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2014 SSAT POSTER PRESENTATION

The Surgical Apgar Score Predicts Postoperative ICU Admission

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Background

In the past, many scoring systems have been developed with a goal of predicting perioperative outcomes, including American Society of Anesthesiologists (ASA) class, Physiologic and Operative Severity Score for the Enumeration [sic] of Mortality and Morbidity (POSSUM), Surgical Risk Score, Biochemistry and Haematology Outcome Models, Acute Physiology and Chronic Health Evaluation (APACHE), Cleveland Clinic Foundation Colorectal Cancer Model, the French Association of Surgery's colorectal scale, and the National Surgical Quality Improvement Program (NSQIP) mortality predictor.[1–5] However, most of these systems are complicated, proprietary, limited (either to preoperative risk or to a single measurement of physiologic variables), and tend to be difficult to implement in the everyday care of patients. For example, the ASA is primarily a frailty index that is simple and widely known but is limited by significant inter-user variability since it does not depend on objective criteria and it does not factor in the patients physiologic condition during the course of their operation.[2] POSSUM uses 12 physiological variables and 6 intraoperative variables to create a score, and because of overprediction of risk in low-risk patients, it has been modified in many ways to try to improve prediction. APACHE and its more recent modifications is a complex and proprietary scoring system that is therefore difficult to use at the bedside.

Postoperative triage to the appropriate level of care may improve outcomes of surgical patients and optimize use of available hospital capabilities.[1,12] However, to date, clinicians lack a simple objective system to optimize postoperative admission to the ICU while avoiding over triage and overutilization of expensive and scarce resources. In this context, the surgical Apgar score (SAS) was developed as a 10-point scoring system easily calculated with limited intraoperative data (blood loss, lowest mean arterial pressure, lowest heart rate during general anesthesia) that predicts postoperative morbidity and mortality.[6] In the last few years, the SAS has been validated in several settings and surgical subspecialties.[7–11] This study aims to investigate the correlation of the SAS with ICU admission after general surgery procedures.

Methods

Data Collection

For participation in the Veterans Health Administration Surgical Quality Improvement Program (VASQIP), a prospective

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database of consecutive patients undergoing any operation (excluding trauma and endoscopy-only procedures) is maintained at the New York Harbor Veterans Health Administration Medical Center. This database collects information on demographics, clinical variables, intraoperative variables, type of surgery, and postoperative outcomes. Surgical Apgar scores were determined by reviewing anesthesiology charts to extract data on blood loss, heart rate, and mean arterial pressure. The investigators who reviewed anesthesia data were different from those who had assessed postoperative outcomes for the VASQIP database. The Institutional Review Board of the New York Harbor Healthcare System VAMC approved this project.

Patient Population

For the purpose of this study, we reviewed data from patients undergoing general surgery procedures (Specialty Code 50) October 2006 through September 2011. Extent of surgery was classified as minor (abdominal or thoracic cavity is not opened), intermediate (extensive superficial dissection or abdominal/thoracic cavity is opened), major (intra-abdominal surgery), or extensive (major cancer surgery). At our institution, we do not use any algorithm for postoperative triage to the surgical ICU, and the determination of level of postoperative care is left to the attending surgeon's clinical judgment. Generally however, every patient undergoing major or extensive surgery is admitted to the ICU for at least 24 h postoperatively.

Outcomes of Interest

Surgical APGAR Score (SAS) was calculated as described previously.[6] Briefly, the SAS is a 10-point score based on patient's estimated blood loss, lowest heart rate, and lowest mean arterial blood pressure during general anesthesia (see Table 1). Because the number of patients with low SAS was small, as in other studies, in order to enhance statistical analysis, cases with SAS ≤4 were aggregated into a single category.[12,13] Thus, we divided our study population into four groups, according to their SAS: ≤4, 5–6, 7–8, 9–10.

Independent Variables

The data fields and definitions of VASQIP included information on patient demographics (age, sex, ethnicity), American Society of Anesthesiologist class, BMI, comorbidities (chronic obstructive pulmonary disease, coronary artery disease, peripheral vascular disease, diabetes, etc.), steroid use, and smoking. Variables related to surgery included the magnitude of surgery and whether or not it was an emergency procedure.

Statistical Analyses

Differences between SAS groups in preoperative conditions and clinical outcomes were evaluated with Pearson's $\chi 2$ or ANOVA as appropriate. Multivariate logistic regression using a maximum likelihood stepwise method was performed to determine the independent effect of ICU admission predictors. Pearson correlation coefficient was used to compare differences in length of stay. Statistical analyses were performed with STATA 12.0 (College Station, TX; StataCorp LP). Results were expressed as mean and standard deviation or percentages. All tests were two-tailed and considered significant for values <0.05. The study end points were ICU admission, ICU transfer, and length of ICU stay.

Results

During the study period, 2198 patients underwent general surgery procedures. After exclusion of patients with pacemakers and/or missing variables, 2125 were available for analysis (SAS ≤4: n=29; SAS 5–6: n=227; SAS 7–8: n=797; SAS 9–10: n=1072). Of these, 608 patients were admitted postoperatively to the ICU and 1517 were admitted to a stepdown unit or to a regular ward. (Figure 1) Demographics, baseline characteristics, intraoperative, and postoperative outcomes of the two triage groups are summarized in Table 2. Patients admitted directly to the ICU were overall older and had more comorbidities and complex operations than the patients initially triaged to the general ward or to a stepdown unit.

Patients in the lower SAS groups had worse functional status, higher ASA score, higher number of preexisting comorbidities, and were more likely to have undergone major or extensive surgery. Low SAS scores were associated with increased postoperative morbidity and 30-day mortality (published previously by Melis et al.[13]). Low SAS was associated with higher probability of ICU admission (79 vs. 57.3 vs. 34.3 vs. 17.0 %, p<0.001). Furthermore, among the 608 (28.6 %) patients admitted to the ICU, a low SAS was associated with

Table 1 Surgical Apgar Score

	Surgical Apgar score, No. of points				
	0	1	2	3	4
Estimated blood loss, mL	>1000	601–1000	101–600	≤100	
Lowest mean arterial pressure, mmHg	<40	40–54	55–69	≥70	
Lowest heart rate/min	>85[a]	76–85[a]	66–75[a]	56–65[a]	≤55[a]

[a] Occurrence of pathologic bradyarrhythmia, including sinus arrest, atrioventricular block or dissociation, junctional or ventricular escape rhythms, and asystole, also receive 0 points for lowest heart rate

Table 2 Demographics of all patients comparing initial ICU triage to patients initially triaged to the floor and among patients initially triaged to the floor, comparing patients transferred to the ICU

Group	Initial triage to floor (n=1517)	Initial triage to ICU (n=608)	P value	Remained on floor (n=1363)	Transferred to ICU (n=154)	p value
Age (years)	61.8±14.5	69.6±12.1	<0.001	62 (15)	71 (12)	<0.001
Proportion male	1359 (89.6 %)	594 (97.7 %)	<0.001	1225 (89.9 %)	150 (97.4 %)	0.002
Race distribution			0.027			0.032
Hispanic, White	129 (10.5 %)	36 (6.9 %)		115 (10.4 %)	7 (5.2 %)	
Hispanic, Black	24 (2.0 %)	16 (3.1 %)		21 (1.9 %)	5 (3.7 %)	
American Indian/Alaska Native	4 (0.3 %)	0		2 (0.18 %)	0	
Black, not Hispanic	445 (36.1 %)	186 (35.4 %)		408 (36.8 %)	39 (29.1 %)	
Asian/Pacific	7 (0.6 %)	5 (1.0 %)		7 (0.63 %)	1 (0.75 %)	
White, not Hispanic	550 (44.6 %)	236 (45.0 %)		486 (43.9 %)	67 (50 %)	
Other/unknown	73 (5.9 %)	46 (8.8 %)		69 (6.2 %)	15 (11.2 %)	
Functional status			<0.001			<0.001
Independent	1431 (94.3 %)	395 (65.0 %)		1286 (94 %)	97 (63 %)	
Partially dependent	60 (4.0 %)	118 (19.4 %)		57 (4.2 %)	28 (18 %)	
Totally dependent	26 (1.7 %)	95 (15.6 %)		20 (1.5 %)	29 (18 %)	
Dyspnea			<0.001			<0.001
None	1469 (96.9 %)	509 (83.7 %)		1316 (97 %)	130 (84 %)	
Minimal exertion	43 (2.8 %)	65 (10.7 %)		42 (3.1 %)	15 (9.7 %)	
Rest	4 (0.26 %)	34 (5.6 %)		4 (0.3 %)	9 (5.8 %)	
Severe COPD	130 (8.6 %)	120 (19.8 %)	<0.001	112 (8.2 %)	27 (18 %)	0.001
Diabetes			<0.001			0.195
Non-diabetic	1254 (82.7 %)	450 (74.0 %)		1132 (83 %)	120 (78 %)	
Diabetic-oral meds	165 (10.9 %)	86 (14.1 %)		149 (11 %)	20 (13 %)	
Diabetic-insulin	98 (6.5 %)	72 (11.8 %)		82 (6.0 %)	14 (9.1 %)	
Hypertension	855 (56.4 %)	435 (71.6 %)	<0.001	771 (57 %)	111 (72 %)	<0.001
History of angina	8 (0.53 %)	17 (2.8 %)	<0.001	7 (0.5 %)	6 (3.9 %)	0.001
Prior cardiac surgery	77 (5.1 %)	61 (10.0 %)	<0.001	61 (4.5 %)	16 (10 %)	0.005
Prior PCI	75 (5.9 %)	39 (7.9 %)	0.122	65 (5.5 %)	10 (11 %)	0.032
Prior MI	7 (0.46 %)	14 (2.3 %)	<0.001	5 (0.4 %)	7 (4.6 %)	<0.001
CHF within 30 days prior to OR	5 (0.33 %)	29 (4.8 %)	<0.001	5 (0.4 %)	7 (4.6 %)	<0.001
History of ascites	13 (0.86 %)	45 (7.4 %)	<0.001	10 (0.7 %)	11 (7.1 %)	<0.001
History of varices	6 (0.4 %)	4 (0.8 %)	0.312	5 (0.4 %)	1 (0.7 %)	0.474
Acute renal failure	6 (0.4 %)	21 (3.5 %)	<0.001	5 (0.4 %)	6 (3.9 %)	<0.001
Hemodialysis	23 (1.5 %)	26 (4.3 %)	<0.001	20 (1.5 %)	11 (7.1 %)	<0.001
Peripheral vascular disease	32 (2.1 %)	18 (3.0 %)	0.268	28 (2.1 %)	4 (2.6 %)	0.559
Rest pain	11 (0.0.73 %)	14 (2.3 %)	0.006	10 (0.7 %)	2 (1.3 %)	0.348
ASA classification						
1	90 (5.9 %)	0	<0.001	82 (6.0 %)	0	<0.001
2	451 (29.7 %)	34 (5.6 %)		399 (29 %)	8 (5.2 %)	
3	904 (59.6 %)	389 (64.0 %)		820 (60 %)	96 (62 %)	
4	67 (4.4 %)	173 (28.5 %)		58 (4.3 %)	46 (30 %)	
5	5 (0.33 %)	12 (2.0 %)		4 (0.3 %)	4 (2.6 %)	
Magnitude of Surgery	607 (40.0 %)	19 (3.1 %)	<0.001	532 (39 %)	5 (3.3 %)	<0.001
Minor	723 (47.7 %)	67 (11.0 %)		672 (49 %)	14 (9.1 %)	
Intermediate major	155 (10.2 %)	357 (58.7 %)		139 (10 %)	75 (49 %)	
Extensive	32 (2.1 %)	165 (27.1 %)		20 (1.5 %)	60 (39 %)	
Emergency procedure	113 (7.5 %)	205 (33.7 %)	<0.001	99 (7.3 %)	50 (32 %)	<0.001
Overall morbidity	80 (5.3 %)	248 (40.8 %)	<0.001	69 (5.1 %)	11 (7.1 %)	0.256
30-day mortality	10 (0.66 %)	47 (7.7 %)	< 0.001	8 (0.59 %)	2 (1.3 %)	0.370
SAS						
0–4	1 (0.07 %)	28 (4.6 %)	<0.001	0	6 (3.9 %)	<0.001
5–6	57 (3.8 %)	170 (28.0 %)		49 (3.6 %)	4 (31 %)	
7–8	518 (34.2 %)	280 (46.1 %)		451 (33 %)	73 (47 %)	
9–10	941 (62.0 %)	130 (21.4 %)		863 (63 %)	27 (18 %)	

Missing data for race (n=20 for readmits; n=215 for never ICU); missing data total length of ICU stay (n=7)

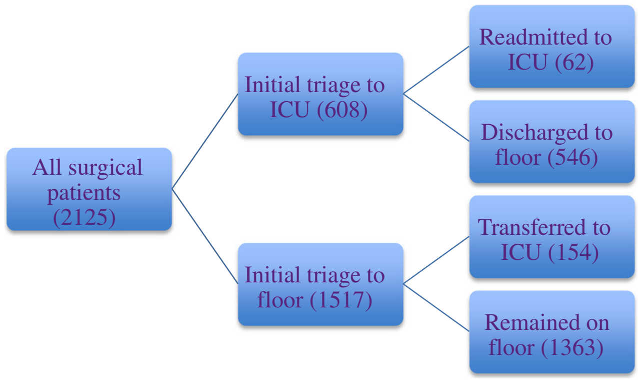

Fig. 1 Breakdown of patients

longer ICU stay (mean 17.3 vs. 14.6 vs. 9.7 vs. 9.9 days, p= 0.009). Figure 2 depicts the probability of being in the ICU at postoperative day (POD) 1, 7, and 30 by SAS. For example, the chance of being in the ICU on POD#7 increases from 1.3 % with SAS of 10 to 34 % with SAS of 5 (r=0.134 with p<0.001). Among the 1517 (71.4 %) patients initially admitted to the regular ward or stepdown unit, 154 (10.2 %) were subsequently transferred to the ICU during the postoperative period. Low SAS was strongly associated with subsequent admission to the ICU (see Table 2).

We used a multivariate analysis to assess the relationship between postoperative ICU admission or transfer and SAS while controlling for variables with statistical significance on univariate analysis, including age, sex, ASA class, functional status, emergency operation, and other comorbidities. This association between SAS and ICU admission or transfer was maintained in a logistic regression controlling for potential confounders. In this multivariate analysis, SAS was the strongest predictor of ICU triage with an odds ratio of 0.731 (95 % CI: 0.673, 0.795) (Tables 3 and 4).

If we include both high-risk groups (those initially admitted to the ICU after surgery and those transferred to the ICU), we know that these patients had lower SAS overall. Nonparametric ROC analysis showed that low SAS alone was strongly associated with ICU stay after surgery (Fig. 3), with an AUC of 0.74.

Discussion

Tools to predict the need for postoperative ICU care may prevent surgical morbidity and mortality and improve use of available resources, preventing unnecessary admissions to the ICU. In our experience, a low SAS was associated with ICU admission and increased length of ICU stay. Furthermore, a poor SAS was also associated with later transfer to the ICU in patients initially triaged to the regular floor after surgery.

Our findings are in line with the current knowledge that SAS correlates with perioperative morbidity and mortality in different hospital settings and for a variety of surgical procedures. However, despite its reliability and ease of use, as of today, the SAS has not been consistently implemented in daily surgical practices. The reason for this slow implementation is probably the current lack of evidence that SAS may be used for practical clinical decision making. The aim of our study was to support the possible role for SAS as a postoperative triage tool. In the past, only Sobol et al. have investigated the relationship between SAS and ICU stay.[14] Similarly to our study, they found a strong association between SAS and the decision to admit a patient to ICU after intra-abdominal surgery (adjusted odd ratio 14.4, 95 % confidence interval 6.88–30.19, p=0.001). Remarkably, their ROC models investigating efficacy of SAS for prediction of ICU admission revealed an area under the curve virtually identical to the one calculated based on our experience (0.76 for Sobol et al., 0.74 in the current study). Unlike our study, Sobol

Fig. 2 Relationship between SAS and the probability of being in the ICU on POD# 1, 7, and 30X-axis shows SAS; Y-axis probability given a particular SAS of being in the ICU at POD #1, POD#7, and POD#30

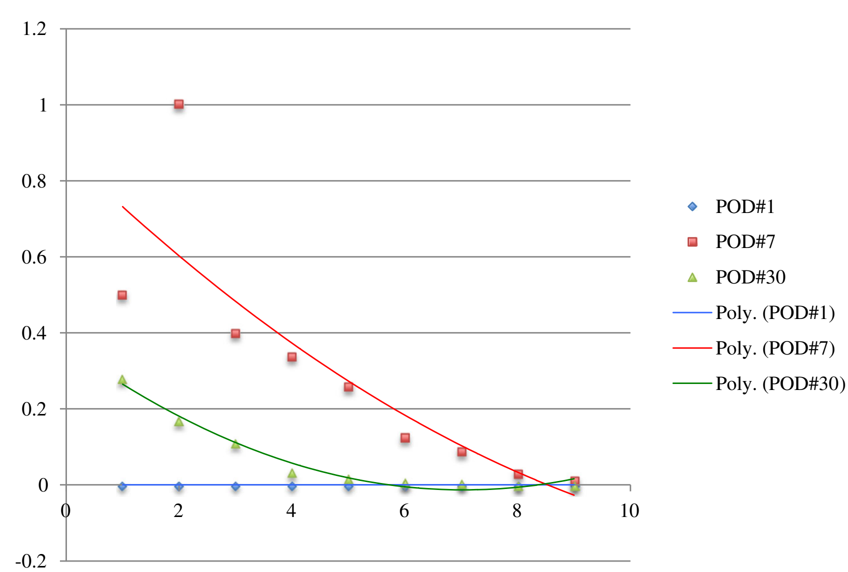

Table 3 Logistic regression analysis for variables associated with ICU admission

Variable	Logistic regression coefficient (β)	Standard error of β	Exp (β)[a]	95 % confidence intervals of Exp (β)	*p* value
Surgical APGAR score	−0.3127	0.0423	0.731	0.673, 0.795	<0.001
Emergency case	0.6230	0.1434	1.865	1.408, 2.470	<0.001
Magnitude of surgery	0.8088	0.0628	2.245	1.985, 2.540	<0.001
History of COPD	0.3850	0.1592	1.469	1.075, 2.007	0.016
Age	0.0085	0.0041	1.009	1.001, 1.017	0.037

[a] Exp (β) is the estimated odds ratio for categorical variables such as functional status

Table 4 Logistic regression analysis for variables associated with ICU transfer (after initial floor admission)

Variable	Logistic regression coefficient (β)	Standard error of β	Exp (β)[a]	95 % confidence intervals of Exp (β)	*p* value
Surgical APGAR score	−0.6948	0.1041	0.4992	0.407, 0.612	<0.001
Emergency case	1.3071	0.2976	3.695	2.062, 6.622	<0.001
Age	0.0474	0.0105	1.049	1.027, 1.070	<0.001
History of angina	2.0494	0.8568	7.765	1.448, 41.627	0.017
Magnitude of surgery	2.0957	0.1685	8.131	5.844, 11.312	<0.001

[a] Exp (β) is the estimated odds ratio for categorical variables such as functional status

SAS cutoff	Sensitivity	Specificity	Correctly Classified
≤0	0.00%	100.00%	64.14%
≤1	0.00%	100.00%	64.14%
≤2	0.13%	100.00%	64.19%
≤3	0.39%	100.00%	64.28%
≤4	3.81%	100.00%	65.51%
≤5	10.89%	99.19%	67.53%
≤6	27.17%	96.40%	71.58%
≤7	47.77%	86.21%	72.42%
≤8	72.57%	63.32%	66.64%
≤9	93.57%	25.31%	49.79%
≤10	100.00%	0.00%	35.86%

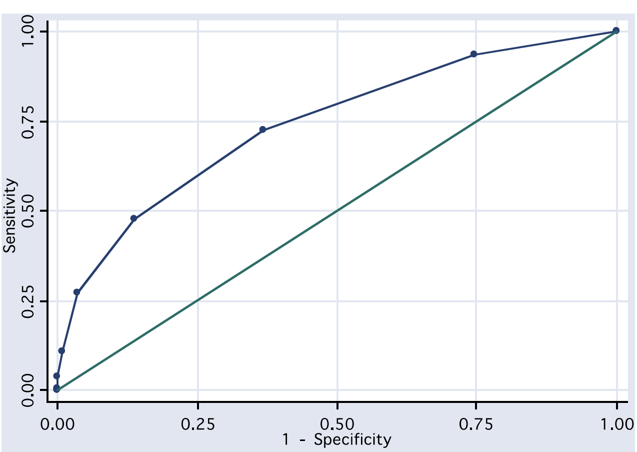

Fig. 3 Sensitivity and specificity of surgical Apgar score in predicting need for ICU stay with associated ROC curve

et al. did not find a relationship between SAS and later admission to the ICU, while the current study showed that the SAS is in fact strongly associated with later admission to the ICU following initial triage to the floor. The reasons for discrepancy between the two studies are unclear and may solely reflect a different threshold for transfer from regular floor to ICU. This hypothesis is supported by our higher late admission rate (4.6 % in the Sobol's study vs. 10.2 % in our study). Obviously, the retrospective design is the main limitation of both studies, which do not clarify whether prospective use of SAS for postoperative triage may avoid unnecessary ICU admissions and inappropriate admissions to the floor.

Preoperative patient comorbidities, family wishes, physician characteristics, ICU bed availability, institutional structure, and regional culture may all influence the goals of triaging a patient after surgery. Therefore, elective admission to the ICU by itself is not necessarily equivalent to appropriate ICU triage in a retrospective analysis. However, our study has other strengths that indirectly suggest SAS is effective in identifying patient in need of ICU monitoring. That is, we found that SAS is strongly associated with length of ICU stay after elective postoperative admission, as well as with later admission to the ICU following initial triage to the floor.

Patients with longer ICU stay were likely those patients that needed ICU level of care or experienced postoperative complications requiring close monitoring. Similarly, regardless of differences in practices and guidelines across different institutions, a later admission to ICU following initial triage to the floor likely reflects an acute deterioration in the general conditions of a postoperative patient. We appreciate that there are many factors that contribute to the need for prolonged length of ICU stay and later ICU admission including medical comorbidities, type of procedure, and subsequent complications that may have altered care outside of the operating room. Ultimately, however, prolonged length of ICU stay and later ICU admission are measurements less prone to patient selection and more likely to reflect a real need for intensive care. While the retrospective nature of this study makes it impossible for us to demonstrate a direct benefit from using SAS to predict patients who would benefit from the intensive care unit stay through interventions and monitoring only available there, our experience provides evidence that the SAS has the potential to be used as a postoperative triage tool.

From evaluating our ROC curves, a cutoff of SAS ≤ 7 could provide a sensitive and specific tool to predict need for ICU stay. Our group is finalizing a protocol to study prospectively whether patients with a high SAS may be safely admitted to a regular floor and whether patients with low SAS should be triaged to the ICU, regardless of the magnitude of their surgery. This will help further delineate how SAS can be used as a screening tool for postoperative care.

Conclusion

Our experience suggests the SAS correlates well with admission to the ICU stay after surgery. Further research in prospective settings may better elucidate whether use of SAS as a postoperative triage tool after general surgery procedures may improve patient outcomes while preventing unnecessary use of scarce hospital resources.

Conflicts of Interest The authors have no conflicts of interest to disclose.

Author Contributions Berman, Cohen, Gouge, Hatzaras, Melis, Newman, Pachter, and Saunders were responsible for the study conception and design; Masi, Neihaus, Okochi, and Pinna for the acquisition of data; Glass and Rosman for the analysis and interpretation of data; Glass and Melis for the drafting of the manuscript; Berman, Cohen, Gouge, Hatzaras, Masi, Melis, Neihaus, Newman, Okochi, Pachter, Pinna, Rosman, and Saunders for the critical revision; and Berman, Cohen, Glass, Gouge, Hatzaras, Masi, Melis, Neihaus, Newman, Okochi, Pachter, Pinna, Rosman, and Saunders for the final approval of the version to be published.

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