Analysis of anesthesia-related prognostic indicators in neurosurgery

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Research article

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Abstract

Background: This retrospective study was conducted to identify prognostic predictors for patients undergoing neurosurgery under general anesthesia.

Methods: From April 2015 to May 2017, a total of 757 patients undergoing neurosurgery in our hospital were analyzed. Baseline and clinical data including age, gender, etiology, surgery procedures, comorbid and underlying diseases, the Glasgow coma scale (GCS), the APACHE II score, ASA score, anesthesia class, operation time, intraoperative cardiac events, intraoperative blood transfusion, and postoperative fever were collected and analyzed. The Glasgow outcome scale (GOS) was used as outcome measure. Logistic regression analysis was performed to identify the independent prognostic factors.

Results: Among the 14 factors analyzed, twelve were significantly correlated to the GOS scores ($P < 0.05$), including age, etiology, type of surgery, hypertension, anesthesia class, APACHE II score and ASA class, intraoperative cardiac events, intraoperative blood transfusion and postoperative fever. Further logistic regression analysis showed the three parameters had prognostic values with odds ratios of 3.933, 1.812 and 2.910, respectively. On other hand, gender and operation time were not correlated to GOS.

Conclusions: Anesthesia class, APACHE II score and ASA class have significant prognostic values for patients undergoing neurosurgical surgery.

Background

Neurosurgery is recognized as the most difficult branch of surgery and interventions may occasionally lead to a poor prognosis [1]. Patient's conditions are variable, and the operation time and recovery time are often long. Therefore, accurate prognosis prediction is important for neurosurgeons and patients to optimize surgical decision-making. Several risk scores are used in neurosurgery, but studies on their clinical relevance are scarce [2]. Earlier studies showed that preoperative ASA physical status classification, the Karnofsky performance score (KPS), the Charlson comorbidity score, the modified Rankin Scale and the sex, KPS, ASA physical status classification, location, and edema score in assessing postoperative outcome in cranial neurosurgery have been evaluated for their value in predicting operative outcome, and KPS is found to be have the strongest support for predicting surgery-related outcomes [2].The prognosis prediction by neurosurgeons is focused on etiology and surgery procedure and by anesthesiologists is focused on preoperative evaluation of physiological, pathological and other conditions of patients. As such, the evaluation of assessment is often made from different perspectives. A comprehensive, accurate and timely risk assessment that includes perioperative information would help anesthesiologists and neurosurgeons make adequate preoperative preparations, and plans for effective measures that deal with potential issues occurring during the intraoperative and perioperative periods [3]. These measures would avoid and minimize the occurrence of adverse events and improve surgical outcome. For better prognosis prediction, it is necessary to take into consideration

of intraoperative and postoperative factors, in addition to preoperative factors. However, such evaluation has been scare.

In this study, we attempted to identify factors, especially anesthesia-related factors that help to predict the prognosis based on clinical data and perioperative period evaluations. The findings would improve our management of neurosurgery, especially the outcomes of neurosurgery.

Methods

Subject

A total of 757 patients undergoing neurosurgery from April 2015 to May 2017 at our hospital were retrospectively assessed. Patients were excluded if the anesthesia was local and they had intraspinal tumors. The study was approved by the Research Ethic Committee of China Three Gorges University and informed consent was obtained from every patient.

Methods

Clinical data and variables that may affect the outcome were collected, including general information such as identification number, name, gender, age, etiology, length of hospital stay, date of admission, date of discharge; commodities such as hypertension, diabetes and other chronic diseases; surgical information such as surgical name, surgical site, surgical type, incision type, anesthesia method and wound healing. For preoperative condition assessment, the Glasgow coma score (GCS), anesthesia class, the American Society of Anesthesiologists (ASA) classification, Acute Physiology and Chronic Health Evaluation II (APACHE II) score and surgical class (according to 2009 National Medical Technology and Clinical Use Guidelines promulgated by the Ministry of Health of China) were collected. Other variables, such as operation time, incidence of cardiovascular events, intraoperative blood transfusion, postoperative fever were included.

Statistical analysis

The data were analyzed by SPSS version 19.0 for Windows (SPSS Inc., Chicago, IL, USA). The frequencies of categorical variables were compared using Pearson χ^2 or Fisher's exact test, when appropriate. Multivariate regression analysis were performed to identify factors affecting the prognosis using Glasgow Outcome Scale (GOS) at discharge as the primary outcome. $P < 0.05$ was considered statistically significant.

Results

Basic data

Of the 757 patients selected, 357 were female and 400 were male. The median age was 51.0 years. The etiology included intracranial tumor (55.1 %), intracranial aneurysms and arteriovenous malformations

(8.1 %), intracranial hematoma (5.4%), craniocerebral trauma (1.7%), hydrocephalus (4.0%), craniocerebral trauma (4.0%) and others such as trigeminal neuralgia, trigeminal neuralgia and skull defect (5.8%). Patients with the GOS scores 4-5 were considered to have good outcomes. With this standard, 280 (78.4%) females and 316 (79.0%) males had good prognosis.

Correlation analysis

We first performed univariate analysis to identify variables that are significantly correlated to the GOS score. In our cohort, 596 patients had a GOS score between 4-5 (good prognosis) and 161 had a COS score between 1- 3 (poor prognosis). The analysis showed that age, etiology, surgical methods, hypertension, intraoperative cardiovascular events and blood transfusion, and postoperative fever were significantly correlated to the outcomes (Table 1). All preoperative assessments such as GCS score, anesthesia class, APACHE II score and surgical method and class were also significantly related to the outcomes (Table 1).

Multivariate regression analysis

To further screen the factors affecting the prognosis, binary logistic regression analysis was conducted. The results showed that three preoperative assessments, including anesthesia class, APACHE II and ASA score, were significantly independent risk factors. The odds ratios (OR) of the three factors were 3.933, 1.812 and 2.910, respectively (Table 2).

Discussion

Assessment of anesthesia and surgical risks, which are also closely related to prognosis, are important for patients undergoing surgery. Currently, GCS score is commonly used to predict the prognosis in neurosurgery [4]. A study with 27625 cases of craniofacial trauma indicated that when the three elements in the GCS scoring system is analyzed separately, they could serve as independent predictors for the prognosis, when the three components are evaluated together, they could predict the mortality of these patients [5]. For patients with severe craniocerebral trauma, factors such as preoperative GCS score, age and body temperature are found to be significant predictors for prognosis [6]. Analysis on 305 cases of severe craniocerebral trauma patients with GCS scores of ≤ 8 showed that when the patient's age is less than 50 years, GCS is high and ICP < 20 mmHg, the mortality is low and the prognosis is relatively good [7]. In this study, although the GCS score is found to be correlated to prognosis, it is not an independent risk factor affecting prognosis.

Currently, ASA and APACHEE II scores are widely used criteria for assessing patients' general conditions. ASA class is mainly used to assess the anesthesia risks in perioperative periods. In addition, ASA class is also shown be able to predict prognosis after surgery [8, 9]; the correlation analysis in 6301 patients between ASA class and prognosis showed that ASA class predicts prognosis [10]. For example, for 22600

patients undergoing total hip arthroplasty and 18434 patients with knee arthroplasty in New Zealand between 2005 and 2008, ASA class can be used to predict postoperative mortality and functional status, as well as the early failure rate of surgery [11]. However, for neurosurgery, whether ASA class predicts prognosis is still debating [12]. This may be due to the fact that ASA classification is relatively subjective, and is, therefore, dependent on the training and experience of physicians [13]. In addition, regional and professional variations in ASA classification are also evident [14–16]. Therefore, more objective, reliable and consistent assessments with clinical operability are very desirable [17].

APACHE II scoring system is one of the widely used assessments for severe illness in ICU [18]. Raj et al. found that it can predict 6 month-mortality well but not prognosis for ICU patients with severe craniocerebral trauma [19]. In another study, APACHE II score at discharge was found to be able to predict the readmission to neurosurgery ICU, when the score is > 8.5, the patients may be suggested to extend ICU stay to reduce the readmission risk [15]. Compared with GCS score, APACHE II score was found to have better sensitivity and specificity in predicting the mortality of patients with brain traumatic injury [16] and if APACHE II score is ≥ 15, it predicts poor prognosis and low mortality [20]. These studies confirm that APACHE II score is reliable for predicting mortality. However, the predictability was believed to be due to the use of the worst value of several physiological variables in the first 24 hours in ICU. Any score that uses data collected over 24 hours is affected by the quality of care provided [21, 22]. Our results also indicate that APACHE II score is significantly related to the outcome, but the OR is low as pointed out previously [23].

Anesthesia class used in the study is based on combined assessment of preoperative conditions including ASA class and other patient's information such as age and the score was shown to have significantly value in predicting perioperative mortality [24]. Binary logistic regression analysis showed that anesthesia class has an OR of 3.933, which is higher than these of ASA score and APACHE II class.

Although the study generates useful information regarding prognosis prediction for neurosurgery, it still has some limitations. As a single center study, the number of samples are relatively small and the causes of diseases are few. Variables were not fully included into to analysis due to data availability. Multi-center studies with larger sample size and more indices are needed to further validate our findings.

Conclusion

Our works indicate that the outcomes of neurosurgery are affected by many factors; anesthesia class, APACHE II score and ASA class have significant prognostic values for patients undergoing neurosurgical surgery.

Declarations

- Ethics approval and consent to participate: The study was approved by the Research Ethic Committee of China Three Gorges University and written informed consent was obtained from every

participants in the study.

- Consent for publication: Written obtained from every participants in the study.
- Availability of data and material: The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.
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Abbreviations

GCS: the Glasgow coma scale

GOS: the Glasgow outcome scale

APACHE: Acute physiology and chronic health evaluation

ASA: American Society of Anesthesiologists

KPS: the Karnofsky performance score

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Tables

Table 1. Univariate analysis of factors related to prognosis of patients

Variable	GOS score 4-5	GOS score 1-3	χ^2	*P*
Gender				
Male	316/400 (79.0)	84/400 (21.0)	1.477	0.914
Female	280/357 (78.4)	77/357 (21.6)		
Age (year)				
≤18	69/92 (75.0)	23/92 (25.0)	21.331	0.003
18-30	64/69 (92.7)	5/69 (7.3)		
30-40	94/104 (90.4)	10/104 (9.6)		
40-50	145/175 (82.9)	30/175 (17.1)		
50-60	138/167 (82.8)	29/167 (17.2)		
60-70	88/128 (68.9)	40/128 (31.1)		
70-80	14/22 (64.1)	8/22(35.9)		
>80	0/1 (0.0)	1/1(100.0)		
Etiology				
Brain traumatic injury	13/36 (35.8)	23/36 (64.2)	31.856	0.000
Intracranial tumor	417/456 (91.4)	39/456 (8.6)		
Intracranial aneurysms and arteriovenous malformation	61/109 (55.9)	48/109 (44.1)		
Hydrocephalus	30/47 (64.2)	17/47 (35.8)		
Intracranial hematoma	41/55 (75.0)	14/55 (25.1)		
Others	44/54 (81.7)	10/54 (18.3)		
Surgical operation				

Emergency		95/187 (50.8)	92/187 (49.2)	12.874	0.000
Elective		503/570 (88.3)	67/570 (11.7)		
	Hypertension				
	No	551/633 (87.0)	82/633 (13.0)	18.821	0.000
	Yes	503/570 (88.3)	67/570 (11.7)		
	GCSscore				
	3-8	7/39 (17.7)	31/39 (82.3)	22.287	0.000
	9-12	24/54 (44.4)	30/54 (55.6)		
	13-15	533/664 (80.3)	131/664 (19.7)		
	Anesthesia class				
	I	1/1 (100.0)	0/1 (0.0)	27.142	0.000
	II	26/27 (96.0)	1/27 (4.0)		
	III	343/355 (96.6)	12/355 (3.4)		
	IV	221/374 (59.1)	153/374 (40.9)		
	ASA class				
	I	6/6 (100.0)	0/6 (0.0)	21.314	0.000
	II	210/219 (95.9	9/219 (4.1)		
	III	290/336 (86.5)	45/336 (13.5)		
	IV	99/196 (50.4)	97/196 (49.8)		
	APACHE II score				
	0	199/226 (88.0	27/226 (12.0)	21.589	0.000
	1-10	382/499	117/499		

	(75.5)	(23.5)		
>10	2/32 (6.3)	30/32 (93.7)		
Operation time (h)				
<4	221/271 (81.5)	50/271 (18.5)	1.427	0.676
4-8	339/418 (81.1)	79/418 (18.9)		
>8	60/68 (88.3)	8/68 (11.7)		
Surgical class				
I	46/57 (80.7)	11/57 (19.3)	22.381	0.000
II	86/112 (76.8)	26/112 (23.2)		
III	293/352 (83.2)	59/352 (16.8)		
IV	183/236 (77.5)	53/236 (22.5)		
Intraoperative cardiovascular event				
Yes	96/132 (72.8)	36/132 (27.2)	4.249	0.025
No	550/625 (88.0)	75/625 (12.0)		
Intraoperative blood transfusion				
Yes	203/270 (75.2)	67/270 (24.8)	3.623	0.045
No	403/487 (82.8)	84/487 (17.2)		
Postoperative fever				
Yes	109/180 (60.7)	71/189 (39.3)	17.616	0.000
No	507/577 (87.9)	70/577 (12.1)		

Table 2. Multivariate analysis of factors related to prognosis of patients

Variable	*b*	S_b	Wald χ^2	*P*	OR	95% CI limit	
						Low	Upper
Anesthesia class	1.104	0.322	9.022	0.004	3.933	1.456	7.896
APACHE II score	0.176	0.040	15.218	0.000	1.812	1.249	3.178
ASA class	0.847	0.128	9.083	0.004	2.910	1.823	3.984