular surgical procedures, SAS achieved a C statistic of 0.73 for predicting major complications and 0.81 for predicting deaths [23]. In another study conducted among patients undergoing emergency abdominal surgery, SAS had a relatively weak discriminatory power with an AUC of 0.63 [24] which was lower than AUC in our study. The low AUC could be due to the perioperative patient optimization which could have affected the scores. SAS had a low sensitivity in predicting the development of complications and mortality post operatively but had a high specifcity in predicting the development of complications and mortality among participants who had had laparotomies. This agrees with findings from a retrospective study done in the Caribbean [14]. Due to its predictive ability, SAS provides a potential platform to identify patients at risk of mortality and morbidity so that aggressive management plans can be instituted.

Form our study, patients with a SAS of ≤ 6 should have their post-operative management plan re-evaluated and revised to reduce the risk of morbidity and mortality. In our study, high SAS category, emergency laparotomies, and the need for ICU were associated with complications post operatively while high SAS category as well as needing ICU were associated with mortality. A pilot study of SAS in general and vascular patients, patients in the high SAS category were 16 times at greater risk of experiencing a major complication compared to those in the low and medium SAS category [13]. In addition, Regenbogen and colleagues found that participants within the high SAS category were 112.0 times more likely to die (95% CI, (15.3–819.7); p<0.001) within 30 days compared to the those with medium and low SAS categories [25]. Te high risk of developing complications and mortality post operatively could be attributed to the high number of surgeries conducted by residents who may have committed errors leading to intraoperative bleeding. Additionally, majority of our participants scheduled for emergency laparotomy had the surgery more than 72 h after initial symptom onset which

could have affected their intraoperative and post operative conditions. Te delayed laparotomy of participants who were at an irreversible physiological deterioration stage made them unsalvageable even with the appropriate treatment or intervention. Like in Rwanda, emergency status were associated with signifcantly increased risk of postoperative major complications and death when compared to elective surgeries [21]. Te need for ICU admission was associated with complications and mortality post operatively. This may be due to the unstable preoperative status of the participants which could have negatively affected the intraoperative and post operative states of the participants hence the high risk.

Study limitations

Different gauze material weight and mixture of blood with peritoneal contaminants (bowel contents, pus, or fluid) in the suction container may have resulted in over estimation of blood loss while underestimation of blood loss may have resulted from blood absorbed by the linen and spillage on the floor. This affected the objective totalblood loss estimated. However, the wide categorization of blood loss used allows for a reasonable accurate estimation since it is easily within the observers' range of precision. Perioperative haemodynamic (blood pressure, pulse rate and mean arterial pressure) were afected by anaesthetic drugs, depth of anaesthesia and interventions, which could have altered the physiological status of participants. Additionally, preoperative fluid resuscitation state of the patient could have affected intraoperative hemodynamic state. This could have affected the computation of the SAS leading to misclassifcation of patients and may have contribute to a high or low complication and/or mortality rate in the different SAS categories. In our study, we did not collect data on the pre-operativetatus of participants and future studies should explore how pre-operative status affects the predictive ability of SAS. Overall complication and mortality may have been underestimated due to premature discharge of participants and the study examining only inpatient complications or mortality. We were unable to assess for neurological complications and future studies should explore the incidence/prevalence of neurological complications among post-operative elderly patients. In addition, SAS has been shown to predict ICU admission in high risk abdominal surgeries [26], more studies could explore this outcome in LMICs where available surgical resources differ.

Conclusion

Low SAS (≤6) is associated with increased risk of developing in-hospital major complications and/or death fol lowing laparotomy at Puri Regional Referral Hospital. SAS can adequately predict, or risk stratify patients undergoing laparotomy in a low resourced Centre SJ MCH, Puri at higher-than-average risk of developing inhospital postoperative major complications and/or dying. SAS has a high specifcity with an overall fair discriminatory ability for predicting those at high or low risk of developing in-hospital major complications and/or death following laparotomy in a low resourced tertiary hospital

References

1. DeathCollaborators GCo. Global, regional, and national age-sex-specific mortality for 264 causes of death, 1980–2016: a systematic analysis for the Global Burden of Disease Study 2016. The Lancet. 2017;390(10100):1151–210.
2. Nepogodiev D, Martin J, Biccard B, Makupe A, and Bhangu A. Surgery (NIFHRGHRUOG). Global burden of postoperative death. Lancet (London, England). 2019;393(10170):401.
3. Haynes AB, Regenbogen SE, Weiser TG, Lipsitz SR, Berry WR, and Gawande AA. Surgical outcome measurement for a global patient population: validation of the Surgical Apgar Score in eight countries. J Am Coll Surg. 2009;209(3):S93–4.
4. Biccard B, Madiba T, Kluyts H, Munlemvo D, Madzimbamuto F, Basenero A, African Surgical Outcomes Study (ASOS) investigators, et al. Perioperative patient outcomes in

the African Surgical Outcomes Study: a 7-day prospective observational cohort study. The Lancet. 2018;391(10130):1589–98.

5.Liu ZJ, Ge XL, Ai SC, Wang HK, Sun F, Chen L, et al. A postoperative decrease in serum albumin predicts short-term complications in patients undergoing gastric cancer resection. World J Gastroenterol. 2017;23:4978–85.

6.Kanda M, Fujiwara M, Tanaka C, Kobayashi D, Iwata N, Mizuno A, et al. Predictive value of drain amylase content for peripancreatic infammatory fuid collections after laparoscopic (assisted) distal gastrectomy. Surg Endosc. 2016;30:4353–62.

7.Park DJ, Lee HJ, Kim HH, Yang HK, Lee KU, and Choe KJ. Predictors of operative morbidity and mortality in gastric cancer surgery. Br J Surg. 2005;92:1099–102.

8.Jiang X, Hiki N, Nunobe S, Kumagai K, Nohara K, Sano T, et al. Postoperative pancreatic fstula and the risk factors of laparoscopy-assisted distal gastrectomy for early gastric cancer. Ann Surg Oncol. 2012;19:115–21.

9.Huddart S, Peden C, Swart M, McCormick B, Dickinson M, Mohammed MA, et al. Use of a quality improvement care bundle to reduce mortality after an emergency laparotomy. J Br Surg. 2015;102(1):57–66.

10. Regenbogen SE, Ehrenfeld JM, Lipsitz SR, Greenberg CC, Hutter MM, and Gawande AA. Utility of the surgical Apgar Score: validation in 4119 patients. Arch Surg. 2009;144(1):30–6.

11. Ngarambe C, Smart BJ, Nagarajan N, and Rickard J. Validation of the surgical apgar score after laparotomy at a tertiary referral hospital in Rwanda. World J Surg. 2017;41(7):1734–42.

12. Hajian-Tilaki K. Sample size estimation in diagnostic test studies of biomedical informatics. J BioMed Informat. 2014;48:193–204.

13. Dullo M., Surgical Apgar Score: Applicability in Patients Undergoing Laparotomy at Kenyatta National Hospital, University of Nairobi, 2013.

14. Singh K, Hariharan S. Detecting major complications and death after emergency abdominal surgery using the surgical Apgar score: a retrospective analysis in a Caribbean setting. Turkish J Anaesthesiol Reanim. 2019;47(2):128.

15. Algadiem EA, Aleisa AA, Alsubaie HI, Buhlaiqah NR, Algadeeb JB, and Alsneini performed blood loss estimation using gauze visual analogue. Trauma Monthly. 2016;21(2).

16. Gawande AA, Kwaan MR, Regenbogen SE, Lipsitz SA, and Zinner MJ. An Apgar score for surgery. J Am Coll Surg. 2007;204(2):201–8.

17. KDIGO 2012 Clinical Practice Guideline for the Evaluation and Management of Chronic Kidney Disease. J Int Soc Nephrol. 2012;3(1).

18. Gül F, Arslantaş MK, Cinel İ, Kumar A. Changing definitions of sepsis. Turk J Anaesthesiol Reanim. 2017;45(3):129.

19. Dindo D, Demartines N, and Clavien P-A. Classification of surgical complications. Ann Surg. 2004;240(2):205–13.

20. Collaborative G. Surgical site infection after gastrointestinal surgery in high-income, middle-income, and low-income countries: a prospective, international, multicentre cohort study. Lancet Infect Dis. 2018;18(5):516–25.

21. Ngarambe C, Smart BJ, Nagarajan N, and Rickard J. Validation of the surgical apgar score after laparotomy at a tertiary referral hospital in Rwanda. World J Surg. 2017;41(7):1734–42.

22. Haynes AB, Regenbogen SE, Weiser TG, Lipsitz SR, Dziekan G, Berry WR, et al. Surgical outcome measurement for a global patient population: validation of the Surgical Apgar Score in 8 countries. Surgery. 2011;149(4):519–24.

23. Regenbogen SE, Ehrenfeld JM, Lipsitz SR, Greenberg CC, Hutter MM, and Gawande AA. Utility of the surgical Apgar Score: validation in 4119 patients. Arch Surg. 2009;144(1):30–6.
24. Cihoric M., Toft Tengberg L., Bay-Nielsen M., and Bang FN. Prediction of outcome after emergency high-risk intra-abdominal surgery using the surgical Apgar Score. Anesth Analg. 2016;123(6):1516–21.
25. Regenbogen SE, Ehrenfeld JM, Lipsitz SR, Greenberg CC, Hutter MM, and Gawande AA. Utility of the surgical apgar score: validation in 4119 patients. Archives of Surgery (Chicago, Illinois: 1960). 2009;144(1):30–6;
26. Sobol JB, Wunsch H, and Li G. The Surgical Apgar Score is strongly associated with ICU admission after high-risk intra-abdominal surgery. Anesth Analg. 2013;117(2):438.