Surgical Apgar Score can Accurately Predict Post-Operative Complication Following Emergency Laparotomy

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Research Article

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Abstract

Background

The Surgical Apgar Score (SAS) describes a feasible and objective tool for predicting surgical outcomes. However, the accuracy and applicability of the score has not been widely tested in majority of low resource settings.

Objective

To determine the accuracy of Surgical Apgar Score in predicting post-operative complications among patients undergoing emergency laparotomy at Muhimbili National Hospital.

Methods

A prospective cohort study was conducted for a period of 12 months; SAS and CCI outcomes were recorded and analyzed according to the risk level and degree of severity. Spearman correlation and simple linear regression were employed to establish the relationship between SAS and CCI, the Accuracy of SAS was evaluated by determining its discriminatory capacity on ROC, data normality was tested by Shapiro-Wilk statistic 0.929 (p < 0.001). Analysis was done using IBM – SPSS.

Results

Among 111 patients who underwent emergency laparotomy, 71 (64%) were male, the mean age was 49 (± 17). The mean SAS was 4.86 (± 1.29) and mean CCI 44.46 (± 25.77), patients in high-risk group SAS (0–4) were more likely to develop severe and life threatening complications with mean CCI 53.3 (47.2-63.4, 95% CI) than the low risk group SAS (7–10) mean CCI of 21.0 (5.3–36.2, 95% CI). There was a negative correlation between SAS and CCI, spearman r -0.575 (p < 0.001) and regression coefficient b -11.5 (p < 0.001). SAS revealed a good accuracy for prediction of post-operative complication on ROC, Area under Curve 0.712 (0.523–0.902, 95% CI, p < 0.001).

Conclusion

We have demonstrated that SAS can accurately predict the occurrence of complications following emergency laparotomy at Muhimbili National Hospital.

Introduction
Post-operative morbidity and mortality reduction is the fundamental goal of every surgical procedure. The key to reduce post-operative morbidity and mortality is to employ effective perioperative management of patients with objective and scrupulous evaluation. Risk scoring system is the best modality approach as it provides a standard means of quantifying the patient’s risk for developing complications based on several factors including the morbidity status of patient. However, vast majority of risk-scoring systems are not feasibly calculated at the bedside; due to their numerous demands for estimation which include laboratory investigations inasmuch as also clinicians and surgeons do not regularly apply them for patients assessment and stratification.\textsuperscript{(1)}

SAS describes a feasible, immediate and an objective modality of determining surgical outcomes. It is a ten point score, which applies three haemodynamic parameters, the lowest heart rate, the lowest mean arterial pressure and estimated blood loss during surgery to predict the attributable complication risk after general or vascular surgery.

Among the most contemporary risk tools available for surgical patients, SAS provides an outstanding pivot for its routine feasible utility and it provides immediate and objective evaluation means as the surgical team can obtain haemodynamic variables and compute the score upon completion of operation. SAS can be used to stratify patients into three categories of risk levels classified as low risk, medium risk and high risk. Patients in high-risk group (SAS 0–4) are 16 folds more likely to experience major complications than patients in low risk (SAS 7–10) \textsuperscript{(2)}

The accuracy of SAS has never been tested at our setting and its predictive accuracy is uncertain since various studies has stipulated variations in its predictive cutoff value influenced by several factors at the setting level \textsuperscript{(1, 3)}. It has been observed that there is increased rate for occurrence of major complications and high mortality among patients with the lowest SAS $\leq 4$, however there is a paucity of evidence to justify if any statistical correlation exist between the risk level of SAS and severity of post-operative complication \textsuperscript{(1–5)}.

**Material And Methods**

A prospective cohort study was conducted in Department of General Surgery at Muhimbili national hospital. We recruited 111 patients who underwent emergency laparotomy from March 2021 to February 2022 by non-probability convenient sampling, patients with age above 18 years and ASA $\geq II$ were included while those who had severe anaemia Hb $\leq 7g/dl$ and Sickle Cell Anaemia were excluded from the study.

The ethical clearance approval protocol for this study was obtained from IRB-MUHAS, REF DA.282/298/01.C. The data were collected and recorded on structured checklist. SAS for patients was estimated by considering the lowest mean heart rate, estimated blood loss using a Gross formula \textsuperscript{(6)} and lowest MAP. Patients were followed within a period of 30 after surgery, the observed complications were recorded and the severity was graded according to modified Clavien Dindo Classification scheme \textsuperscript{(7–9)}.
The numerical value of complication severity for every individual patient was calculated using the weighted CCI Calculator. The correlation for Complication severity expressed in CCI and the SAS risk level was determined by Spearman rank and simple linear regression analysis. The predictive accuracy of SAS for post-operative complication was tested by considering its discrimination capacity by Area under Curve on ROC. The analysis was accomplished using the IBM SPSS version 27.

**Results**

Among patients who were recruited the Male were predominant at 71 (64.0%), with a median age of 49 (36, 59) most of the patients were in the age group of between 61 and 75 years in 42 (37.8%) followed by those between 44 and 60 years in 26 (23.4%). The mean body weight in Kg and the mean baseline haemoglobin in g/dl of patients in were 63.8 ± 9.93 and 11.22 ± 2.98. Peritonitis and intestinal obstruction were the leading indications for emergency laparotomy with proportion of 44.1% and 36.9% respectively Table 1.

**Perioperative Clinical Characteristics Of The Patients**

The mean SAS for patients was 4.86 (± 1.29) and the mean CCI for a 30-day complication was 44.46 (± 25.77) with mortality rate of 16.2%, 86.5% of complications occurred within ≤ 10 days Table 2.

**Severity Pattern For a 30-day Post Operative Complication**

Complications were graded based on modified Clavien Dindo Classification scheme, category I-II and III-V were classified as Low and High grade respectively. Most of severe and detrimental complications were attributable to high grade with a preponderance score of grade III-V, Fig. 1.

Several complications were identified within 30 days of post operative period and each individual patient developed at least one or more complication, respiratory infection was the most prevalent 21.62% followed by death 16.22% as illustrated in Fig. 2.

Patients were stratified into three categories of risk level as high, medium and low based on the SAS classification 0–4, 5–6 and 7–10 respectively. It was observed that patients in high-risk group were more likely to develop severe and life threatening complications with the mean CCI of 53.3 (47.2–63.4, 95% CI). The medium risk group had a mean CCI of 31.8 (28.9–35.7, 95% CI) and the low risk group was less likely to develop severe complication with the mean CCI of 21.0 (5.3–36.2, 95% CI), One Way ANOVA was done to compare the means which yielded the significant mean difference (F = 16.6, p < 0.001) Fig. 3.

**The Correlation Of Comprehensive Complication Index And Surgical Apgar Score**
The correlation test was performed to determine if there is any existing relationship between Surgical Apgar score and the complication severity expressed in CCI. The spearman coefficient shows an existing negative weak correlation, $r = -0.575$, $p < 0.001$. A simple linear regression analysis was also performed to test if there is any existing degree of dependence for Comprehensive Complication Index by changes of value in Surgical Apgar Score. The statistic model $y = 100 + -11.5*X$ was derived and revealed a negative relationship between the two variables with regression coefficient, $b = -11.5$, $p < 0.001$, which depicts a decrease change of CCI by 11.5 for every increment of one value of SAS with coefficient of determination, $r^2 = 0.336$, $p < 0.001$ Fig. 4.

**The Accuracy Of SAS For Prediction Of Post-operative Complication Severity**

It was observed that within the period of 30 days, every individual patient developed at least one complication, and each complication was described into a dichotomous variable with either low or high grade outcome classified based on modified Clavien Dindo. The ROC was carried out and Area Under Curve for SAS was 0.712 (0.523–0.902, 95% CI, $p < 0.001$) with Sensitivity 61.76%, Specificity 77.78%, PPV 96.92% and NPV 15.22%, $p < 0.035$ and diagnostic cutoff point of 5, Fig. 5.

**Discussion**

The study aimed at determining the accuracy of SAS for predicting post-operative complications among patients undergoing emergency laparotomy. SAS has proven a simple objective instrument for identifying patients at high risk of developing life-threatening complications and mortality after undergoing major surgery.

Emergency laparotomy is one of the most performed delicate surgical procedure usually done in patients who already have sustained severe physiological stress and hemodynamic instability antecedent to severe hemorrhage, electrolyte imbalance, systemic inflammatory response and sepsis. Based on these factors patients are usually susceptible to increased risk of developing detrimental complications and high rate of mortality within 30 days of post-operative period. Post-operative respiratory infection rate accounts for about 40% of patients who undergo abdominal surgery\(^{(10,11)}\). In this study, it was determined that the most prevalent major complication was respiratory infection, 21.62% which accounted for increased morbidity and mortality, this related to what another study depicted in India where pulmonary morbidity accounted for 34% with high rate of pneumonia 19.7%\(^{(12)}\). The surgical site infection rate was 18.02%, this was more less compared to the overall surgical site infection rate of 25% which was described in the study done by Dullo et al.\(^{(1)}\). The mortality rate was 16.22% this was significantly higher than 7.9% mortality rate determined at Kitui District Hospital in Kenya\(^{(1)}\), however it related with the results from other studies with mortality rate from 15-27.7%\(^{(3,12)}\).
A large proportion of patients in this study were scaled according to their complication severity as high grade (III-V) based on CDC scheme, this corresponded with their mean Comprehensive Complication Index of 44.46. The mean SAS was 4.86 equivalent to the mean SAS derived from other studies with a mean range of 4–6 (1,3).

SAS was stratified into three categories of risk level as High risk (0–4), Medium risk (5–6) and Low risk (7–10). (3,12,13), there was increased degree of complication severity observed among patients with high risk, SAS ≤ 4, mean CCI 53.3 compared to the group with low risk ,SAS ≥ 7 which had a mean CCI 21.0 this relationship was in keeping with findings from other studies tested by different statistic of associations (1,3,4,12–15).

The spearman rank correlation and simple linear regression was carried out in this study to determine the relationship between SAS and the degree of complication severity estimated by weighted CCI. The two variables were found to be negatively related with a significant reduction of CCI for every single unit increment of SAS, spearman correlation coefficient, (r = -575, p = 0.001) and regression coefficient (b = -11.5, p = 0.001), this indicates that patients within high-risk SAS group are more likely to develop severe complications.

SAS has revealed a good predictive accuracy, AUC 0.712 on ROC ,this modest discriminatory capacity delineates a fair predictive ability that proves equivalent correspondence to other study findings which have elaborated similar results with a range of AUC 0.710–0.751.(3,16,17). Moreover, other studies has proven a more good discriminatory power in the range of 0.75–0.796 of this tool. (1,3)

**Conclusion**

In our setting emergency laparotomy is significantly attributable to high rate of morbidity and mortality, this portends an irrefutable utility demand of objective directed tool for risk level determination and proactive optimization to prevent deplorable post-operative outcomes. We have demonstrated that SAS can accurately predict the occurrence of complications following emergent laparotomy at Muhimbili National Hospital.

**Declarations**

**Acknowledgement:** To everyone who contributed resources for accomplishment of this project.

**Funding:** No financial disclosure should be reported

**Conflict of Interest:** Authors declare no competing of interest

**Ethical Approval:** Approval for Ethical Clearance was obtained from MUHAS-IRB, REF DA.282/298/01.C.

**References**
# Tables

**Table 1**: Baseline characteristics and indications for surgery among patients who underwent emergency laparotomy at MNH 2021.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean ± SD</th>
<th>Frequency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age group</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;44</td>
<td>19 (17.1)</td>
<td></td>
</tr>
<tr>
<td>44-60</td>
<td>26 (23.4)</td>
<td></td>
</tr>
<tr>
<td>61-75</td>
<td>42 (37.8)</td>
<td></td>
</tr>
<tr>
<td>&gt;75</td>
<td>24 (21.6)</td>
<td></td>
</tr>
<tr>
<td><strong>Median age</strong></td>
<td>49 (36,59)</td>
<td></td>
</tr>
<tr>
<td><strong>Sex</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>71 (64.0)</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>40 (36.0)</td>
<td></td>
</tr>
<tr>
<td><strong>Mean Body weight in Kg</strong></td>
<td>63.8 (±9.93)</td>
<td></td>
</tr>
<tr>
<td><strong>Mean Haemoglobin in g/dl</strong></td>
<td>11.22 (±2.98)</td>
<td></td>
</tr>
<tr>
<td><strong>Pre-operative diagnosis</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peritonitis</td>
<td>49 (44.1)</td>
<td></td>
</tr>
<tr>
<td>Intestinal obstruction</td>
<td>41 (36.9)</td>
<td></td>
</tr>
<tr>
<td>Abdominal visceral injury</td>
<td>7 (6.3)</td>
<td></td>
</tr>
<tr>
<td>Diaphragmatic tear</td>
<td>2 (1.8)</td>
<td></td>
</tr>
<tr>
<td>Entero-cutaneous fistula</td>
<td>6 (5.4)</td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>6 (5.4)</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td>(n = 111)</td>
</tr>
</tbody>
</table>

**Table 2**: SAS variables of patients who underwent emergency laparotomy at MNH in 2021.
<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean ± SD</th>
<th>Frequency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median estimated blood loss (IQR)</td>
<td>747.00 (361.00,1085.00)</td>
<td></td>
</tr>
<tr>
<td>Mean haemoglobin (g/dl)</td>
<td>10.60 (± 8.37)</td>
<td></td>
</tr>
<tr>
<td>Mean lowest DBP (mmHg)</td>
<td>55.42 (± 12.79)</td>
<td></td>
</tr>
<tr>
<td>Mean lowest SBP (mmHg)</td>
<td>94.05 (±18.10)</td>
<td></td>
</tr>
<tr>
<td>Mean lowest heart rate (bpm)</td>
<td>87.95 (±16.66)</td>
<td></td>
</tr>
<tr>
<td>Mean lowest MAP (mmHg)</td>
<td>67.69 (±13.45)</td>
<td></td>
</tr>
<tr>
<td>Mean CCI</td>
<td>44.46 (±25.77)</td>
<td></td>
</tr>
<tr>
<td>Mean SAS</td>
<td>4.86 (±1.29)</td>
<td></td>
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</table>

Complication onset (days)

<table>
<thead>
<tr>
<th>Days</th>
<th>Frequency (%)</th>
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</thead>
<tbody>
<tr>
<td>0-10</td>
<td>96 (86.5)</td>
</tr>
<tr>
<td>11-20</td>
<td>13 (11.7)</td>
</tr>
<tr>
<td>21-30</td>
<td>2 (1.8)</td>
</tr>
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</table>

Complication severity (CDC)

<table>
<thead>
<tr>
<th>Grade</th>
<th>Frequency (%)</th>
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<tbody>
<tr>
<td>Low grade (I-II)</td>
<td>9 (8.1)</td>
</tr>
<tr>
<td>High grade (III-V)</td>
<td>102 (91.9)</td>
</tr>
</tbody>
</table>

TOTAL

(n = 111)

**Figures**
Figure 1

Clavien-Dindo Classification of complications among post emergency laparotomy patients at MNH 2021.
Figure 2

Pie chart showing complications occurring among emergency laparotomy patients at MNH in 2021

Figure 3

Mean CCI according to SAS category
Figure 4

CCI and SAS regression scatter plot

$r^2 = 0.336$

$y = 100 + 11.5 * X$

$p < 0.001$
Figure 5

Receiver Operating Curve showing the Area under Curve for complication predictive accuracy of SAS

AUC = 0.712

p < 0.001