Surgical Apgar score is significantly useful as a predictor of major complications after thoracic spinal surgery: a retrospective cohort study

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Research Article

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Abstract

Background: Prediction of postoperative complications and management based on that prediction are important for improving outcomes. The surgical Apgar score, a simple score for surgical outcomes, has been used to predict postoperative complications. The purpose of this study was to investigate the usefulness of the surgical Apgar score to predict major complications after thoracic spinal surgery.

Methods: The subjects were 104 patients who underwent thoracic spinal surgery at a single institution from 2014 to 2018. Background patient and disease characteristics assessed included age, gender, body mass index (BMI), comorbidities (diabetes, hypertension or coronary artery disease), anticoagulant and antiplatelet medications, preoperative hemoglobin, controlling nutritional status (CONUT) score, and American Society of Anesthesiologists-Physical Status (ASA-PS) classification. Surgical factors evaluated were operative time, approach, presence of instrumentation, and multiple intervertebral surgery. The surgical Apgar score was calculated from intraoperative estimated blood loss, minimum heart rate, and minimum mean blood pressure. Major complications were defined as unexpected elongation of intubation for more than 48 hours, postoperative blood transfusion (bleeding) of more than 4U in 72 hours, coronary artery disease, renal failure, cerebrovascular disease, sepsis, pneumonia, severe delirium, deep vein thrombosis, pulmonary embolism (PE), or wound complications. Postoperative hospitalization days were also investigated. A multivariate statistical analysis was performed using stepwise logistic regression. The occurrence of complications and the duration of postoperative hospitalization were compared using a *t*-test. A *p*-value of <0.05 was considered significant.

Results: Major complications were observed in 19 (18.3%) patients; these were bleeding (8 patients), delirium and wound complications (4 patients each) PE (2 patients) and pneumonia and acute kidney injury (1 patient each). The multivariate analysis revealed that the surgical Apgar score (odds ratio=0.3) was significantly associated with major complications. Postoperative hospital stay was significantly longer in patients with complications (59 days) than in patients without complications (36 days; $p=0.0015$).

Conclusion: The surgical Apgar score is an objective index that can be easily calculated from anesthesia records, and this study suggests that it may be useful in predicting major complications after thoracic spinal surgery.

Background

The occurrence of postoperative complications is not only detrimental to patients, but it is also the cause of additional healthcare costs and should be avoided whenever possible [1, 2]. The importance of predicting the risk of occurrence, in an attempt to prevent it, is something the authors consider cannot be overstated. Factors that increase surgical complications associated with spinal surgery include advanced age, medical complications such as diabetes mellitus, history of cerebrovascular disease and cancer, and inadequate nutrition [3–6], as well as the presumed influence of surgical time [7] and surgical invasions,

such as surgery with instrumentation [8, 9]. Recently, the surgical Apgar score, which is a relatively easy score to calculate based on intraoperative blood loss, minimum mean intraoperative blood pressure, and minimum intraoperative heart rate, has been reported [10] (Table 1). The Surgical Apgar Score has demonstrated validity in a wide range of surgical fields [11, 12]. Studies have shown that in high-risk abdominal surgery, the lower the SAS, the higher the ICU admission rate after total surgery, making it a powerful tool for clinical decision making regarding ICU transport immediately after surgery. It has also been reported that thoracic spine surgery is often associated with severe stenosis and more complications at the thoracic level compared to spine surgery at the cervical or lumbar level [13]. Therefore, establishing the proper methodology to predict the occurrence of major complications after thoracic spinal surgery becomes necessary. The purpose of this study was to investigate the usefulness of the surgical Apgar score to predict major complications after thoracic spinal surgery.

Table 1
Surgical Apgar score

	Score				
Parameter	**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, bpm	> 85	76–85	66–75	56–65	≤ 55
Abbreviations: - no data, *bpm* beats per minute					

Methods

A total of 104 patients underwent thoracic spinal surgery—excluding biopsies and minor operations—at our hospital from 2014 to 2019. We evaluated patient and disease characteristics uch as age, gender, BMI, comorbidities (diabetes, hypertension, or coronary artery disease), anticoagulant and antiplatelet medications, preoperative hemoglobin concentration, American Society of Anesthesiologists physical status (ASA-PS) classification, and the controlling nutritional status (CONUT) score. The CONUT score is a simple nutritional assessment index based on a composite of three factors: albumin, lymphocytes, and cholesterol. [14].

Surgical factors included operative time, approach (posterior, anterior, or combined operation), use of instrumentation, multi-level vertebral surgery (≥ 5 vertebrae) and the surgical Apgar score. Major complications were defined as unexpected intubation for more than 48 hours, postoperative bleeding requiring a blood transfusion of more than 4 U in 72 hours postoperatively, coronary artery disease, renal injury, cerebrovascular disease, sepsis, pneumonia, severe delirium, deep vein thrombosis (DVT), pulmonary embolism (PE), or wound complications [10]. The occurrence of major complications within 30 days postoperatively and the duration of postoperative hospitalization were also investigated.

Statistical analysis was performed using the Chi-square test or Fisher's exact test, the Mann-Whitney *U* test for univariate analysis, a stepwise selection procedure, and multivariable logistic regression for multivariate analysis. Factors identified with a significance of $p < 0.1$ in the initial univariate analysis were used in further analyses. Possible confounding among explanatory factors during univariate analysis was assessed. Logistic regression analysis using a stepwise method was performed to identify possible independent risk factors which could have a significant influence on clinical outcomes.

The incidence of complications and Duration of stay after surgery were compared using a *t*-test. A *p*-value of < 0.05 was considered significant.

Data are expressed as mean ± standard deviation. The odds ratio (OR) for the incidence of failure and 95% confidence intervals (CI) were calculated as an approximation of the relative risk estimates. All statistical analyses were conducted using JMP 15 (SAS Institute Inc., Cary, NC, USA).

Results

Overall, the study comprised 27 cases of a thoracic spinal cord tumor, 21 cases of a metastatic thoracic spine tumor, 15 cases of ossification of the posterior longitudinal ligament, 15 cases of ossification of the yellow ligament, 9 cases of traumatic fracture, 6 cases of thoracic myelopathy, 3 cases of disk herniation, and 8 cases of other causes (Table 2). There were 58 males and 46 females and the mean age was 59 years (range,24–81). Major complications were observed in 19 (18.3%) patients; these were bleeding (8 patients), delirium and wound complications (4 patients each) PE (2 patients) and pneumonia and acute kidney injury (1 patient each). The univariate analysis revealed that the surgical Apgar score was significantly associated with major postoperative complications ($p < 0.001$), although a significant association was lacking between any background factors and major postoperative complications (Table 3). Postoperative hospital stay was significantly longer in patients with complications (59 days) than in patients without complications (36 days, $p = 0.0015$; Table 4) When stepwise multivariate analysis was performed, the surgical Apgar score was detected as an independent factor significantly associated with major postoperative complications ($p < 0.001$ OR = 0.3; Table 5).

Table 2
Diagnosis for target cases (*N* = 104)

Diagnosis	***n* (%)**
Thoracic spinal cord tumor	27 (26.0)
Metastatic spinal tumor	21 (20.2)
Ossification of the posterior longitudinal ligament	15 (14.4)
Ossification of the yellow ligament	15 (14.4)
Trauma	9 (8.6)
Cervical spondylotic myelopathy	6 (5.8)
Disc herniation	3 (2.9)
Other	8 (7.7)

Table 3
Background patient and disease characteristics associated with thoracic spinal surgery

	All cases (*N* = 104)	Major complications		
		Yes (n = 19)	No (n = 85)	p-value*
Gender, *n*				0.83[a]
Male	58	11	47	
Female	46	8	38	
Age, years	59 ± 14	67 ± 12	63 ± 13	0.11[c]
BMI, kg/m^2	24.1 ± 4.6	23.8 ± 5.1	24.2 ± 4.5	0.38[c]
Disease characteristics, *n*				
Diabetes	20	5	15	0.45[a]
High blood pressure	35	5	30	0.23[a]
Coronary artery disease	5	1	4	0.64[b]
Anticoagulants	4	1	3	0.56[b]
Antiplatelet agents	4	1	3	0.56[a]
Preoperative Hb (g/dL)	13.7 ± 1.8	13.8 ± 1.8	13.2 ± 2.6	0.22[c]
ASA-PS classification				0.19[b]
1, 2	61	11	50	
3, 4	43	8	35	
CONUT score				0.09[b]

Data are the mean ± standard deviation, unless shown otherwise.

Abbreviations: ASA-PS American Society of Anesthesiologists-Physical Status, *BMI* body mass index, *CONUT* controlling nutritional status, *Hb* hemoglobin

* $p < 0.05$ is significant.

[a] Chi-square test.

[b] Fisher exact test.

[c] Mann-Whitney *U* test.

	All cases (*N* = 104)	Major complications		
		Yes (n = 19)	No (n = 85)	p-value*
0–1	167	8	55	
2–4	83	8	28	
5–8	7	3	5	
9–12	4	0	2	

Data are the mean ± standard deviation, unless shown otherwise.

Abbreviations: ASA-PS American Society of Anesthesiologists-Physical Status, *BMI* body mass index, *CONUT* controlling nutritional status, *Hb* hemoglobin

* $p < 0.05$ is significant.

[a] Chi-square test.

[b] Fisher exact test.

[c] Mann-Whitney *U* test.

Table 4
Surgical factors associated with thoracic spinal surgeries and summary of postoperative admission days

	All cases (*N* = 104)	Major complications		
		Yes (n = 19)	No (n = 85)	p-value*
Operation time (min)	385 ± 167	454 ± 193	372 ± 158	0.11[b]
SAS	6.5 ± 1.6	4.6 ± 1.7	6.9 ± 1.4	< 0.001[b]
Approach, *n*				0.45[a]
Posterior	103	18	85	
Anterior and posterior	11	9	2	
Use of implants, *n*	65	17	58	0.06[a]
Multi-level surgery (≥ 5 intervertebral bodies), *n*	54	14	44	0.08[a]
Postoperative admission, days	40 ± 27	59 ± 36	36 ± 24	0.0015[b]

Data are the mean ± standard deviation, unless shown otherwise.

Abbreviations: SAS surgical Apgar score

* $p < 0.05$ is significant.

[a] Chi-square test.

[b] Mann-Whitney *U* test.

Table 5
Multivariable logistic regression analysis

Factor	Odds ratio	(95% confidence interval)	*p*-value*
CONUT score	1.39	(1.10–1.77)	0.068
SAS	0.47	(0.26–0.68)	< 0.001

Abbreviations: CONUT controlling nutritional status, *SAS* surgical Apgar score

* $p < 0.05$ is significant.

Discussion

Several reports exist about assessments of the surgical Apgar score in the orthopedic field. Studies that evaluated patients undergoing hip and knee replacement surgery have shown that the surgical Apgar score alone does not provide a comprehensive stratification of postoperative risk [15], although the surgical Apgar score has been reported to predict risk stratification for patients undergoing spinal surgery [16]. Moreover, the surgical Apgar score is considered more useful to predict complications after spinal surgery than in general orthopedic surgery [17]. Differences in the predictive value of the surgical Apgar score between spinal and limb surgeries may suggest that complications occurring after spinal surgery exert a greater influence on circulatory dynamics intraoperatively.

There are previous reports that suggest increased blood loss leads to increased complications during spinal surgery [18]. In contrast, the study data we report demonstrated that there was no correlation between the amount of blood loss and the occurrence of complications. This indicates that intraoperative circulatory dynamics can mirror the response to blood loss and significantly reflects an individual's reserve capacity. Therefore, the surgical Apgar score can be significantly associated with an increase in the invasiveness of the surgery compared with the amount of blood loss alone.

In the present study, an assessment of the surgical Apgar score was useful in predicting postoperative major complications associated with thoracic spinal surgeries. In addition to efforts made to control intraoperative bleeding, patients with a poor surgical Apgar score may require more vigilant postoperative management.

Conclusion

Based on the results of our study, we revealed that the surgical Apgar score is a significant independent factor associated with major postoperative complications in thoracic spinal surgeries. Poor intraoperative hemodynamics may be a significant risk factor contributing to the occurrence of major complications.

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Abbreviations

BMI body mass index, *CONUT* controlling nutritional status, *ASA-PS* American Society of Anesthesiologists- Physical Status, *DVT* deep vein thrombosis, *PE* pulmonary embolism

Declarations

Ethics approval and consent to participate

This study was approved by the ethical committee of Tsukuba Clinical Research and Development Organization (H30-087). Informed consent was obtained from all participants. We also confirm that all methods were performed in accordance with the relevant guidelines.

Consent for publication

Not applicable.

Availability of data and materials

All data generated or analyzed during this study are included in this published article.

Competing interests

The authors declare no competing interests.

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Authors' contributions

YS and KoM designed the study. MasK collected and analyzed the data. TA, KS, FE, KeM, HK, and KN contributed to clinical management of the case. YS wrote the article. KoM, MasK, TA, KS, FE, MamK, HN, HT, TF, MT, and MY reviewed the article. All authors read and approved the final manuscript.

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