COMPARISON OF BIS VALUE PARAMETERS MAX, MIN AND MEAN IN EVALUATING THE PROGNOSIS OF PATIENTS WITH ACUTE CEREBRAL HEMORRHAGE

Lei Lu[1,#], Pengling Xu[2,#], Qun Liu[3,*]
[1]Department of Emergency, The Second Affiliated Hospital of Jiaxing University, Jiaxing, PR China - [2]Department of Rehabilitation Medicine, The Affiliated Huai'an Hospital of Xuzhou Medical University and The Second People's Hospital of Huai'an, Huai'an, PR China - [3]Department of Neurology, Lianshui County People's Hospital, Huai'an, PR China
[#]*These authors contributed equally to this work as co-first authors*

ABSTRACT

Objective: *The BIS value parameters, max, min, and mean, were analyzed to evaluate their prognostic value for patients with acute cerebral hemorrhage.*

Method: *78 patients with acute cerebral hemorrhage were randomly selected from those who had been admitted to our hospital between October 2017 and July 2019. According to the prognosis of patients, they were divided into a good-prognosis group and a poor-prognosis group. Each patient's invasive arterial pressure was monitored and recorded. The pupils' light reflection and the Glasgow prognostic score (GPS) were employed. Then, the skin of a patient's forehead was wiped with alcohol and dried, before an electrode pad was attached on the surgical site. The patient was continuously monitored for 12h for the maximum BIS value (BIS value$_{max}$) and monitored every 1h for the minimum BIS value (BIS value$_{min}$); finally, the average BIS value was calculated (BIS value mean). The ROC curve and the Youden index were applied to compare the BIS parameters, max, min, and mean. The Glasgow prognostic scores (GPSs), changes in the calcium ion-binding protein 100 (S100 protein), and neuron-specific enolase (NSE) levels were analyzed.*

Results: *The GPSs of the good-prognosis group were significantly higher than those of the poor-prognosis group, and the difference was statistically significant ($p<0.05$). The expressions of serum indexes for S100 and NSE were significantly lower than those for the poor-prognosis group, and that difference was also statistically significant ($p<0.05$). The pupil reflectance, BIS value$_{max}$, BIS value$_{min}$, and BIS value mean results for the good-prognosis group were significantly higher than those for the poor-prognosis group, and the difference was statistically significant ($p<0.05$). The areas under the ROC curve were (95% CI: 0.845-0.957), (95% CI: 0.768-0.903), and (95% CI: 0.811-0.945); see Figure 1. The BIS value$_{max}$ for sensitivity and specificity were 82.30% and 84.70%, BIS value$_{min}$ for sensitivity and specificity were 84.5% and 70.20%, and the BIS value$_{mean}$ for sensitivity and specificity were 90.50% and 75.60%, respectively. These results demonstrate that the BIS value max plays the greatest role in evaluating the prognosis of patients with acute cerebral hemorrhage.*

Conclusion: *The BIS value can objectively and directly reflect the degree of cerebral oxygen consumption, thereby indicating the degree of a cerebral hemorrhage, in patients with acute cerebral hemorrhage. The method of investigation is simple and convenient, and extremely important for evaluating the prognosis of patients with cerebral hemorrhage. Among the three values, the BIS value max is the most accurate in evaluating the prognosis of patients with acute cerebral hemorrhage.*

Keywords: *Acute cerebral hemorrhage, BIS value$_{max}$, BIS value$_{min}$, BIS value$_{mean}$, prognostic value.*

DOI: 10.19193/0393-6384_2021_5_442

Received *March 15, 2020;* ***Accepted*** *October 20, 2020*

Introduction

Acute cerebral hemorrhage refers to bleeding caused by a rupture of the blood vessels in the non-traumatic brain parenchyma, which is acute and creates severe clinical neurological damage(1). Middle-aged and elderly patients are susceptible, mostly those who are male. The clinical symptoms reach a peak within a few minutes to several hours after the onset(2). Symptoms can include a severe headache, nausea and vomiting, a marked rise in blood pressure, movement and language disorders, drowsiness or a coma, and hemiplegia(3). Most patients' acute cerebral hemorrhages are caused by a rupturing of blood vessels due to arteriosclerosis or hypertension(4). Acute cerebral hemorrhage accounts for 20% to 30% of all strokes and the mortality rate for an acute attack is 30% to 40%, with higher morbidity and mortality[5]. The Bispectral Index (BIS) refers to the use of dual-frequency analysis methods to standardize and digitize the frequency and power of an EEG into a simple digital signal, which can judge the level of sedation, detect the depth of anesthesia, and evaluate a patient's state of consciousness[6].

In China, the incidence of acute cerebral hemorrhage is higher than in other countries, but there is still no effective method to treat it[7]. Therefore, there is an urgent need to explore the value of BIS in judging and evaluating the prognosis of patients with acute cerebral hemorrhages, if we are to control the risk factors that cause cerebral hemorrhage, engage in primary prevention, and improve the prognosis.

Materials and methods

General information

The researchers randomly selected 78 patients with acute cerebral hemorrhages; of these, there were 40 males and 38 females, all of whom had been admitted to the ICU in our hospital between October 2017 and July 2019.

The inclusion criteria for this study were as follows:

- Patients needed to be 45-65 years old;
- Spontaneous intracerebral hemorrhage must have occurred for the first time, ruling out patients with a recurrent or traumatic cerebral hemorrhage;
- All patients were required to have been diagnosed with cerebral hemorrhage by cranial CT;
- All must have been admitted to hospital within 24 hours after its onset;
- The family of the patient was required to sign with their informed consent;
- Their inclusion in the study must have been approved by the hospital ethics committee.

According to the prognosis of patients, the patients were divided into a good-prognosis group and a poor-prognosis group. Among the total number of patients, 48 cases were in the good-prognosis group. Of these, 25 cases were male, and 23 cases were female. Their average age was 46.78 (±18.73) years old and their body mass index (BMI) was 22.50 (±2.10) kg/m^2. There were 30 patients, meanwhile, in the poor-prognosis group.

Of these, there were 15 males and 15 females, with an average age of 47.01 (±18.45) and a BMI of 22.52 (±2.12) kg/m^2. In terms of general information, the two groups of patients were $p<0.05$. These results are shown in Table 1.

Group	Gender (Male/Female)	Age (Year)	BMI (kg/m^2)
Good-prognosis group	25/23	46.78±18.73	22.50±2.10
Poor-prognosis group	15/15	47.01±18.45	22.52±2.12
χ^2	0.032	0.531	0.041
P	0.858	0.958	0.968

Table 1: Comparison of general information between the two groups.

Method

After admission, patients in both groups underwent routine tests such as an electrocardiogram, blood routine, blood pressure, urine routine, and blood oxygen saturation, to provide nutritional support. The BIS test was then performed; after venous access was opened, the patient underwent radial artery catheterization. The patient's invasive arterial pressure was then monitored, and the patient's pupil light reflection was recorded.

After this, the skin of the patient's forehead was wiped with alcohol and dried, before electrode pads were applied to the forehead on the surgical site. The patient was continuously monitored for 12h for the maximum BIS value (BIS value$_{max}$) and monitored every 1h for the minimum BIS value (BIS value$_{min}$); finally, the average BIS value was calculated (BIS value$_{mean}$).

Observation index

- Each patient's Glasgow prognostic score (GPS), changes in the calcium ion-binding protein 100 (S100 protein), and neuron-specific enolase (NSE) levels, were analyzed. The GPS includes three criteria: open-eye response, motor response, and language response. The highest score is 15 points and the lowest score is 3 points; >14 points is considered to be normal, <8 points indicates a coma, and >3 points indicate brain death (i.e., a poor
- The ROC curve and the Youden index were employed to compare the BIS parameters, max, min, and mean.
- The changes in pupil reflectance, BIS value max, BIS value min, and BIS value mean levels were analyzed for the two groups of patients.

Statistical analyses

The SPSS 13.0 software was then utilized for the analysis of the data. Measurement data was used ($\bar{x}\pm s$), t test was used. The area under the ROC curve was calculated, and the best cutoff value was found to be the Youden index. The difference of p<0.05 was found to be statistically significant.

Results

Comparison of GPS, S100 protein levels, and NSE levels between the two patient groups

The results demonstrated that the GPS for the good-prognosis group was significantly higher than that for the poor-prognosis group, and the difference was statistically significant (p<0.05).

The expression of serum indicators for the S100 and NSE levels was significantly lower than that for the poor-prognosis group, and the difference was also statistically significant (p<0.05). These results are shown in Tables 2 and 3.

Group	n	GPS (Point)	S100 (μg)	NSE (μg)
Good-prognosis group	48	9.40±4.40	2.29±1.68	49.94±53.83
Poor-prognosis group	30	4.20±3.30*	8.65±10.50*	121.85±108.11*
t		5.564	4.128	3.803
P		<0.001	<0.001	0.003

Table 2: Comparison of GPS, S100 protein levels, and NSE levels for the two groups of patients.
**P<0.05, compared with the good-prognosis group.*

Group	Pupil light reflectance	BIS $value_{max}$	BIS $value_{min}$	BIS $value_{mean}$
Good-prognosis group	90	89.03±11.98	73.04±21.82	81.93±15.46
Poor-prognosis group	44	61.43±17.52*	43.52±15.76*	52.36±16.53*
t		6.216	6.425	8.002
P		<0.001	<0.001	<0.001

Table 3: Comparison of BIS $value_{max}$, BIS $value_{min}$, and BIS $value_{mean}$ between the two groups
**P<0.05, compared with the good-prognosis group.*

Comparison of pupils' light reflectance, BIS $value_{max}$, BIS $value_{min}$, and BIS $value_{mean}$

The results for pupils' light reflectance, BIS $value_{max}$, BIS $value_{min}$, and BIS_{value} mean for the good-prognosis group were significantly higher than those for the poor-prognosis group, and the difference was statistically significant (p<0.05). These results are shown in Table 4.

Comparison of the prognostic value of BIS $value_{max}$, BIS $value_{min}$, and BIS $value_{mean}$ between two groups of patients with acute cerebral hemorrhages

The BIS $value_{max}$, BIS $value_{min}$, and BIS $value_{mean}$ indicators were utilized to evaluate patients with acute cerebral hemorrhages. The area under the ROC curve was (95% CI: 0.845 - 0.957), (95% CI: 0.768 - 0.903), and (95% CI: 0.811 - 0.945).

The BIS $value_{max}$ sensitivity and specificity levels were 82.30% and 84.70%, the BIS $value_{min}$ sensitivity and specificity levels were 84.5% and 70.20%, and the BIS $value_{mean}$ sensitivity and specificity levels were 90.50% and 75.60%, respectively. These results demonstrated that the BIS value max played the greatest role in evaluating the prognosis of patients with acute cerebral hemorrhages.

Index	95% CI	Sensitivity (%)	Specificity (%)	*P*
BIS $value_{max}$	0.845~0.957	82.30%	84.70%	0.000
BIS $value_{min}$	0.768~0.903	84.50%	70.20%	0.000
BIS $value_{mean}$	0.811~0.945	90.50%	75.60%	0.000

Table 4: Comparison of the prognostic value for the two groups of patients of BIS $value_{max}$, BIS $value_{min}$, and BIS $value_{mean}$ in the diagnosis of patients with acute cerebral hemorrhage.

Comparison of the prognostic value of BIS $value_{max}$, BIS $value_{min}$, and BIS $value_{mean}$ between two groups of patients with acute cerebral hemorrhages

The BIS $value_{max}$, BIS $value_{min}$, and BIS $value_{mean}$ indicators were utilized to evaluate patients with acute cerebral hemorrhages. The area under the ROC curve was (95% CI: 0.845 - 0.957), (95% CI: 0.768 - 0.903), and (95% CI: 0.811 - 0.945).

The BIS $value_{max}$ sensitivity and specificity levels were 82.30% and 84.70%, the BIS $value_{min}$ sensitivity and specificity levels were 84.5% and 70.20%, and the BIS $value_{mean}$ sensitivity and specificity levels were 90.50% and 75.60%, respectively. These results demonstrated that the BIS $value_{max}$ played the greatest role in evaluating the prognosis of patients with acute cerebral hemorrhages.

Discussion

The mortality and morbidity rates of acute cerebral hemorrhage are relatively high, mainly relating to cerebrovascular disease, and survivors of the condition leave hospital capable of different degrees of exercise, with speech and cognitive impairment of varying severity. Acute cerebral hemorrhage is the condition with the highest mortality rate in China[8]. It is necessary to evaluate the prognosis of patients with acute cerebral hemorrhage as early as possible, to reduce the patient's pain and improve their prognosis.

However, there is a lack of safe and reliable methods for monitoring the condition in clinical practice. BIS is a method of EEG signal analysis that is different from EEG or brainstem auditory-evoked potential. It combines the features of frequency, power, spectrum, and position from an EEG; therefore, it is closely related to the EEG[9]. It is essential to be able to reflect cerebral cortical function and cerebral perfusion to monitor brain metabolism, evaluate the prognosis of a cerebral hemorrhage, judge the depth of sedation, and adjust the treatment plan. EEG is currently a more accurate method for evaluating the mental consciousness of patients with cerebral hemorrhages[10].

The main principle of BIS is the analysis of the bispectrum and energy spectrum parameters of an EGG through a Fourier transform, converting the time–amplitude relationship into frequency–power relationship, selecting the EEG signals that represent different sedation levels, standardizing and digitizing them, and finally converting them into a simple quantitative indicator[11].

The GPS is the score for the coma index, based upon indicators such as eye-opening response, language response, and limb movement. The sum of the three is an evaluation of the degree of coma in a patient[12]. The lower the GPS, the greater the degree of coma in the patient[13]. However, as it comes under the influence of some human judgment factors, the GPS is not objective and reliable. In this study, the GPS of the good-prognosis group was significantly higher than that for the poor-prognosis group, and the difference was statistically significant ($p<0.05$). The expression of the serum indicators for S100 and NSE levels was significantly lower than that for the poor-prognosis group, and the difference was again statistically significant ($p<0.05$). When the expression of serum indicators for S100 and NSE levels increased, the GPS and the BIS value decreased; thus, they were negatively correlated. This indicates that the lower the BIS value in patients with cerebral hemorrhage, the more serious the degree of cerebral hemorrhage; the higher the expression of S100 and NSE levels, the more prognosis difference. A BIS value of 100 represents an awake state, 65-85 represents a state of sedation, 40-65 represents an anesthetized state, below 40 may be explosive, and 0 represents a complete absence of brain electrical activity (cortical inhibition)[14].

The change in BIS value can reflect the cerebral oxygen consumption and the degree of injury in patients with acute cerebral hemorrhage. We can assess whether the consciousness of cerebral hemorrhage patients has recovered as the higher the BIS value, the more conscious the patient is. When the BIS value is ≥65, the patient has a good prognosis[15]. In this study, the BIS value max, BIS value min, and BIS value mean values for the good-prognosis group were significantly higher than those for the poor-prognosis group, and the difference was statistically significant ($p<0.05$). This shows that the BIS value can objectively and accurately reflect the sedation depth and anesthetic status of patients with acute cerebral hemorrhage.

In this study, the BIS value max, BIS value min, and BIS value mean values have been taken as the ordinate, and the prognosis has been taken as the abscissa, to make the ROC curve chart. On this chart, the area under the curve of the BIS value max, BIS value min, and BIS value mean is (95% CI : 0.845 - 0.957), (95% CI: 0.768 - 0.903), and (95% CI: 0.811 - 0.945). The BIS value max sensitivity and specificity levels are 82.30% and 84.70%, the BIS value min sensitivity and specificity levels are 84.5% and 70.20%, and the BIS value mean sensitivity and specificity levels are 90.50% and 75.60%, respectively. This result shows that all three indicators can be employed to evaluate the prognosis of patients with acute cerebral hemorrhages, but—with a positive rate of 84.70%-the accuracy of BIS value max for evaluating the prognosis of patients with acute cerebral hemorrhage is the highest.

In conclusion, the BIS value can objectively and directly reflect the degree of cerebral oxygen consumption in patients with acute cerebral hemorrhage, thereby indicating the degree of a cerebral hemorrhage. The operation is simple and convenient, and it is extremely important for use in evaluating the prognosis of patients with cerebral hemorrhages. Among the indicators, the BIS value max is the most accurate for assessing the prognosis of patients with acute cerebral hemorrhages. The BIS value max is an important diagnostic method that should be employed to improve the prognosis of patients with acute cerebral hemorrhages and reduce their pain; the method is worthy of clinical promotion.

References

1) Gopal M, Gupta K, Preet Singh A, Salunke P. 65-year-old with acute cerebral hemorrhage. Brain Pathol 2020; 30: 429-430.
2) Tan J. Effect of pre-hospital emergency nursing on prognosis of acute cerebral hemorrhage patients. Smart Healthcare 2019; 5: 24.
3) Lattanzi S, Cagnetti C, Provinciali L, Silvestrini M. Neutrophil-to-lymphocyte ratio and neurological deterioration following acute cerebral hemorrhage. Oncotarget 2017; 8: 57489-57494.
4) Chen C, Yu YH, Li Q. The accuracy of predicting the prognosis of patients with acute cerebral hemorrhage. Chin J Anesthesiol 2017; 37: 606.
5) Du H, Fan LD, Fan X, Liu K, Fu ZX. Clinical observation of the effect of awaking coma after hypertensive intracerebral hemorrhage perceived behavioral intervention. J Nurse Training 2018; 33: 1904-1906.
6) Zhu XP, Luo WQ, Nan F, Yang FF, Cui L. Application of blood lipid, uric acid and glucose in patients with acute cerebral hemorrhage and its prognostic value. Med J West China 2017; 29: 1406-1408.
7) Garbay G, Giraud L, Gali SM, Hadziioannou G, Grau E, et al. Divanillin-based polyazomethines: Toward biobased and metal-free π-conjugated polymers. ACS Omega 2020; 5: 5176-5181.
8) Yu M, Jia HY, Li GC. Correlative study on changes of hemorheology indexes in patients with acute cerebral hemorrhage. J Clin Neurol 2017; 30: 1-4.
9) Su L, Chang WL. Application of EEG dual-frequency index monitoring in sedation of patients after cerebral hemorrhage. Chin J Pract Nervous Dis 2015; 11: 131-132.
10) Li QH. Clinical analysis of nursing intervention EEG dual-frequency index monitoring for patients with coma after intracranial hematoma. Minim Invasive Med 2014; 9: 371-373.
11) Zhang JM, Wang F, Hong LV, Xin Z. Use of bispectral index (BIS) monitor in inspecting the depth of anesthesia in pediatric patients undergoing general anesthesia. J Capital Med Univ 2017; 31: 664-667.
12) Bateman GA, Yap SL, Subramanian GM, Bateman AR. The incidence of significant venous sinus stenosis and cerebral hyperemia in childhood hydrocephalus: prognostic value with regards to differentiating active from compensated disease. Fluids Barriers CNS 2020; 17: 33.
13) Fallenius M, Skrifvars MB, Reinikainen M, Bendel S, Raj R. Common intensive care scoring systems do not outperform age and Glasgow Coma Scale score in predicting mid-term mortality in patients with spontaneous intracerebral hemorrhage treated in the intensive care unit. Scand J Trauma Resusc Emerg Med 2017; 25: 102.
14) Tong ZR, Xv B, Yang WJ, Zhao L. Role of bispectral index monitoring in Intensive Care Unit mechanical ventilation patients: A meta-analysis. Chin J Neuromed 2018; 1137-1142.
15) Wang XX, Pan DB, Deng HW, Zhou Q. Meta-analysis of the effect of dexmedetomidine on postoperative cognitive impairment in elderly patients. Chin J Gerontol 2018; 38: 3396 3400.

Corresponding Author:
Qun Liu
Email: fqtzx8@163.com
(China)