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ORIGINAL RESEARCH

Extended Glasgow Outcome Scale correlates with bispectral index in traumatic brain injury patients who underwent craniotomy

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Background: Assessing consciousness in traumatic brain injury is important because it also determines the treatment option, which will influence patients' outcome. A tool used to objectively assess consciousness level is the bispectral index (BIS) monitor, which was originally designed to monitor the depth of anesthesia. Glasgow Outcome Scale-Extended (GOS-E) provides a measuring tool to assess traumatic brain injury (TBI) outcome. The goal of this study was to assess the correlation between GOS-E scores with BIS values in patients with TBI who underwent craniotomy.

Patients and methods: A total of 68 patients admitted to the emergency department with decreased consciousness due to TBI who underwent craniotomy were included in the study. BIS value was measured upon admission, then GOS-E score was determined 6 months after the incident took place. Spearman's correlation coefficient was used to assess the correlation between GOS-E score and BIS value.

Results: In 68 patients, the GOS-E score was found to have a strong correlation (r =0.921, p<0.01) with BIS values. From this study, the formula to estimate GOS-E score based on BIS value upon admission stands as: GOS-E =0.19 (BIS) – 8.31.

Conclusion: This study found that there is a strong correlation between GOS-E score and BIS value. These findings suggest that BIS scores upon admission may be used to predict the outcomes in patients with TBI. However, the wide distribution of BIS values for each GOS-E score may limit the use of BIS scores in accurately predicting GOS-E scores.

Keywords: decreased consciousness, head injury, outcome, prediction

Introduction

Head injury is a common case found in the emergency department (ED). In Europe, 262 cases per 100,000 persons per year were admitted due to traumatic brain injury (TBI), and it is the most common cause of death in young adults (15–24 years), with males being more commonly affected than females.[1,2] The mortality rate from head trauma in Indonesia in 2005 ranged from 6.2% to 11.2%, almost twice as high as compared to the range found in the common literature, 3% to 8%.[3]

Assessment of consciousness level is important in patients with TBI because the level of consciousness is one of the parameters used by clinicians in making decisions when determining therapy or intervention.[3,4] A tool used to assess the level of consciousness objectively is bispectral index (BIS). The BIS monitor was originally introduced as a modality for measuring patient consciousness during general anesthesia. BIS values range from 0 (isoelectric signals) to 100 (conscious patients). Currently,

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BIS monitors are also being used for other purposes, from assessing consciousness level in TBI to monitoring sedation effects in intensive care unit.[3–5]

Senapathi et al[6] found that in patients with TBI, BIS value upon ED admission is significantly correlated (r =0.744, P<0.01) with Glasgow Coma Scale (GCS) score. Patients with TBI often suffer from disability and even death, so it is necessary to assess the prognosis of TBI patients treated in the hospital. The outcome of head injury is dependent to correct choice of treatment performed upon admission. One most common treatment is craniotomy to remove a clot bleeding occurring within the brain.

Glasgow Outcome Scale (GOS) was developed to allocate people who have suffered acute brain damage from head injury or nontraumatic brain insults based on broad outcome. Its revision, the GOS-extended (GOS-E), was proposed by Jennett et al in 1981 and is the gold standard for measuring TBI outcome of adults in clinical trials.[7] Assessments using GOS-E are usually performed 6 months after the trauma took place. It reflects disability and handicap rather than impairment.

The goal of this study was to assess the correlation between BIS value and GOS-E score in patients with TBI who underwent craniotomy in Sanglah General Hospital of Denpasar.

Patients and methods

This study was approved by the Research Ethics Committee of Sanglah General Hospital and Udayana University. All patients or their guardians provided written informed consent to be included in this study. Patients aged from 16 to 65 years old with TBI who were admitted to ED, scheduled for craniotomy, and met eligibility criteria were enrolled in the study. The exclusion criteria included patients with mental, neurological, motor, hearing, or speech disturbance prior to ED admission.

BI recordings were done upon admission at the emergency unit of Sanglah Hospital, and the study was conducted from September to October 2016. House visit to evaluate GOS-E was conducted from March to April 2017 by 1 researcher only to avoid interobserver variability.

Kolmogorov–Smirnov test was used to see if the data were normally distributed. To assess the correlation between BIS and GOS-E scores, because both variables were not normally distributed, the Spearman's rank correlation test was used. Correlation is considered statistically significant if the p-value was <0.05.

Results

A total of 68 subjects were included in data analysis. The study population consisted of 56 males (82.4%) and 12 females (17.6%). The proportion of patients with GCS 14 (mild head injury), 9–13 (moderate head injury), and 3–8 (severe head injury) were 19 (27.9%), 24 (35.3%), and 25 (36.8%), respectively. Subject characteristics are shown in Table 1.

Table 2 shows the median values (interquartile range) of the observed GOS-E and BIS values were 6.0 (7) and 69.5 (27), respectively, with correlation coefficient (r) 0.921 (p<0.01). This indicates a strong positive correlation between GOS-E and BIS value. The scatter plot of the correlation is shown in Figure 1.

After obtaining strong positive correlation between GOS-E and BIS score, we proceeded with linear regression analysis (Table 3) to see if we can estimate GOS-E score at a certain BIS value. These researchers created an equation to estimate GOS-E score based on BIS value upon admission. The equation is as follows: GOS-E =0.19 (BIS) – 8.3.

Discussion

Since its introduction in clinical practice, BIS has been widely used in the operating room and intensive care unit settings. However, the ability of BIS to provide clinical insight in the absence of hypnotic drugs has not been extensively studied.

Table 1 Subject characteristics

Characteristics	Value
Age (years), median (IQR)	24 (22)
Sex, n (%)	
Male	56 (82.4)
Female	12 (17.6)
The degree of head injury, n (%)	
Mild head injury	19 (27.9)
Moderate head injury	24 (35.3)
Severe head injury	25 (36.8)
The nature of head injury, n (%)	
Epidural hematoma	13 (19.1)
Subdural hematoma	10 (14.7)
Intracerebral hematoma	22 (32.4)
Combinations	23 (33.8)
Comorbid disease upon admission, n (%)	
Without comorbid disease	57 (83.8)
Diabetes mellitus	2 (2.9)
Hypertension	4 (5.9)
Diabetes and hypertension	5 (7.4)

Abbreviation: IQR, interquartile range.

Table 2 Spearman's correlation analysis between BIS numbers and GCS score

Variables	Median (IQR)	*r*	*P*-value
GOS-E score	6.0 (7)	0.921	<0.01
BIS numbers	69.5 (27)		

Abbreviations: BIS, bispectral index; GCS, Glasgow Coma Scale; GOS-E, Glasgow Outcome Scale-Extended; IQR, interquartile range.

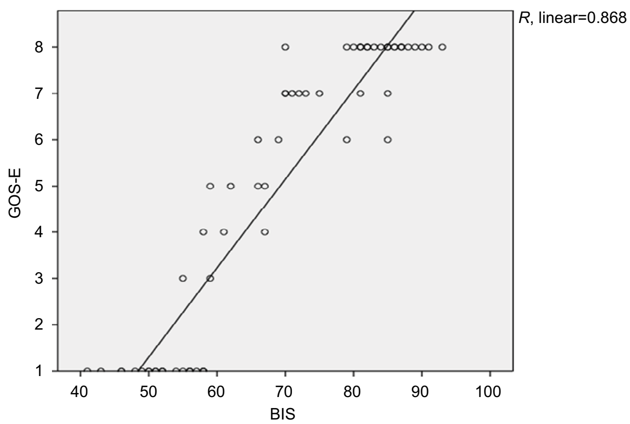

Figure 1 Scatter plot distribution between GOS-E and BIS.
Abbreviations: BIS, bispectral index; GOS-E, Glasgow Outcome Scale-Extended.

Table 3 Linear regression analysis relationship between GOS-E and BIS

Variables	β	95% CI	*P*-value	R^2
BIS	0.192	0.174–0.211	<0.01	86.8%
Constant	–8.314			

Abbreviations: BIS, bispectral index; GOS-E, Glasgow Outcome Scale-Extended.

Although BIS was not designed for brain-injured patients, its availability in intensive care unit has led to many studies focusing its use in this population.[8]

The BIS monitor is the first tool capable of providing a quantitative electroencephalogram (EEG) picture. The BIS monitor is able to integrate multiple subparameters of the EEG into a single variable. Figures appearing on BIS monitors are obtained by utilizing a mixture of various EEG signal processing techniques including bispectral analysis, spectral power analysis, and time domain analysis.[9]

GOS was first introduced by Jennett and Bond in 1975 to encompass areas of major life functions, with a categorical scale 1 to 5 used to characterize overall disability after TBI. GOS-E, with a categorical rating from 1 to 8, improves the lack of sensitivity from GOS to specific deficits within the category.[7] The use of a structured interview is recommended to facilitate consistency in GOS-E scores. A known bias in GOS-E assessment is the interrater variability score, which is why we assigned 1 trained person to make house visits and assess the GOS-E score of our subjects.

This study was designed to determine the correlation between BIS and GOS-E. In this study, we found the correlation between BIS value upon ED admission and GOS-E in patients with TBI was very strong (r =0.921, p<0.01).

The GOS-E is one established functional outcome scale to assess disability following TBI. Some variables affecting TBI outcome are severity of injury, female gender, older age, and comorbidity, and these should be considered in long-term follow-up and intervention programs. Age is associated with brain auto-regulation, and so old age may lead to a decline in organ functions, including brain perfusion.[10,11]

Comorbid diseases are also said to affect the outcome in patients undergoing surgery. Hypertension and diabetes mellitus contribute significantly to poor outcomes, associated with cerebral perfusion pressure.[12,13] In patients with hypertension and diabetes mellitus, brain perfusion pressure decreases due to various pathophysiologies. Increased systemic vascular resistance and mean arterial blood pressure and occurrence of microangiopathy in diabetes disrupt the wound healing process. In this study, age, hypertension history, and diabetes history each had no correlation (p>0.01) to the GOS-E score, with p-values for age and comorbidities being 0.481 and 0.123, respectively.

Craniotomy is expected to provide better outcomes in patients suffering from TBI with surgical findings on a computed tomography scan. It is the lowering of the pressure inside the skull via blood clotting removal which will improve the brain perfusion, thus improving the outcome. This is an emergency surgery that must be done soon; the sooner the surgery is performed the better the outcome, because herniation and ischemic events of the brain can be avoided or minimized. Surgical complications, like bleeding, are sometimes unavoidable. These decrease brain perfusion, resulting in poor patient outcome.

Limitations

The limitations of this study are design related. Compared with other analytic design studies, cross-sectional study designs are considered to be less accurate in describing disease progression processes, and have weaker predictive and correlative analysis capabilities compared with cohort designs. Other known variables of TBI outcome, such as initial GCS upon admission, pupil condition, and specific computed tomography findings were not adjusted in data analysis; therefore, we cannot conclude that BIS is superior to predict TBI outcome compared to those variables.

Conclusion

There is a strong positive correlation between GOS-E score and BIS value in patients with decreased consciousness due to TBI who underwent craniotomy with correlation coefficient value (r) 0.921 and p-value <0.01. An equation to predict GOS-E from BIS value derived from the linear regression analysis in this study, and this is GOS-E =0.19(BIS) – 8.3.

Disclosure

The authors report no conflicts of interest in this work.

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