Original Research Article

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Efficacy of the surgical Apgar score in predicting post-operative morbidity and mortality in patients undergoing laparotomy

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ABSTRACT

Background: A surgical score that predicts the risk of developing complications and mortality will help surgeons to be alert and take appropriate pro-active steps. The objective of this study was to evaluate the efficacy of the Surgical Apgar Score in predicting post-operative morbidity and mortality in patients undergoing major laparotomy surgeries. **Methods:** 100 patients undergoing major surgery were enrolled. 45 of these were emergency surgeries for peptic ulcer obstructions, bowel obstructions, pelvic abscess, mesenteric infarction and pancreatic necrosis. 55 cases were elective surgeries for cancers of the stomach, colon and rectum, pancreas, liver and ovaries. The Surgical Apgar Score (SAS) was calculated intra-operatively based on estimated blood loss, lowest mean arterial pressure and lowest heart rate. Post-operative complications and mortality were recorded.

Results: Of the 23% of patients with a low SAS (<4), major complications were noted in 41%, and 30-day mortality was seen in 26%. On the other hand, of patients with a high SAS of (9-10), only 11% suffered 30-day morbidities, and 4% had 30-day mortality. Patients with a SAS of <2 had a relative risk of 13.6 for development of complications, and a relative risk of 239 for 30-day mortality.

Conclusions: The surgical Apgar scoring system helps predict post-operative morbidity and mortality. A lower surgical Apgar score is associated with a higher chance of developing morbidity or mortality. This score allows surgeons to identify patients at highest risk of major complications or death. By enabling earlier identification of potential problems it affords the opportunity to provide increased surveillance for patients at higher risk.

Keywords: Surgical Apgar score, Laparotomy, Predicting complications, Predicting mortality

INTRODUCTION

One of the challenges that a surgeon faces intra- and postoperatively, is that of reliably and accurately predicting patient groups that are at risk of mortality and morbidity. Surgeons have lacked a routine, objective evaluation of the condition of the patient after surgery.¹ This lack of tools that can be easily applied for routine measurement of surgical outcomes has hindered efforts to significantly reduce the overall complication rate after surgeries.²

Current scoring methods such as the physiological and operative severity score for the enumeration of mortality

and morbidity (POSSUM Score) and the acute physiology and chronic health evaluation (APACHE score) have deficiencies; they are not easily calculated at the bedside, necessitate numerous data elements, and depend on laboratory data that are not uniformly collected. The POSSUM score was reported to show moderate calibration and poor discrimination.³ The APACHE II score is less subjective, but is complex, cumbersome and time-consuming, which makes it difficult to use bedside. The American Society of Anesthesiologists (ASA) score was developed to assess the physical state of patients before undergoing surgery; it is generally considered a good qualitative indicator of postoperative mortality but

is not a quantitative measure of the risk of morbidity and mortality. It is not designed for perioperative use and requires multiple variables and data entries entered over the first 24 hours of admission.⁴

Another method of assessing surgical quality, the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) assesses 20 preoperative risk factors (such as the presence of diabetes mellitus, hypertension, whether the patient is ventilator-dependent, whether the patient is on steroids for a chronic condition) in correlation with observed and expected complication rates to the treatment provided. Generally, it is the difference in pre-operative risk factors that give rise to a significant variability in postoperative outcomes. Furthermore, it is not validated for emergency surgery.

A revolutionary 10-point scoring system introduced in 1953, the Apgar score, was a simple, effective method that provided clinicians with clear, graded feedback on the condition of newborns.⁵ More than five decades later, Gawande et al published an Apgar score for surgery, a 10-point score to rate surgical outcome.⁶ These researchers studied several parameters that were collected in the operating theatre and concluded that only three intraoperative variables are important prognosticating factors in postoperative outcomes. These variables are estimated blood loss (EBL), lowest heart rate (HR), and lowest mean arterial pressure (MAP) during an operation. The Surgical Apgar Score is currently the simplest score available for the prediction of postoperative risks.

The present study was aimed at evaluating the surgical Appar score in predicting morbidity and mortality in patients undergoing major surgeries in an Indian hospital setting.

METHODS

Subjects

A recent study⁷ evaluating the Apgar score index with the development of complications showed that the odds ratio on comparison of patients with a score of \leq 4 was 3.5; in other words, patients who had a score of \leq 4 were 3.5 times more prone to develop post-operative complications. A higher SAS is associated with a lower rate of complications, and a lower score is associated with a higher rate of complications. Based on these findings and keeping the power of this study at 95% (false negatives=5%) with an α error of 5%, we estimated that 96 patients need to be recruited into the study.

100 patients undergoing major surgery at MS Ramaiah Medical Teaching Hospital, Bengaluru, India between November 2014 and May 2016, fulfilling the inclusion and exclusion criteria, were enrolled in the study. Both elective and emergency surgeries were included in this study. 45 of the 100 cases were emergency surgeries; these included surgeries for peptic ulcer obstructions,

bowel obstructions, pelvic abscess, mesenteric infarction and pancreatic necrosis. 55 cases were elective surgeries and included surgeries for cancers of the stomach, colon and rectum, pancreas, liver and ovaries.

Inclusion criteria

Inclusion criteria were all patients undergoing major surgeries (defined as an invasive operative procedure in which a body cavity is entered, organs are removed, or normal anatomy is altered). For the sake of uniformity and to prevent large variables in a patient's vitals intra-operatively, we chose to apply the score only to those patients undergoing laparotomies; patients over the age of 18 years; any form of anesthesia; available for routine follow-up.

Exclusion criteria

Exclusion criteria were patients undergoing endoscopic/laparoscopic surgeries; patients in the paediatric age group; pregnant patients.

After obtaining informed consent, detailed histories were taken, with enquiries regarding any pulmonary comorbidities (including but not limited to pre-existing chronic obstructive pulmonary disease, pneumonia, or ventilator dependence), cardiovascular co-morbidities (including but not limited to previous myocardial infarction, angina, congestive cardiac failure), and a history positive for stroke/ Transient Ischemic Attack (TIA).

The patients then underwent the planned surgery. The surgical Appar score (SAS) was calculated intraoperatively based on 3 parameters; (1) estimated blood loss (EBL), (2) lowest mean arterial pressure (MAP), and (3) lowest heart rate (HR).

Assessment of blood loss

Blood loss was assessed by counting the blood-soaked mops and gauze pieces (and multiplying them by the estimated volume of blood they carried), measuring blood lost to suction bottles and estimating that which was in and around the operative field.⁹

The following modified Gross' formula using preoperative and post-operative haematocrit values were used:⁸

Actual blood loss = BV [Hct (i)-Hct (f)]/ Hct (m)

Where BV is the blood volume calculated from the Body Weight

(Blood volume = body weight in kg x 70 mlkg-1)

Hct (i), Hct (f) and Hct (m) were the initial, final and mean (of the initial and final) haematocrits respectively.

The blood loss calculated by the surgeon and the anaesthesiologist, were discussed at the end of the surgery to decide on a mutually-agreed volume.

Assessment of lowest heart rate and lowest mean arterial pressure

Lowest heart rate and lowest mean arterial pressures reached during the procedure were collected from the anesthesiologists' records (electronic/manual). The

lowest mean arterial pressure reading and the heart rate reading were taken from both the electronic monitor and from handwritten anaesthesia monitoring records.

Surgical Appar score (SAS)

The SAS was calculated as the sum of the points from each category (as depicted in the table below), and each patient was assigned a score between 0 and 10.

Table 1: Calculation of surgical Appar score.

	Points				
Intra-operative Parameter	0	1	2	3	4
EBL (ml)	>1000	601-1000	101-600	≤100	-
Lowest MAP (mm/Hg)	<40	40-54	55-69	≥70	
Lowest HR (beats/min)	>85	76-85	66-75	56-75	≥55

EBL=Estimated blood loss; MAP=Mean arterial pressure; HR=Heart rate.

Occurrence of pathologic bradyarrhythmia, including sinus arrest, atrioventricular block or dissociation, junctional or ventricular escape rhythms, and asystole also received 0 points for lowest heart rate. These patients were then followed up for 30 days after the surgery, to ascertain whether or not they developed major complications.

Patient follow-up

Patients were followed up for occurrence of any major morbidities, or mortality within 30 days of surgery (telephonically if discharged). A hundred percent follow-up rate of patients enrolled was achieved.

Major complications were defined as Clavein Class 4 complications or greater and one of the following: acute renal failure, bleeding requiring ≥4 U red cell transfusion within 72 hours after operation, cardiac arrest requiring CPR, coma for 24 hours or longer, deep venous thrombosis, septic shock, MI, unplanned intubation, ventilator use for 48 hours or longer, pneumonia, pulmonary embolism, stroke, wound disruption, deep or organ-space surgical site infection, sepsis, systemic inflammatory response syndrome, vascular graft failure.9 Complications such as anastomotic leak, cystic duct leak after cholecystectomy, pericardial effusion requiring drainage and gastric outlet obstruction requiring reoperation were classified as major complications. All deaths were considered major complications. Superficial surgical site infection and urinary tract infection were not considered major complications.

Statistical analyses

All the quantitative values such as age of patient, duration of disease, blood loss, HR variability, blood pressure, were expressed as mean, standard deviation and interquartile range. Qualitative parameters such as various

complications e.g. acute renal failure, MI etc. were expressed as proportion with 95% confidence interval. In order to find out the independent predictors for an outcome event, multiple logistic regression modeling was employed. Chi-square test was used to compare the morbidity and mortality outcomes with age, gender etc. Positive and negative likelihood ratios were also estimated.

RESULTS

66% of the 100 subjects were male, 34% were female. 21% were less than 40 years old, 27% were aged between 40 and 50 years, 24% were between 51 and 60 years old, and 28% were over 60 years old.

Table 2: Post-operative complications in elective and emergency surgeries.

Major post-operative complications	Elective cases (%)	Emergency cases (%)
Acute renal failure	1	4
Transfusion > 4 units	10	14
Cardiac arrest needing CPR	5	5
Deep vein thrombosis	1	0
Myocardial infarction	5	10
Prolonged ventilation > 48 hours	6	8
Pneumonia	9	7
Pulmonary embolism	0	0
Stroke	0	0
Wound disruption	1	7
Deep organ space infection	1	6
Sepsis and shock	4	9
Total	43	70

Post-operative complications in elective and emergency surgeries

Of the 55 subjects who underwent elective surgeries, 18% had 30-day complications; 23% of the 45 cases of emergency surgeries had 30-day complications. Table 2 depicts the 30-day complications that were observed in our subjects.

Surgical APGAR score with major complications and 30-day mortality

40% of the cases had a high SAS of 7-10 (i.e. fewer expected complication rates), while 23% of the cases had a low SAS of <4 (i.e. higher rates of complication anticipated).

With an SAS of 9-10 taken as the reference category, the relative risk was ascertained. Subjects with an SAS of 1-2 had almost 14 times higher risk of developing complications compared to the reference category; the risk was 10 in patients with SAS of 3-4, 6 in patients with SAS of 5-6, and 3 in patients with SAS of 7-8.

The risk of mortality with relative to SAS was also calculated, keeping an SAS of 9-10 as reference. The relative risk of mortality in patients with SAS of 1–2 was 239; the relative risk for patients with SAS of 3–4 was 12, while it is almost 10 and 6 for patients with SAS of 5–6 and 7–8 respectively.

The numbers of subjects with complications and with 30-day mortality for the 45 cases of elective surgery in relation to the SAS are shown in Table 3.

Table 3: Post-operative complications and 30-day mortality after elective surgery

SAS*	Total No. of Cases	No. of cases with complications	% of cases with complications	30-day mortality	% 30-day mortality
1–2	2	2	100	1	50
1–2 3–4	10	9	90	3	30
5–6	12	7	58	3	20
7–8	13	0	0	0	0
9–10	8	0	0	0	0

^{*}SAS=Surgical Apgar score.

Table 4: Postoperative complications and 30-day mortality after emergency surgery.

SAS	Total no. of cases	No. of cases with complications	% of cases with complications	30-day mortality	% 30-day mortality
1–2	1	1	100	0	0
3–4 5–6	10	10	100	8	80
5–6	25	12	48	6	24
7–8	12	1	8.3	0	0
9–10	7	1	14.2	0	0

Table 5: Surgical Appar score in relation to age.

Age group	Surgical A	Surgical APGAR score				
(years)	1–2	3-4	5-6	7 -8	9–10	
< 40	1	1	9	6	4	21
41–50	1	3	14	3	6	27
51-60	0	7	5	9	3	24
> 60	2	9	8	7	2	28

The numbers of cases with complications and 30-day mortality for the 55 cases of emergency surgery in relation to the SAS are presented in Table 4.

Distribution of surgical APGAR score in relation to age group

The percentage of patients under the age of 40 who had an SAS <4 was 9.5%; this percentage for patients aged 41–50 was 15%, for those between 51 and 60 years of

age was 29% and this figure was 39% for those over 60 years of age (Table 5).

DISCUSSION

The SAS was created with the objective of providing a simple, objective auditing system that accurately predicts a patient's post-operative outcome at the bedside. However, before it can be accepted widely as a good scoring system in the intra-operative period, more

validation studies in various settings would need to be performed. The ideal surgical outcome score should be (1) simple enough for collation on completion of an operation for any patient in any setting, irrespective of financial resources and technological capabilities (2) valid for predicting major post-operative complications and death, and (3) applicable to the various fields of surgery.¹⁰

A simple surgical auditing system based on the estimated blood loss volume, lowest heart rate and the lowest mean arterial pressure during a surgery provides a meaningful estimate as to a patient's post-operative condition.

More than two thirds of the patients (66%) in the current study were males. In the study by Regenbogen et al, a female preponderance was noted but no significant association between gender, surgical Apgar score and post-operative outcomes were noted. The majority of complications were noted in the age group of >50 years. 11% of patients in the age group of >60 years had a low SAS of <4. In comparison, only 1% of patients in the age group of <40 years were found to have a SAS of <4. Interestingly, 88% of our patients with a higher SAS of >7 belonged to the age group of <60 years. In their landmark study Gawande et al found that the mean age of patients associated with a higher risk of postoperative complications was 64 years.

Pre-existing comorbidities in our subjects included hypertension (35%), diabetes mellitus (32%), obesity (26%), malignancy (21%), smoking (19%), chronic renal failure (4%), cardiac disease (15%), pulmonary disease (10%) and pre-existing SIRS/sepsis (3%). Of these, we found that obesity, hypertension, cardiac disease, diabetes mellitus, SIRS/sepsis and smoking were significantly associated with the development of postoperative morbidity and a 30-day mortality were (p<0.05) (data not shown). Interestingly, Gawande et al reported no significant difference with obesity, cardiac disease, or pre-existing SIRS/sepsis.6 In our study we found no statistically significant difference in the occurrence of complications or 30 day mortality noted with pulmonary disease, renal failure, pre-existing malignancy or steroid therapy.

Of the 100 patients in this study, there was a 19% rate of 30-day mortality, and a 30% rate of 30-day morbidity. The difference in surgical outcome between patients in each score group was statistically significant. Of the 23% of patients with a SAS<4, major complications were noted in 41%, and 30-day mortality was seen in 26% of the cases. On the other hand, in patients with a SAS of 9-10, only 11% suffered 30-day morbidities, and only 4% of patients succumbed to a mortality within 30 days. In each 2-point score category, the incidence of 30-day morbidity and mortality was significantly higher, when compared to that of patients in the next (higher) category (p<0.001). Patients with a SAS of <2 had a relative risk of 13.6 for the development of complications, and a

relative risk of 239 of 30-day mortality. Thus, a patient with a lower surgical Appar score is more likely to develop complications and faces a higher risk of mortality than a patient with a high score.

CONCLUSION

This study based in a hospital setting in India on 100 patients undergoing elective or emergency surgeries confirms that the surgical Appar scoring system is a useful modality in predicting postoperative 30-day morbidities and mortalities. Based on the calculated relative risk, a lower surgical Appar score is associated with a higher chance of a patient developing a postoperative morbidity or mortality. The surgical APGAR score allows surgeons to consistently identify patients coming out of operations who are at highest risk of major complications or death, and test standards and innovations to improve our ability to save such patients. It enables earlier identification of potential problems thus providing the opportunity to provide increase surveillance for patients at higher risk. For example, patients with low surgical Appar scores to be shifted to the ICU setting for postoperative monitoring. This score provides a target for surgical teams and researchers aiming to improve outcomes, and a measure for monitoring quality even in resource-poor settings.

We conclude that the SAS is a simple, easily calculated and objective metric for patients undergoing laparotomies.

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