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Research paper

Utility of the surgical Apgar score in predicting morbidity and mortality: A prospective study

Harsha Huliyappa, Sreevathsa Maddibande Ramachar

Department of Surgery, M S Ramaiah Medical College, Rajiv Gandhi University of Medical Sciences, Bangalore, Karnataka, India

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Abstract

Introduction: Optimization of postoperative care is often contingent upon the risk stratification tools such as surgical scores that are used to prognosticate potential complications.

Aim: This study evaluates the utility of surgical Apgar score (SAS) as a tool to predict morbidity and 30-day mortality among patients post general surgical procedures.

Material and methods: The study cohort comprised of 400 patients aged between 15 to 75 years, and prospectively undergoing emergency or elective general surgery. SAS of patients were extracted from the anesthesiologist's records on estimated blood loss, lowest heart rate and lowest mean arterial pressure. Post-operative outcomes such as major complications and mortality within 30 days of surgery were monitored.

Results and discussion: Out of the 297 elective procedures, 22 (7.41%) cases had major complications. While among those undergoing emergency surgeries (103), 38 (36.86%) patients developed major complications. The odds of developing major complications in patients with the high-risk SAS scores (31; 51.67%) was 5.42 (CI: 3.03–9.70) times greater than in patients with low-risk SAS scores (29; 48.33%). The odds of expiring after a general surgery was 11.92 times higher in high-risk patients (9; 75%) when contrasted with low-risk patients (3; 25%). The sensitivity and specificity of SAS in predicting major complications is 51.67% and 83.53%, respectively. The sensitivity and specificity of SAS in predicting mortality are 75% and 79.9%, respectively.

Conclusions: SAS serves as a simple and dependable tool to predict morbidity and 30-day mortality in patients undergoing surgical procedures under anesthesia other than local, requiring intensive perioperative monitoring.

Corresponding author: Harsha Huliyappa, Department of Surgery, M S Ramaiah Medical College, Rajiv Gandhi University of Medical Sciences, Bangalore, Karnataka, India. Tel: +91 9450389205
E-mail address: harsha_huliyappa@yahoo.com

1. INTRODUCTION

Risk stratification before and after surgery is a component of holistic post-operative management strategy that expedites recovery. Most of the contemporary scoring mechanisms for post-operative outcomes are laborious, time consuming and therefore clinicians are compelled to rely on subjective clinical examinations.[1] In emergency cases, time is of the essence and obtaining a detailed medical history along with evaluation of comorbidities to predict surgical outcomes is next to impossible. This necessitates development of an affordable, objective, and simple method to predict surgical outcomes and identify of high-risk patients, thereby resulting in better allocation of limited medical resources and delivery of quality healthcare, in addition to reducing morbidity and mortality.[2]

Some of the previously developed methods include the acute physiology and chronic health evaluation score (APACHE), the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) and the physiologic and operative severity score for the enumeration of mortality (POSSUM).[2,3] However, their applicability across the panoply of surgical procedures remains inadequate.[4] Gawande et al. heralded a better postoperative scoring mechanism called the surgical Apgar score (SAS), inspired from the Apgar obstetric scoring system.[5] Initially, the use of SAS was mainly in vascular and general surgery cases, and later expanded to a diverse range of specialities and settings. SAS entails a 10-point system for risk stratification of postoperative outcomes which is based on the mean arterial pressure (MAP), estimated blood loss (EBL) and lowest heart rate (HR) noted during surgery. A high score is interpreted as low risk of facing major complications or mortality postoperatively, while a low score is representative of heightened risk.[1,6]

SAS simplified predicting post-operative outcomes and the score is calculated faster, facilitating evidence-based planning and management of post-surgical outcomes.[7] However, validation of SAS system among different surgical procedures and its prominence in elective versus emergency systems has not been sufficiently explored.

2. AIM

This study was undertaken to correlate SAS with the patient's outcomes such as complications after surgery (morbidity) and mortality within 30-days of general surgery.

3. MATERIAL AND METHODS

Four hundred randomly selected patients scheduled to undergo a general surgery at a tertiary care hospital were enrolled in this prospective study. Patients aged between 15 and 75 years, undergoing emergency or elective general surgery under general, epidural, or spinal anesthesia were recruited. Patients were recruited only if they required intensive perioperative monitoring.

Demographic details including age, sex, comorbid conditions, and past surgical procedures were recorded. Both elective and emergency surgical procedures were categorized in accordance with the classification provided by Arvidsson et al.[8]

By assessing parameters such as EBL, MAP and lowest HR observed during the surgical procedure, the SAS was calculated from the anesthesiologist's record.[9] The cumulative scores were subsequently separated into two categories as follows: less than 7 scores and 7 and more scores as per the classification by Wied et al.[10] EBL is calculated using the formulae:[11]

$$\text{Blood Loss} = \frac{\text{EBV} \times (H_i - H_f)}{(\text{Hct}_i + \text{Hct}_f)/2} + (500 \times T_u)$$

where, estimated blood volume (EBV) is assumed to be 70 cm^3/kg, H_i and H_f represent pre-operative and post-operative haemoglobin, while Hct_i and Hct_f represent pre-operative and post-operative haematocrit respectively. T_u is an aggregate of packed red blood cells (PRBC), autologous whole blood (AWB), and cell saver (CS) units (fresh frozen plasma, cryoprecipitate) transfused.

Signs of potential complications in patients as indicated by the physiological parameters studied were immediately followed up by clinical investigations. The following events were considered major complications: acute renal failure, profuse bleeding requiring transfusion of 4U or more of red blood cells within 72 h after surgery, cardiac arrest requiring cardiopulmonary resuscitation, coma of more than 24 h, myocardial infarction, deep vein thrombosis, pneumonia, pulmonary embolism, ventilator use for 48 h or more, unplanned intubation, stroke, wound disruption, deep or organ-space surgical site infection, sepsis, septic shock , systemic inflammatory response syndrome, post-operative complications of Clavien-Dindo class III and above that require re-surgical, endoscopic, or radiological re-interventions for the diagnosis of complications requiring intensive care.[12]

The collected data was analysed using SPSS v. 16.3. Categorical predictors of elective and emergency surgery groups were evaluated using Monte-Carlo simulations in χ^2 tests, at $P < 0.05$ threshold of statistical significance. Patients were classified into low and high-risk based on the SAS scores and the association between major complications and 30-day mortality rate with SAS scores was evaluated using a χ^2 test.

4. RESULTS

Out of 400 patients, 216 (54%) were male. Table 1 presents the demographic details of the patients recruited. The cohort was predominated by an age group of 50–59 (140; 35%). In total, 297 (74.25%) recruited patients underwent elective surgeries and 103 (25.75%) patients underwent emergency surgeries. Most patients were in the high-risk SAS category (313; 78.25%).

Table 1. Distribution of patients based on their demographic characteristics.

Variable	Number of patients, *n*(%)	*P* value
Gender		
Male	216(54)	
Female	184(46)	
Age (years)		
<40	108(27)	
40–50	96(24)	(0.2982)
50–60	140(35)	<0.001C*
≥60	56(14)	
Type of surgeries		
Elective	297(74.25)	
Emergency	103(25.75)	
Surgical APGAR score		
<7	87(21.75)	
≥7	313(78.25)	

Comments: C – χ^2 test, *statistically significant.

Out of 108 patients aged less than 40 years, 89 individuals (82.41%) had a SAS of 7–10 points, while those aged 40–50 years (77; 80.21%), also scored 7–10 points. Among 140 patients aged 50–60 years, 120 (85.71%) had an SAS between 7 and 10 points whereas among 56 patients aged 60 years and more, 29 (51.79%) had a high-risk Apgar score (<7 points). Figure 1 illustrates the distribution of SAS across age groups. The most common associate co-morbidity was hypertension (336; 84%) while intake of steroids (24; 6%) was the least common cause of complication (Table 2).

In the study sample 212 (53%) patientsunderwent minor and intermediate surgeries while 188 (47%) underwent major and extensive surgeries. Out of 212 patients who had minor and intermediate surgeries, 114 (53.77%) had simple alimentary procedures, 34 (16.04%) underwent breast surgery and 26 (12.26%) underwent surgeries for inguinal and paraumbilical hernia. Out of the 188 patients who underwent major and extensive surgeries, 105 (55.85%) underwent complex alimentary and retroperitoneal surgeries and 55 (29.26%) underwent ventral hernia/ incisional hernia surgery.

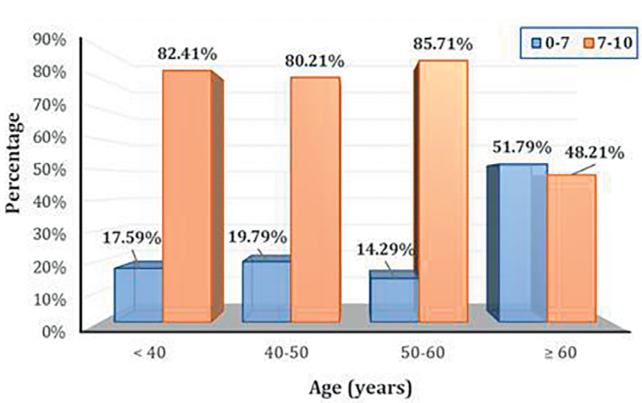

Figure 1.

Table 2. Distribution of patients based on comorbidities and post-operative complications, *n*(%).

Comorbidities	Post-operative complications		
	No complications	Complications/ death	Total
Obesity (BMI > 25)	80(20)	64(16)	144(36)
Hypertension	96(24)	240(60)	336(84)
Pulmonary disease	20(5)	120(30)	140(35)
Cardiovascular disease	40(10)	120(30)	160(40)
Diabetes mellitus	88(22)	152(38)	240(60)
Renal failure	24(6)	52(13)	76(19)
Sepsis	28(7)	36(9)	64(16)
CVA/TIA	4(1)	12(3)	16(4)
Smoking	80(20)	172(43)	252(63)
Cancer	20(5)	48(12)	68(17)
Steroid therapy	8(2)	16(4)	24(6)

Within a post-operative period of 30 days, out of 400 patients, 60 (15%) patients presented with major complications while 12 (3%) patients expired. Among 297 patients who underwent elective surgeries, 7.41% presented with major complications. However, among 103 patients who underwent emergency surgeries, 37.86% presented with major complications (Table 3).

Major complications and mortality rates were significantly higher among low-risk patients when juxtaposed with the high-risk group (Table 4). The odds of developing a major complication were 5.42 (CI: 3.03–9.70) times higher in the high-risk SAS group in comparison to patients in the

Table 3. Major complications observed in patients after elective and emergency surgical procedures and classification of patients based on the SAS score, *n*(%).

Variables	Elective $n = 297$	Emergency $n = 103$
Post-operativemajor complications		
Acute renal failure	4(1.35)	8(7.77)
Transfusion of more than 4 units	0(0)	4(3.88)
Cardiac arrest with CPR	1(0.34)	2(1.94)
Deep vein thrombosis	1(0.34)	1(0.97)
Myocardial infarction	2(0.67)	2(1.94)
Prolonged ventilation (>48 h)	0(0%)	2(1.94)
Pneumonia	3(1.01)	7(6.8)
Pulmonary embolism	2(0.67)	0(0)
Stroke	1(0.34)	0(0)
Wound disruption	4(1.35)	5(4.85)
Deep organ space infection	3(1.01)	4(3.88)
Sepsis and shock	1(0.34)	3(2.91)
Total	**22(7.41)**	**38(36.89)**
Surgical Apgar score		
<7	51(17.17)	36(34.95)
≥7	246(82.83)	67(65.05)

Table 4. Comparison of major complications and mortality between low-risk and high-risk groups according to SAS, *n*(%).

Surgical Apgar score	Major Complications		*P* value	Mortality		*P* value
	Yes	No		Yes	No	
0–7	31(51.67)	56(16.47)	<0.001C*	9(75%)	78(20.1)	<0.001MC*
7–10	29(48.33)	284(83.53)		3(25%)	310(79.9)	

Comments: *C-Chi square test, MC-Chi square test with Monte Carlo simulation.

low-risk SAS group. Similarly, the odds of experiencing death were 11.92 (CI: 3.15–45.08) times higher in high-risk SAS group as compared with patients in the low-risk SAS group. The sensitivity and specificity of SAS in predicting major complications is 51.67% and 83.53%, respectively. The sensitivity and specificity of SAS in predicting mortality is 75% and 79.9%, respectively.

5. DISCUSSION

This study evaluated the utility of a simple surgical score calculated from an estimation of blood loss, lowest HR, and lowest MAP during surgery to predict major complications and mortality after surgery. The most frequently noted complications in the study were acute renal failure and pneumonia. Of the 12 fatalities in the study period, 9 patients died of cardiopulmonary arrest due to cardiovascular events, acute respiratory distress syndrome and sepsis, 2 patients died of disseminated intravascular coagulation and 1 patient succumbed to a cerebrovascular accident. High mortality rate was observed in patients suffering from hypertension, smoking, diabetes mellitus, sepsis, pulmonary disease, and cardiac disease. Regenbogen et al. also reported hypertension as the most prevalent form of comorbidity (51%) followed by sepsis (21%), and diabetes mellitus (15%), in patients who expired after a surgery.[13] Some of the additional risk factors noted were the American Society of Anesthesiologist's physical classification system (ASA class) more than 3, BMI less than 18.5, open wound, weight loss over 10% in 6 months, ascites and gangrene.[13]

In this study, 74.25% were elective surgeries, while 25.75% were emergency surgeries. Most surgeries were minor or intermediate (55%) while major or extensive surgeries were performed in 45% of patients. About 4.2% of minor surgeries had major complications, with a 30-day mortality rate of 1.1%, whereas 27.1% of major complications and 4% of 30-day mortality rates were noted in the case of major and extensive surgeries. A study by Regenbogen et al. showed an incidence of major complications to be 4.8% vs. 21.3% in minor vs. major surgeries.[14] Among major surgeries, patients with SAS of 4 or less were 11.3 times more likely to have a major complication (95%CI: 4.7–8.9, $P < 0.001$) and the relative risk of death was 140.7. However, even after minor or intermediate surgeries, patients with a SAS of 4 or less were 22.8 times more vulnerable to major complications and had a 81.4 times greater chance of dying ($P < 0.001$).[14] In the present study, out of 400 patients, 60 (15%) had major complications within the 30-day post-operative period, 12 (3%) died within 30 days of the post-operative period and 328 (82%) were complication free. Ohlsson et al. reported a relative risk of developing a major complication to be 7.4 (95%CI: 2.88–17.5) among patients with the low SAS scores when juxtaposed with the high SAS scorers.[16] In agreement with the above study, the present study also found the odds of developing major complication post-surgery to be significantly lesser with increase in SAS scores.

Reynolds et al. inferred that mortality is significantly linked to lower surgical Apgar scores across a multitude of subspecialties albeit with varying odds for each.[7] The present study results are in concurrence with the existing literature and report a decline in the odds ratio for mortality with a corresponding increase in SAS.

The sensitivity and specificity of SAS as a predictor of major complications and mortality following general surgical procedures was comparatively higher than those observed by Pinho et al. (67.3% and 56.1%) among patients following colorectal surgeries and in patients undergoing intraabdominal surgeries.[15,18] Though the sensitivity is low, the specificity of the SAS threshold at 7 to categorize patients into high and low-risk is good (>75%) and therefore can distinguish better between cases that could develop major complications from those that would follow a normal course after surgery.

6. CONCLUSIONS

(1) SAS is a quick and simple tool to predict the likelihood of acquiring major complications and 30-day mortality in patients undergoing general surgical procedures requiring intense perioperative monitoring.
(2) The odds of acquiring major complications post-operatively and progressing to mortality significantly increase with a low SAS.
(3) Hence SAS can be of great help in a healthcare setting with minimal resources, where high-risk patients vulnerable to developing life-threatening complications can be managed effectively.

Conflict of interest
None.

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References

1 Urrutia J, Valdes M, Zamora T, Canessa V, Briceno J. Can the surgical Apgar score predict morbidity and mortality in general orthopaedic surgery?. *Int Orthop*. 2012;36(12):2571–2576. https://doi.org/10.1007/s00264-012-1696-1.

2 Kenig J, Mastalerz K, Lukasiewicz K, Mitus-Kenig M, Skorus U. The surgical Apgar score predicts outcomes of emergency abdominal surgeries both in fit and frail older patients. *Arch Gerontol Geriatr*. 2018;76:54–59. https://doi.org/10.1016/j.archger.2018.02.001.

3 Rajgopal V, Kulkarni SV. Efficacy of the surgical Apgar score in predicting post-operative morbidity and mortality in patients undergoing laparotomy. *Int Surg J* 2019;6(8):2791–2796. https://dx.doi.org/10.18203/2349-2902.isj20193318.

4 Thorn CC, Chan M, Sinha N, Harrison RA. Utility of the Surgical Apgar Score in a district general hospital. *World J Surg*. 2012;36(5):1066–1073. https://doi.org/10.1007/s00268-012-1495-2.

5 Gawande AA, Kwaan MR, Regenbogen SE, et al. An Apgar score for surgery. *J Am Coll Surg*. 2007;204(2):201–208. https://doi.org/10.1016/j.jamcollsurg.2006.11.011.

6 Ngarambe C, Smart BJ, Nagarajan N, Rickard J. Validation of the surgical Apgar score after laparotomy at a tertiary referral hospital in Rwanda. *World J Surg*. 2017;41(7): 1734–1742. https://doi.org/10.1007/s00268-017-3951-5.

7 Reynolds PQ, Sanders NW, Schildcrout JS, Mercaldo ND, St Jacques PJ. Expansion of the surgical Apgar score across all surgical subspecialties as a means to predict postoperative mortality. *Anesthesiology*. 2011;114(6): 1305–1312. https://doi.org/10.1097/aln.0b013e318219d734.

8 Arvidsson S, Ouchterlony J, Sjostedt L, Svardsudd K. Predicting postoperative adverse events: clinical efficiency of four general classification systems: the project perioperative risk. *Acta Anaesthesiol Scand*. 1996;40(7):783–791. https://doi.org/10.1111/j.1399-6576.1996.tb04533.x.

9 Haddow JB, Adwan H, Clark SE, et al. Use of the surgical Apgar score to guide postoperative care. *Ann R Coll Surg Engl*. 2014;96(5):352–358. https://dx.doi.org/10.1308%2F003588414X13946184900840.

10 Wied C, Foss NB, Kristensen MT, Holm G, Kallemose T, Troelsen A. Surgical apgar score predicts early complication in transfemoral amputees: Retrospective study of 170 major amputations. *World J Orthop*. 2016;7(12):832–838. https://dx.doi.org/10.5312%2Fwjo.v7.i12.832.

11 McCullough TC, Roth JV, Ginsberg PC, Harkaway RC. Estimated blood loss underestimates calculated blood loss during radical retropubic prostatectomy. *Urol Int*. 2004;72(1):13–16. https://doi.org/10.1159/000075266.

12 Dindo D, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. *Ann Surg*. 2004;240(2):205–213. https://doi.org/10.1097/01.sla.0000133083.54934.ae.

13 Regenbogen SE, Bordeianou L, Hutter MM, Gawande AA. The intraoperative Surgical Apgar Score predicts postdischarge complications after colon and rectal resection. *Surgery*. 2010;148(3):559–566. https://doi.org/10.1016/j.surg.2010.01.015.

14 Regenbogen SE, Ehrenfeld JM, Lipsitz SR, Greenberg CC, Hutter MM, Gawande AA. Utility of the surgical apgar score: validation in 4119 patients. *Arch Surg*. 2009;144(1):30–37. https://doi.org/10.1001/archsurg.2008.504.

15 Pinho S, Lagarto F, Gomes B, Costa L, Nunes CS, Oliveira C. CR-POSSUM and surgical Apgar score as predictive factors for patients' allocation after colorectal surgery [in Portuguese]. *Rev Bras Anestesiol*. 2018;68(4):351–357. https://doi.org/10.1016/j.bjan.2018.01.002.

16 Ohlsson H, Winsö O. Assessment of the Surgical Apgar Score in a Swedish setting. *Acta Anaesthesiol Scand*. 2011;55(5):524–529. https://doi.org/10.1111/j.1399-6576.2011.02424.x.

17 Sobol JB, Gershengorn HB, Wunsch H, Li G. The Surgical Apgar Score Is Strongly Associated with Intensive Care Unit Admission After High-Risk Intraabdominal Surgery. *Anesth. Analg*. 2013;117(2):438–446. https://doi.org/10.1213/ane.0b013e31829180b7.