

## The Surgical Apgar Score in esophagectomy

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### ABSTRACT

**Objective:** The Surgical Apgar Score is a validated prognostic tool that is based on select intraoperative variables (heart rate, mean arterial pressure, and blood loss). It has been shown to be a strong predictor of morbidity and mortality in a variety of surgical populations. Esophagectomy for malignancy represents a unique subset of patients at high risk for postoperative complications. This study assessed the ability of a modified esophagectomy Surgical Apgar Score (eSAS) to predict 30-day major morbidity.

**Methods:** A retrospective review included 168 patients who underwent elective esophagectomy for malignant disease at the University of Wisconsin from January 2009 through July 2013. Preoperative patient characteristics, intraoperative details, and short-term outcomes were recorded. Primary outcome was 30-day major morbidity. Univariate and multivariate analyses were performed to determine associations between predictive variables, eSAS, and major morbidity.

**Results:** Major morbidity occurred in 35% of cases. Univariate analysis showed that eSAS of 6 or less was strongly associated with major morbidity (unadjusted odds ratio, 2.55; 95% confidence interval, 1.32-4.91;  $P = .005$ ). Other risk factors included transhiatal technique, body mass index less than 20 or greater than 35 kg/m<sup>2</sup>, and history of diabetes mellitus. In multivariate analysis, eSAS of 6 or less remained a strong predictor of postoperative complications (adjusted odds ratio, 3.75; 95% confidence interval, 1.70-8.26;  $P = .001$ ).

**Conclusions:** The eSAS was strongly associated with 30-day major morbidity after esophagectomy. Prospective studies are needed to determine whether improved outcomes can be achieved with the eSAS for risk-stratified triage and postoperative care modification. (*J Thorac Cardiovasc Surg* 2015;150:806-12)

Esophagectomy Surgical Apgar Score (eSAS)					
	0 points	1 point	2 points	3 points	4 points
EBL (mL)	>300	201-300	151-200	≤150	
Lowest MAP (mmHg)	<40	40-54	55-69	≥70	
Lowest HR (beats/minute)	>85	76-85	66-75	56-65	≤55

Esophagectomy Surgical Apgar Score (eSAS).

### Central Message

The esophagectomy Surgical Apgar Score, derived from the intraoperative lowest heart rate, lowest mean arterial pressure, and estimated blood loss, is a strong predictor of major morbidity.

### Perspective

Intraoperative factors associated with adverse outcomes have not been extensively investigated for esophagectomy. The esophagectomy Surgical Apgar Score (eSAS) is a simple, objective score that is based on the intraoperative lowest HR, lowest MAP, and EBL. We found that an eSAS of 6 or less was strongly associated with major morbidity. Prospective studies are needed to determine whether risk-stratified triage and modified care that are based on the eSAS will improve outcomes.

See Editorial Commentary page 813.

Despite advances in surgical technique and postoperative care, esophagectomy remains a high-risk procedure, with complications rates as high as 60% in select series.<sup>1-3</sup> Numerous risk factors have been found to be associated with major morbidity and mortality after esophagectomy<sup>3-5</sup>; however, previously reported risk models have been unreliable.<sup>6,7</sup> These studies have primarily focused on preoperative risk assessment in an effort to improve outcomes through better patient selection and to facilitate risk-stratified comparative analyses for quality assessment.

Although much attention has centered on *preoperative* risk factors in the esophagectomy population, there has been little investigation into risk stratification on the basis of *intraoperative* factors. In 2007, Gawande and colleagues<sup>8</sup> developed a simple, objective scoring system to risk stratify general surgical and vascular surgical patients according to the operative course. Gawande and colleagues<sup>8</sup> initially evaluated 28 intraoperative variables and found that the lowest heart rate (HR), lowest mean arterial blood pressure (MAP), and estimated blood loss (EBL) were independent predictors of 30-day major morbidity and mortality. These variables were incorporated into a 10-point scoring system, referred to as the Surgical Apgar Score (SAS). The SAS has now been externally validated in a number of large patient populations,<sup>9,10</sup> for specific procedures,<sup>11-16</sup> and for surgical specialties.<sup>17-19</sup> These studies have demonstrated significant predictive value of the SAS for postoperative morbidity and mortality.

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**Abbreviations and Acronyms**

HR	= heart rate
MAP	= mean arterial blood pressure
EBL	= estimated blood loss
SAS	= Surgical Apgar Score
eSAS	= esophagectomy Surgical Apgar Score
BMI	= body mass index
ILE	= Ivor Lewis esophagectomy
MKE	= McKeown esophagectomy
NSQIP	= National Surgical Quality Improvement Program
ICU	= intensive care unit
OR	= odds ratios
CI	= confidence interval

Intraoperative risk factors associated with adverse postoperative outcomes have not been extensively investigated in the esophagectomy population. A simple, objective scoring system that reassesses risk immediately after surgery might allow for more informed, risk-stratified triage of patients and for modified postoperative care. The purpose of this study was to assess the ability of a modified esophagectomy SAS (eSAS) to predict 30-day major morbidity after esophagectomy. Secondary outcomes investigated included prolonged stay and discharge disposition.

**MATERIALS AND METHODS****Patients**

A retrospective review of 172 patients who underwent esophagectomy at the University of Wisconsin Hospitals and Clinics (Madison, Wis) from January 2009 through July 2013 was performed. Patients were identified from an institutional database of major thoracic surgical procedures. Patients who underwent nonelective esophagectomy or underwent resection for benign disease were excluded ( $n = 4$ ). Data collected included preoperative patient characteristics, intraoperative details, and short-term postoperative outcomes. Data not routinely collected in the institutional database were obtained by retrospective review of the medical record. Our institutional review board approved this study (IRB #M-2009-1308). The need for individual consent was waived because of the retrospective nature of the analysis.

**Patient Characteristics**

Patient data, including age, sex, body mass index (BMI), American Society of Anesthesiologists score, smoking history, and comorbid disease, were recorded. Chronic comorbid conditions were recorded as composite variables for pulmonary disease (chronic obstructive or restrictive pulmonary disease), cardiovascular disease (coronary artery disease, congestive heart failure, peripheral vascular disease, or cerebrovascular disease), chronic kidney disease (baseline creatinine  $>1.8$  mg/dL or on hemodialysis), and diabetes mellitus. Administration of neoadjuvant chemotherapy or radiation therapy was also recorded.

**Intraoperative Data Collection**

Operative time, approach, and esophagectomy technique were recorded. Techniques included transhiatal esophagectomy, Ivor Lewis esophagectomy (ILE), and McKeown esophagectomy (MKE), which were performed

through open, hybrid, or minimally invasive approaches. Hybrid approaches used a combination of minimally invasive and open approaches (laparoscopy and thoracotomy or laparotomy and thoracoscopy). Procedures that used only laparoscopic or thoracoscopic approaches were considered minimally invasive. Minimally invasive and hybrid approaches that required conversion were categorized as open procedures.

The methodology described by Regenbogen and colleagues<sup>9</sup> was used to collect and assign points for the intraoperative lowest MAP and lowest HR. The ranges used to assign points for EBL in the original SAS scoring system were adjusted, with the EBL cutoff points based on quartile values of EBL in our patient cohort. Median EBL was 200 mL (range, 50-1500 mL; interquartile range, 150-300 mL). Operative notes reporting “minimal” EBL were recorded as 50 mL. Adjustment of the SAS EBL range has previously been described in validation studies for both gastrectomy and total cystectomy procedures.<sup>11,15</sup> Details of the modified eSAS are shown in [Box 1](#).

**Definition of Outcomes**

The primary outcome of our study was 30-day major morbidity. Similar to the original SAS study and subsequent validation studies, major complications were based on National Surgical Quality Improvement Program (NSQIP)-defined adverse events, including bleeding requiring at least 4 units of packed red blood cells within 72 hours of operation, cardiac arrest requiring cardiopulmonary resuscitation, myocardial infarction, deep venous thrombosis, pulmonary embolism, coma for at least 24 hours, stroke, acute renal failure, wound disruption, deep or organ-space surgical site infection, systemic inflammatory response syndrome, sepsis, septic shock, pneumonia, unplanned intubation, and ventilator use for at least 48 hours.<sup>20</sup> Additional complications not meeting the NSQIP definitions for major complication were individually reviewed and evaluated according to the Clavien classification.<sup>21</sup> Complications meeting the definition for Clavien class III complications (requiring surgical, endoscopic, or radiologic intervention) and class IV (requiring readmission to the intensive care unit [ICU] or considered life threatening) were also categorized as major morbidity. All patients with 30-day mortality had at least one major complication and therefore were recorded as having major morbidity. Esophagectomy-specific complications (anastomotic leak, gastric outlet obstruction, chylothorax, and recurrent laryngeal nerve injury) were also noted. All anastomotic leaks (clinically or radiographically detected) were recorded as deep or organ space surgical site infections, whether they were treated conservatively or with interventions such as percutaneous drainage, esophageal stenting, or reoperation. Other esophagectomy-specific complications were included the analysis only if they met the NSQIP definitions for major morbidity or Clavien class III or IV criteria. Prolonged stay was defined as a hospital stay longer than 10 days, which was determined by quartile values (median, 8 days; range 2-107 days; interquartile range, 7-10 days). Disposition status was defined as either home or nonhome discharge, excluding in-hospital deaths.

**Statistical Analysis**

To improve discriminative power, as well as ease of interpretation and clinical utility, preoperative and intraoperative continuous variables were grouped into clinically relevant categories, including age ( $<50$ , 50-59, 60-69, 70-79, or  $\geq 80$  days), BMI ( $<20$ , 20-24.9, 25-29.9, 30-34.9, or  $\geq 35$  kg/m<sup>2</sup>), operative time ( $<6$  hours or  $\geq 6$  hours), and the focal variable of eSAS. The eSAS was assessed as a dichotomous variable for subgroup analysis. As in the study by Thorn and associates,<sup>22</sup> the cutoff score with optimal accuracy for major morbidity was used to group patients into high-risk (below the cutoff) and low-risk (above the cutoff) eSAS cohorts. Accuracy was defined as the sum of true positives (number of patients below the cutoff score who had major complications) and true negatives (number of patients with a score above the cutoff who did not have major complications) divided by the total number of patients who underwent esophagectomy. Surgical approach was categorized as open, hybrid, or minimally invasive. Surgical technique was grouped as either transhiatal

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