The Reliability of Surgical Apgar Score in Predicting Immediate and Late Postoperative Morbidity and Mortality: A Narrative Review

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ABSTRACT

Surgical Apgar Score is a simple, 10-point scoring system in which a low score reliably identifies those patients at risk for adverse perioperative outcomes. Surgical techniques and anesthesia management should be directed in such a way that the Surgical Apgar Score remains higher to avoid postoperative morbidity and mortality.

KEY WORDS: Apgar score, morbidity, mortality, postoperative complications, risk factors, surgery

INTRODUCTION

Surgical risk scoring is important to predict postoperative outcomes, to plan admission to the intensive care unit (ICU), to prognosticate the general condition of the surgical patient, and to plan specific interventions postoperatively. A unit which is not fully equipped with multispecialty areas could plan...
transfer of a patient to a more specialized center based on the risk score.

Virginia Apgar, an anesthesiologist, described the 10-point scoring system, the Apgar score, in 1952 for assessing newborn babies. Scoring is done at 1 min and 5 min after birth. The score is helpful in predicting overall outcome after resuscitation of a child. Anesthesiologists and surgeons anticipate the perioperative events involved after major surgeries (laparotomies, resection/anastomosis, vascular surgery, neurosurgery, emergency or urgent surgery) on the basis of factors like age, associated co-morbidities, surgical blood loss, and surgery duration. An otherwise uneventful intraoperative course does not predict the postoperative course in any patient. Complications occurring after surgery, especially after patient discharge, lead to increased morbidity, increased cost of treatment in the form of hospital admissions, and unwanted interventions.

THE RISK SCORING SYSTEMS

The Physiological and Operative Severity Score for the Enumeration of Mortality and Morbidity (POSSUM), the Simplified Acute Physiology Score (SAPS), and Acute Physiology and Chronic Health Evaluation (APACHE) scoring systems have been used to predict postoperative course.

Copeland et al. initially described POSSUM in 1991, for predicting morbidity and mortality of surgical patients. In 1998, the Portsmouth modification or the P-POSSUM was described. The P-POSSUM was found to be more reliable and accurate when compared to the POSSUM described by Copeland. Twelve physiologic variables and six operative variables are used by POSSUM (Table 1).

Although P-POSSUM also uses the same indices that are used for POSSUM, the equation used to calculate the score is different. All the values have to be entered, and the score is derived either by adding up or by using software. Moreover, many investigations such as hemoglobin, urea, white cell count, sodium, potassium, and electrocardiogram are required. Surgical events are also used for scoring (peritoneal soiling, multiple surgeries). There could be a lot of personal differences when certain entries are made like assessment of surgery and respiratory status. In addition, POSSUM is not applicable for trauma patients, and an overestimation of POSSUM is possible in hepatopancreatobiliary surgeries.

Another score used to predict outcomes in medical and surgical patients is the Simplified Acute Physiology Score (SAPS). The SAPS II is used to score the status of patients admitted in the intensive care unit (ICU). It includes 17 variables: 12 physiologic variables, age, type of admission, and 3 disease-related variables. The SAPS II score registers the worst value of selected variables within the first 24 h after admission and can have a score between 0 and 163 points (0–116 points for physiologic variables, 0–17 points for age, and 0–30 points for previous diagnosis). Logistic regression is used to calculate the probability of death.

The Acute Physiology and Chronic Health Evaluation (APACHE) II was developed using a database of North American ICU patients in 1985. It uses a score derived from 12 routine physiologic measurements taken during the first 24 h after admission, age, and previous medical issues to provide information about the severity of disease. A score from 0 to 71 is calculated based on these measurements. A higher score signifies a more severe disease with

| Physiologic Indices       | Operative Indices         |
|---------------------------|---------------------------|
| Age                       | Hemoglobin                |
| Cardiac history           | White cell count          |
| Respiratory history       | Urea                      |
| Pulse rate                | Sodium                    |
| Blood pressure            | Potassium                 |
| Glasgow coma scale        | Electrocardiogram         |

A total of 18 indices must be entered to derive a POSSUM score. The score could be unreliable if any one index is missing.
greater risk of death. The APACHE II has been used
to prognosticate acutely ill patients and has helped
researchers to compare the efficacy of various forms
of treatment modalities. However, APACHE II led to
an overestimation of mortality as physiologic vari-
ables used were dynamic and kept changing during
treatment. Later APACHE III was introduced with
two new variables: patient origin and the lead-time
bias. Here, the score varied between 0 and 299 points. Later, APACHE IV was introduced in which
another five variables were added: mechanical venti-
lation, thrombolysis, impact of sedation on Glasgow
Coma Score (GCS), re-scaled GCS, and PaO2/FiO2
(arterial oxygen tension and fractional concentra-
tion of inspired oxygen) ratio.

The SAPS and APACHE were found to be more
reliable in predicting severity of condition and out-
comes in medical patients when compared to surgi-
cal patients. Rapsang et al. have described nine
routinely used scoring systems for predicting the
morbidity and mortality of patients admitted in the
ICU. The authors felt that selecting an inappropriate
scoring methodology could lead to a significant waste
of time, unwanted investigations, increased cost,
and unwarranted extrapolations. Anesthesiologists
use the American Society of Anesthesiologists–
Physical Status (ASA-PS) classification for describ-
ing patients based on co-morbidities, functional
status, and emergency or elective surgery. The ASA-
PS was not designed to predict the mortality of a
surgical patient. The ASA classification, with a po-
tive predictive value of 57% for complications and a
negative predictive value of 80%, is not considered
reliable for predicting the 30-day postoperative
course accurately.

THE SURGICAL APGAR SCORE

Gawande et al. described the Surgical Apgar Score
(SAS) in 2007. The score was derived from a retro-
spective analysis of 303 patients who underwent col-
lectomy at Brigham and Women’s Hospital, Boston,
MA. This 10-point score is based on the patient’s
surgical blood loss, the lowest intraoperative heart
rate, and lowest recorded mean arterial pressure.
The authors observed that as the score increased,
outcomes improved at the end of 30 days. Many
papers (discussed later on in this article) were
subsequently published that interpreted prospective
and retrospective data and concluded that SAS could
accurately predict morbidity and complications in
several surgical subspecialties. The SAS uses a 10-
point scoring system that has been used to
accurately predict early and 30-day postoperative
complications in all major surgeries in the last
decade. The 10-point SAS is shown in Table 2.

APPLICATION OF SAS BY OTHER
RESEARCHERS IN OTHER SURGERIES

The correlation of SAS with perioperative morbidity
and complications was different when used in
different subspecialties by different researchers.
However, when the patient’s ASA-PS classification
was adjusted using relevant software, SAS scores
remained associated with death and complications
in several subspecialties. We searched PubMed,
Scopus, Embase, and Google Scholar databases with
the keywords “Surgical Apgar Score,” “Postoperative
complications,” “Surgery,” “Morbidity,” and “Mort-
tality” and identified 25 retrospective studies and 11
prospective studies that used SAS as a prognosti-
cator tool to correlate with early and late postopera-
tive complications (up to 30 days). The details of the
retrospective and prospective data, type of surgical
patients reviewed, total number of patients reviewed,
and the reliability of SAS in predicting postoperative
events are presented in Tables 3 and 4. Most of
the published papers that have investigated the effi-
cacy of SAS are based on retrospective data collected

| Parameters                  | 0 Points* | 1 Point | 2 Points | 3 Points | 4 Points |
|----------------------------|-----------|---------|----------|----------|----------|
| Estimated blood loss (mL)  | >1000     | 601-1000| 101-600  | ≤100     | -        |
| Lowest mean arterial pressure (mmHg) | <40       | 40-54   | 55-69    | ≥70      | -        |
| Lowest heart rate (beats/min) | >85       | 76-85   | 66-75    | 56-65    | ≤55      |

* Occurrence of pathological bradyarrhythmia (including sinus arrest, atrioventricular block of dissociation, junctional or ventricular escape rhythms) and asystole also receives 0 points for lowest heart rate.

Reprinted from Gawande et al., ©2007, with permission from the American College of Surgeons.
Table 3. All Retrospective Studies Using SAS Scores for Various Surgeries to Predict Immediate and Delayed Postoperative Complications (30 days).

| Surgery Type (# of Patients) Ref. | Prognostic Value (Y/N) | Remarks |
|----------------------------------|------------------------|---------|
| Knee arthroplasty (3,511)13      | No                     | The authors felt SAS was insufficient for prognostication |
| Colectomy (795)14                | Yes                    | SAS predicted inpatient as well as late post-discharge complications |
| General/vascular surgery (4,119)15 | Yes                    |         |
| Major intra-abdominal surgeries (8,501)16 | Yes                    |         |
| Esophagectomy (189)17            | Yes                    | SAS predicted major morbidity associated with longer hospital stay |
| Esophagectomy (168)18            | Yes                    |         |
| Ivor Lewis (234)19               | No                     | SAS could not predict adverse outcomes |
| Esophagectomy (399)20            | Yes                    |         |
| Gastrectomy (328)21              | No                     | Original SAS not found useful; modified SAS was helpful in predicting complications |
| Hysterectomy for malignancy (632)22 | No                     | SAS uncorrelated with postoperative events |
| Pancreatoduodenectomy (2012)23   | Yes                    |         |
| Intracranial and spine neurosurgery (918)24 | Yes |         |
| Surgery for spinal metastasis (97)25 | No                     | SAS an insignificant predictor of major perioperative complications following spinal metastasis surgery; preoperative functional status and age were stronger predictors |
| Lower extremity amputations (228)26 | Yes | Predicted potential development of complications |
| Wide surgical subspecialties (123,864)27 | Yes |         |
| Intracranial meningioma excision (999)28 | Yes | SAS predicted early and late complications |
| Pancreatoduodenectomy (103)29    | Yes                    | SAS was a significant independent risk factor for overall and recurrence-free survival |
| Radical prostatectomy (994)30    | Yes                    |         |
| Lumbar spine fusion (199)31     | Yes                    |         |
| Gastrectomy (191)32             | Yes                    | SAS predicted survival after surgery |
| Major intra-abdominal surgery (629)33 | Yes                    | SAS predicted survival after surgery |
| Kidney transplant (204)34       | Yes                    | SAS correlated with ICU stay and overall cost of treatment |
| Microvascular head and neck reconstruction (154)35 | No | SAS uncorrelated with postoperative complications |
| Surgery for traumatic hip fractures (43)36 | Yes |         |
| Pancreatic resection (143)37     | Yes                    | SAS along with hypoalbuminemia and blood transfusion correlated well with hospital stay and complications |
| Major gastrointestinal surgeries (1,833)38 | Yes | The authors modified SAS by including intraoperative blood transfusion and assigned zero estimated blood loss (EBL) score to patients who received transfusion; they concluded that intraoperative transfusion improved risk stratification of SAS |
Table 4. Prospective Studies Using SAS Scores for Various Surgeries to Predict Immediate and Delayed Postoperative Complications (30 days).

| Surgery Type (# of Patients) Ref. | Prognostic Value (Y/N/Insignificant) | Remarks |
|-----------------------------------|--------------------------------------|---------|
| General/vascular surgery (143)\(^{39}\) | Insignificant | Suggested conducting randomized control trial |
| Spine (268)\(^{40}\) | Yes | |
| General orthopedic (723)\(^{41}\) | No | SAS did not predict 30-day major complications after general orthopedic surgery |
| Radical cystectomy (155)\(^{42}\) | Yes | |
| General surgery (2,125)\(^{43}\) | Yes | |
| Laparotomy (218)\(^{44}\) | Yes | |
| Non-cardiac surgeries (5,909)\(^{45}\) | Yes | |
| General and vascular surgeries (224)\(^{46}\) | Yes | |
| General, vascular, and orthopedic surgeries (223)\(^{47}\) | Yes | SAS uncorrelated with orthopedic patients who had major events |
| Renal mass excision (886)\(^{48}\) | Yes | |
| High-risk intra-abdominal surgeries (355)\(^{49}\) | Yes | SAS was significantly predictive but weakly discriminative for adverse events |

from electronic hospital records; the SAS was calculated from the records. The authors used univariate and multivariate analyses to assess factors associated with major postoperative complications. Data collected from the National Surgical Quality Improvement Program underwent logistic regression using 27 preoperative variables as predictors; the outcome was determined by using the incidence of major postoperative complications to generate a multivariable preoperative risk prediction model. Twenty out of 25 retrospective studies concluded that SAS correlated with adverse postoperative events. The SAS could not predict unfavorable events in patients who underwent knee arthroplasties (Wuerz et al.\(^{43}\)), hysterectomy for malignancy (Clark et al.\(^{22}\)), Ivor Lewis esophagectomies (Stroyer et al.\(^{49}\)), spine surgery for metastasis (Lau et al.\(^{45}\)), gastrectomy (Miki et al.\(^{21}\)), and microvascular head and neck reconstruction (Ettinger et al.\(^{35}\)). The authors felt that preoperative functional status and age were stronger predictors than SAS. Out of the 11 prospective studies, one study that analyzed patients undergoing orthopedic surgeries suggested that SAS could not predict adverse surgical outcomes. Haddow et al.\(^{39}\) analyzed 143 general and vascular surgical patients, and suggested conducting a randomized control trial due to the few cases, which provided inconclusive data. Thorn et al.\(^{47}\) found that general and vascular surgery patients with a lower SAS correlated well with postoperative outcomes. However, there was poor correlation in orthopedic patients. The initial hypotension that occurs after administering a spinal anesthetic may explain the poor SAS correlation of postoperative events in these patients.

Hypotension usually improves with crystalloid boluses or a few doses of vasopressors. House et al.\(^{50}\) retrospectively analyzed data from 2007–2012 and found that a low SAS score was due to increased cardiac troponin levels after non-cardiac surgery. Out of 46,799 patients, 209 (0.4%) had increased troponins and 192 (0.4%) patients experienced myocardial infarction following non-cardiac surgeries.\(^{49}\) Jering et al.\(^{51}\) used the Area Under the Receiver Operating Characteristic Curve (AUROC) and suggested that combining ASA physical classification with continuously measured SAS was better in predicting major postoperative complications than using ASA physical status and SAS alone.\(^{54}\)
DISCUSSION

An ideal surgical risk scoring system should be simple; require minimal calculation, data and variables; be reasonably accurate; and must be objective, economical, and suitable for all situations (elective/emergency surgeries and valid in all specialties). The SAS is a simple way to predict complications during the postoperative period. It is a simple and inexpensive scoring system that can reliably predict serious postoperative consequences relying on only three variables. Patients undergoing major thoracic, abdominal, and vascular surgeries with significant co-morbidities are expected to have adverse perioperative outcomes. In spite of this, the SAS was able to predict either alone, or in combination with associated risk factors, the occurrence of life-threatening events in the postoperative period. A patient with a low intraoperative SAS should be considered at risk and monitored meticulously. A patient with a low SAS should be monitored for an extended period in the ICU.

The SAS does not appear to correlate well with surgeries performed under regional anesthesia (e.g. arthroplasties, as shown by Wuerz et al.13 and Thorn et al.47). Well-designed prospective studies in the future could provide better insight into the reason behind the lack of correlation between regional anesthesia and SAS. The score could also help surgeons to improve or change their practice. This might include, for example, preventing surgical bleeds by meticulous use of electrocautery, identifying and ligating possible bleeders, and/or using a tourniquet whenever possible; giving time for bleeding to maintain mean arterial pressure (MAP); and avoiding events that lead to severe bradycardia by using slow insufflations after port insertion, maintaining normal intra-abdominal pressure, and avoiding forceful omental/peritoneal handling.

Hyder et al.52 investigated the effect on the SAS of different sampling methods for extracting vital signs data. In the study that involved more than 3,000 patients, they found that larger SAS sampling intervals resulted in better model discrimination and improved reclassification. The authors had a large sample size, studied a variety of non-cardiac surgeries, and had a detailed classification of preoperative and postoperative morbidity. Optimized algorithms and larger sampling intervals of required parameters are needed to use SAS to predict patients at risk for adverse postoperative events. Smaller sampling intervals could lead to inadequate data, leading the investigator to find SAS unsatisfactory in predicting adverse outcomes.

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