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Validation of the Surgical APGAR Score Among Patients Undergoing Major Surgery at the Chinese General Hospital

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Surgery does not have a routine reliable objective evaluation of patient condition after surgery to determine postoperative prognostication and to guide clinical practice. Surgical APGAR score is a 10-point score based on a patient's intraoperative estimated blood loss, lowest heart rate and lowest mean arterial pressure that can predict major complications 30 days after surgery.

Objective: This study sought to validate Surgical APGAR Score in predicting major postoperative complications 30 days after surgery in our hospital setting.

Methods: All patients undergoing major general surgery in Chinese General Hospital and Medical Center from March to October 2009 were enrolled. Three intraoperative variables were measured: estimated blood loss (EBL), lowest mean arterial pressure (LMAP) and lowest heart rate (LHR). Base on these 3 variables, Surgical APGAR Scores were obtained. Resulting data were analyzed and the relationship between the scores and the incidence of major complications evaluated.

Results: Eighty patients were enrolled in this study. There was a significant association of incidence of major complications and decreasing surgical APGAR score (Fisher's exact test, P=0.030). With increasing scores, the incidence of major complications decreased monotonically. The optimum cutoff point for Surgical scores was $\leq$6. At this cutoff point, sensitivity was 80%, specificity was 78.57%, positive predictive value was low at 34.8%, while negative predictive value was high at 96.5%.

Conclusion: Results showed that a simple surgical score can be derived from intraoperative data alone that are readily available. It validated that this 10-point scoring system based on estimated blood loss (EBL), lowest mean arterial pressure (LAMP) and lowest heart rate (LHR) can predict group of patients at higher risk of major complications within 30 days of surgery. This system can be a significant tool for prognostication and clinical guide for early intervention of postoperative care in surgery.

Key words: estimated blood loss, lowest mean arterial pressure

Immediate outcomes of childbirth before introduction of APGAR score were based only on the subjective clinical impressions of obstetricians and pediatricians. In 1950's, with the introduction of scoring system by Virginia Apgar, evaluation and care of newborns were revolutionized.[1] This scoring system proved simple to use and effective at providing objective prediction of 28-day survival of newborns.[2,3] As a result, newborns at high risk for death are easily identified and early measure are developed and instituted. Until today, the APGAR score is an indispensable tool in safety of newborn care.

Unlike in Obstetrics and Pediatrics, Surgery does not have a routine reliable objective evaluation of patient condition after surgery to inform postoperative prognostication and to guide clinical practice. Surgeons rely mainly on subjective assessment of the patient and delayed feedback from postoperative curse.[4] The Acute Physiologic and Chronic Health Evaluation (APACHE)[5] score and the Physiologic and Operative Severity Score for the Enumeration of Mortality (POSSUM)[6] have both been proposed as clinical measures of patient risk factor. These complex models can provide adequate predictions of risk of complication after surgery but have not come into standard use because they are not easily calculated at the bed side, require numerous data elements and rely on laboratory data that are not uniformly collected or available and often are not well understood among the members of the surgical team.

In 2007, Gawande[7] started to develop a surgical scoring system that surgeons could routinely and easily calculate to grade the condition of patients at the end of surgical procedure. This system is a 10-point score based on a patient's intraoperative estimated blood loss, lowest heart rate and lowest mean arterial pressure. The resulting score was correlated with major complications or death within 30 days after surgery. Two years later, Scott[8] tested this scoring system by reviewing operative data of 4,119 cohort patients from different institutions. He concluded that this Surgical APGAR Score system can provide an objective means of predicting patients' outcome in surgery.

This study sought to validate Surgical APGAR Score in predicting major postoperative complications 30 days after surgery.

Methods

All patients undergoing major general surgery in Chinese General Hospital and Medical Center from March to October 2009 regardless of anesthesia type were enrolled. Major general surgery procedures were specified as the following cases: modified radical mastectomy (MRM), colectomy, gastrectomy, small bowel resections, open cholecystectomy, choledochoduodenostomy, and pancreatic surgery. Excluded cases were those patients under age 18 and those undergoing operations for trauma. To avoid having the sample dominated by a single procedure, no more than 20 of the specified major general surgery cases each were enrolled.

Three intraoperative variables were measured: estimated blood loss (EBL), lowest mean arterial pressure (LMAP) and lowest heart rate (LHR). Based on these 3 variables, Surgical APGAR Scores were obtained as originally devised to rate surgical outcomes at Brigham and Women's Hospital in the pioneer study of Gawande.[7] Table I gives the values used to calculate the 10-point score. The score is the sum of the points from each category. 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.

A 30 day follow up was made following surgery with note of major complications or death. Major complications were the following as defined by National Surgical Quality Improvement Program (NSQIP)[9]: acute renal failure, bleeding that required a transfusion of 4U or more of red blood cells within 72 hours after surgery, cardiac arrest requiring cardiopulmonary resuscitation, coma of 24 hours or longer, deep venous thrombosis, myocardial infarction, unplanned intubation, ventilator use for 48 hours or more, pneumonia, pulmonary embolism, stroke,wound disruption, deep or organ-space surgical site infection, sepsis, septic shock, and systemic inflammatory response syndrome. Complications that require surgery, endoscopic or radiologic intervention or intensive care admission were also considered major complications as defined in the Clavien classification.[10]

Resulting data were analyzed and accuracy parameters were determined. Association of scores with occurrence of major complications was also determined using Fisher's exact test.

Eighty (80) patients were enrolled in this study and of these, 10 developed major complications within 30 days including 1 death. Forty two (42) patients scored 9-10 points , 2 of which developed major complications (4.76%). Twenty-seven (27) patients scored 5-8 points and 2 cases developed major complication (7.40%). Eleven (11) patients scored 0-4 points and 6 cases developed major complications including 1 death (54.54%). Prevalence of major complication was 8/80 or 10%.

Association of scores with occurrence of major complications was determined, and results showed significant association (Fisher's exact test, P=0.030), with a relative risk of 9.91 (2.27-43.20) or scores of ≤6 were 9.9 times more likely to result with major complication than scores of > 6 (Table 3).

Table 1. The 10-point surgical APGAR score.

	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 (beats/min)	>85	76-85	66-75	56-65	≤55

Table 2. Type of surgical procedures, surgical scores and complications.

Patient	Procedure	Age/ Sex	Estimated Blood Loss (mL)	Lowest Mean Arterial Pressure (mmHg)	Lowest Heart Rate (Beats/ minute)	Surgical Score	Complication
1	Anterior resection	52F	850	63	72	5	-----
2	Sigmoidectomy	67F	800	70	68	5	-----
3	*Ileal resection*	69F	100	80	60	9	ICU admission
4	Subtotal gastrectomy	53F	1,200	60	70	4	Transfusion of 5u of PRBC. Acute renal failure
5	Sigmoidectomy	84F	300	85	70	7	-----
6	Left hemicolectomy	54M	450	60	60	7	-----
7	Transverse colectomy	81M	650	70	65	6	-----
8	Low anterior resection	63M	700	65	73	5	-----
9	Abdomino-perineal resection	65M	950	65	67	5	-----
10	Whipple's procedure	57F	1,100	65	69	4	ICU admission
11	Sigmoidectomy	88M	400	75	74	7	-----
12	Hartmann's procedure	55M	350	85	65	8	-----
13	Abdomino-perineal resection	53M	900	50	77	3	Pneumonia; Sepsis vs SIRS
14	Subtotal gastrectomy	30M	950	88	64	7	-----
15	Anterior resection	90	600	67	66	5	-----
16	Sigmoidectomy	52F	400	90	63	8	-----
17	Right hemicolectomy	56M	400	80	54	9	-----
18	Right hemicolectomy	54M	200	90	50	9	-----
19	Sigmoidectomy	57F	450	88	65	8	-----
20	Ileo-cecal resection	44F	200	75	54	9	Loculated intraabdominal abscess
21	Left hemicolectomy	68M	550	80	70	7	
22	Total gastrectomy	72M	1,300	60	79	3	Transfusion of 4u of PRBC; ICU admission; 48hrs ventilator support
23	Segmental ileal resection	48F	900	65	76	4	Acute renal failure
24	Left hemicolectomy with ileostomy	54F	600	54	70	4	Sepsis; Death
25	Sigmoidectomy	60M	700	65	73	5	-----
26	Right hemicolectomy	51M	250	87	68	7	-----
27	Ileocecal resection	35F	300	85	60	8	-----
28	Low anterior resection	58F	650	68	70	5	-----
29	Sigmoidectomy	55M	400	80	55	9	-----
30	Total gastrectomy	68M	1,200	60	76	3	-----
31	Right hemicolectomy	61F	300	84	65	7	-----
32	Subtotal gastrectomy	59F	800	68	65	6	-----
33	Ileal resection	44F	200	90	50	9	-----
34	Gastrojejunostomy roux-en-y	55M	1,100	65	78	3	-----
35	Gastrojejunostomy roux-en-y	61M	700	60	66	5	-----

36	Distal pancreatectomy	58F	800	65	71	5	Sepsis vs SIRS
37	Gastrojejunostomy roux-en-y	41M	950	65	65	6	-----
38	Anterior resection	65M	750	70	64	7	-----
39	Sigmoidectomy	59F	300	72	75	8	-----
40	Right hemicolectomy	44F	300	80	60	8	-----
41	Ileo-cecal resection	38F	450	82	59	8	-----
42	MRM left	55F	<100	70	65	9	-----
43	MRM left	59F	<100	75	55	10	-----
44	MRM right	61F	150	74	55	9	-----
45	MRM right	49F	200	75	54	9	-----
46	MRM left	45F	<100	80	65	9	-----
47	MRM left	56F	150	87	55	9	-----
48	MRM left	48F	<100	84	60	9	-----
49	MRM right	59F	<100	75	58	9	-----
50	MRM left	49F	200	87	52	9	-----
51	MRM right	50F	<100	90	59	9	-----
52	MRM right	44F	<100	95	50	10	-----
53	MRM right	55F	<100	90	63	9	-----
54	MRM right	56F	<100	88	59	9	-----
55	MRM left	56F	<100	74	61	9	-----
56	MRM left	50F	<100	97	65	9	-----
57	MRM right	53F	<100	77	65	9	-----
58	MRM right	55F	150	77	52	9	-----
59	MRM right	59F	150	80	50	9	-----
60	MRM left	70F	200	80	55	9	-----
61	MRM right	65F	<100	83	60	9	-----
62	Cholecystectomy	49M	<100	92	52	10	-----
63	Cholecystectomy	47M	<100	80	65	9	-----
64	Cholecystectomy	47M	<100	85	64	9	-----
65	Cholecystectomy	58M	<100	87	65	9	-----
66	Cholecystectomy	55M	<100	90	60	9	-----
67	Cholecystectomy	31F	<100	94	64	9	-----
68	Cholecystectomy	33F	<100	90	65	9	-----
69	Cholecystectomy with CBDE	44F	1,100	65	68	4	-----
70	Cholecystectomy with CBDE	44M	300	75	55	9	-----
71	Cholecystectomy	39M	<100	65	54	9	-----
72	Cholecystectomy	45F					-----
73	Excision of choledochal cyst	27M	1,200	50	60	4	-----
74	Cholecystectomy	45M	<100	85	55	10	-----
75	Cholecystectomy with CBDE	35M	200	80	54	9	-----
76	Cholecystectomy	49F	250	90	55	9	-----
77	Cholecystectomy	68M	150	60	65	6	Pneumonia; Sepsis
78	Cholecystectomy	62M	<100	68	55	9	-----
79	Cholecystectomy	35F	1,100	54	65	4	-----
80	Cholecystectomy	56M	150	84	50	9	-----

Table 3. Association of surgical APGAR scores with occurrence of major complications.

Score	With Complication	Without Complication	Total
≤6	8	15	23
>6	2	55	57
Total	10	70	80

RR= 9.91 ; 95% CI= 2.27-43.20

An ROC curve was constructed and an optimum cutoff point for surgical scores that would optimize sensitivity and specificity was determined. The values from Table 4 were then plotted to come up with a receiver operating characteristic (ROC) curve as shown in Figure 1. The plots of the resulting sensitivity and specificity for each cutoff score was also determined, and the intersection at ≤6 was considered the optimum cutoff point. Table 5 shows the actual values in a 2x2 table which were the bases for determining the validation parameters. From these tables, it can be seen that for the cutoff of ≤6, sensitivity was 80%, specificity was 78.57%, positive predictive value was a low 34.8% while negative predictive value was a high 96.5%.

Table 4. Criterion values and coordinates of the ROC curve.

Criterion	Sensitivity	95% CI	Specificity	95% CI	+LR	-LR	+PV	95% CI	-PV	95% CI
≤ 3	0.00	0.0 - 31.0	100.00	94.8 - 100.0		1.00			87.5	78.2 - 93.8
≤ 3	20.00	3.1 - 55.6	97.14	90.0 - 99.6	7.00	0.82	50.0	8.3 - 91.7	89.5	80.3 - 95.3
≤ 4	60.00	26.4 - 87.6	92.86	84.1 - 97.6	8.40	0.43	54.5	23.5 - 83.1	94.2	85.8 - 98.4
≤ 5	70.00	34.8 - 93.0	82.86	72.0 - 90.8	4.08	0.36	36.8	16.4 - 61.6	95.1	86.3 - 98.9
≤ 6 *	80.00	44.4 - 96.9	78.57	67.1 - 87.5	3.73	0.25	34.8	16.4 - 57.3	96.5	87.9 - 99.5
≤ 8	80.00	44.4 - 96.9	57.14	44.7 - 68.9	1.87	0.35	21.1	9.63 - 7.3	95.2	83.8 - 99.3
≤ 9	100.00	69.0 - 100.0	7.14	2.4 - 15.9	1.08	0.00	13.3	6.6 - 23.2	100.0	48.0 - 100.0
≤ 10	100.00	69.0 - 100.0	0.00	0.0 - 5.2	1.00		12.5	6.2 - 21.8		

Variable	Score
Classification variable	Class. Var
	Class. Var
Positive group	
Class variable	= 1
Sample size	10
Negative group	
Class variable	= 0
Sample size	70
Disease prevalence (%)	unknown
Area under the ROC curve (AUC)	0.810
Standard error	0.0594
95% Confidence interval	0.707 to 0.889
z statistic	5.220
Significance level P (Area=0.5)	0.0001

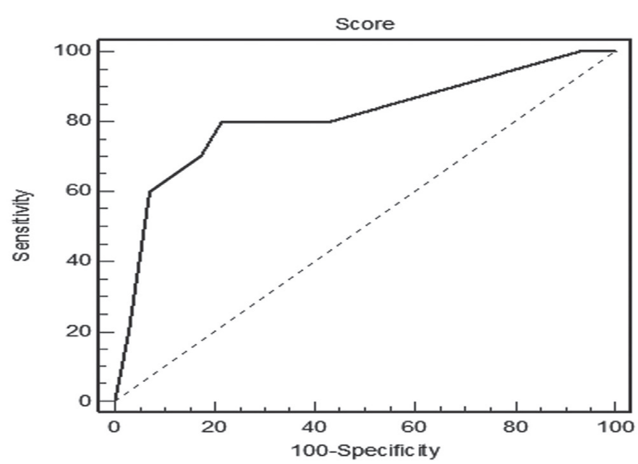

Figure 1. ROC curve.

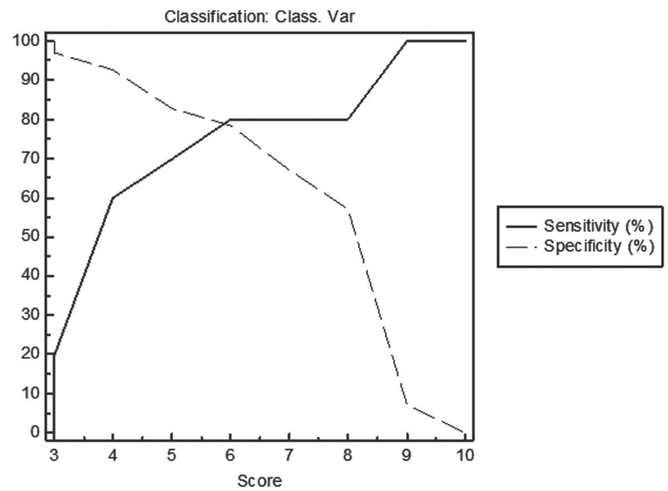

Figure 2. Plot of the sensitivity and specificity of each score.

Discussion

A simple clinical scoring based on blood loss, lowest mean arterial pressure and lowest heart rate during an operation provides a meaningful estimate of patients' condition and risk after surgery. This 10-point scoring system is predictive of major complication in the postoperative period. The score successfully identifies not only patients at highest risk of postoperative complication but also those at markedly lower than average risk. Patients with score of 9-10 (52.5% of the sample) had only a 4.76% incidence of major complication and no incidence of death. In contrast, patients with score of 0-4 (13.75% of the sample) had a 54.54% incidence of major complication. This scoring system seems to be more specific than sensitive in predicting major complication and more sensitive than specific in predicting non-occurrence of major complication with decreasing scores and increasing scores, respectively. Like the previous studies done by Gawande[7] and Scott,[8] there was a significant association of incidence of major complications and decreasing surgical APGAR score. In the study of Scott[8], there was 5% incidence of major complication in scores of 9-10 and 56.3% incidence of major complication in scores of 0-3. This result was replicated in this study.

The optimum cutoff point for surgical scores that would optimize sensitivity and specificity was the score of $\leq$6. At this cutoff point, sensitivity was 80%, specificity was 78.57%, predictive value positive was a low 34.8%, while predictive value negative was high at 96.5%.

This Surgical APGAR Score could serve a very important tool. Just like the Apgar score in Pediatrics and Obstetrics, it can provide surgeons with immediate feedback on the condition of every postoperative patient.[12] It can serve as an objective measure to strengthen the clinical feeling of surgeons.[4,13] The resulting score can greatly assist in identifying cases that should receive intensive postoperative monitoring and therefore early intervention can be instituted before problems arise.

Complex models (APACHE and POSSUM)[5,6] are not commonly used in clinical settings because they are difficult for members of surgical team to interpret and communicate at bed side and often not readily calculated because of unavailability of some critical data variable.[14,15] The Surgical Apgar Score variables are readily available, immediately usable, easily and inexpensively collected and computed for clinical use.

Table 5. 2x2 table to determine validation parameters for a $\leq$ 6 cutoff score.

Score	With Complication	Without Complication	Total
$\leq$6	8	15	23
>6	2	55	57
Total	10	70	80

Sensitivity = 8/10 or 80%
Specificity= 55/70 or 78.6%
PVP = 8/23 or 34.8%
PVN = 55/57 or 96.5%

These characteristics made the Apgar score in obstetrics and pediatrics a powerful tool and revolutionized newborn care.[15,16] This may also be the future of this Surgical Apgar Score.

Conclusion

The results showed that a simple surgical score can be derived from intraoperative data alone that are readily available. It validated that this 10-point scoring system based on estimated blood loss (EBL), lowest mean arterial pressure (LAMP) and lowest heart rate (LHR) can predict group of patients at higher risk of major complications within 30 days of surgery. Scores of ≤ 6 were 9.9 times more likely to result with major complication than scores of > 6. This system can be a significant tool for prognostication and clinical guide for early intervention in surgery. It will be a useful guide in routine care and improvement of postoperative management because of its simplicity and reliability.

Recommendation

Continuation of this study to increase its statistical power is highly recommended. Also, the authors recommend that a study should be done comparing Acute Physiologic and Chronic Health Evaluation (APACHE) score and the Physiologic and Operative Severity Score for the Enumeration of Mortality (POSSUM) and this study to determine which system is easier to use at the same time can accurately predict patient outcome condition.

The preoperative risk factors of patients enrolled in this study were not determined. It would be of great value if a study determining significant relationship between patient's preoperative risk factors, surgical score and the occurrence of major complications.

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