Journal of Experimental and Clinical Medicine
https://dergipark.org.tr/omujecm

Research Article

J Exp Clin Med
2021; 38(4): 440-444
doi:10.52142/omujecm.38.4.7

Relationship between the national institutes health stroke scale score and bispectral index in patients with acute ischemic stroke

Serdar ÖZDEMİR[1,*], Tuba CİMİLLİ ÖZTÜRK[2], Özge ECMEL ONUR[3]

[1]Department of Emergency Medicine, University of Health Sciences Ümraniye Training and Research Hospital, Istanbul, Turkey

[2]Department of Emergency Medicine, University of Health Sciences Fatih Sultan Mehmet Training and Research Hospital, Istanbul, Turkey

[3]Department of Emergency Medicine, Marmara University, Istanbul, Turkey

Received: 16.02.2021 • **Accepted/PublishedOnline:** 24.02.2021 • **Final Version:** 30.08.2021

Abstract

This study aimed to investigate the relationship between the bispectral index and the National Institutes of Health Stroke Scale (NIHSS) score in patients admitted to the emergency department with a first-time acute ischemic stroke. Methods: This prospective, observational study was conducted with patients admitted to our clinic with acute ischemic stroke symptoms. Patients with known cranial pathologies, such as space-occupying lesions, those with a history of clinically significant cerebrovascular events or sedative drug administration, and those with altered consciousness due to metabolic causes were excluded from the study. The National Institutes Health Stroke Scale scores were recorded by the clinician. Cerebral arterial territories were assessed on DWI and CT. The relationship between the NIHSS score and bispectral index was evaluated. Results: Forty-three patients were included in the study. The mean bispectral index of the cases was 84.23 ± 9.50. There was no significant correlation between the bispectral index values and the NIHSS score ($p<0.05$). Conclusion: In our study, the bispectral index values were decreased due to ischemic stroke. The results should be reevaluated studies conducted with larger series to reveal the relationship between infarcted territories, NIHSS score, bispectral index, and the GCS score.

Keywords: consciousness, consciousness monitors, ischemic stroke, physical examination, stroke

1. Introduction

Stroke refers to a sudden onset of focal neurological syndrome due to cerebrovascular disease. The World Health Organization defines stroke as rapidly developed clinical signs of focal or global disturbance of cerebral function, lasting more than 24 hours or leading to death, with no apparent cause other than of vascular origin (1).

The National Institutes Health Stroke Scale (NIHHS) is an instrument that examines neurological functions and offers an idea about the long-term prognosis in patients that have had an ischemic stroke (2). In this patient group, there are also scales for a clinical evaluation, such as the Glasgow Coma Scale (GCS) and electronic devices for monitoring consciousness, such as the bispectral Index (3). The bispectral index equipment is based on an algorithm incorporating the Fourier analysis that compiles the pattern of electrical activity in the frontal region. It also shows the electroencephalography (EEG) line, suppression rate, and electromyographic response. It measures cortical inputs and guides anesthetic depth control since it is expected to show lower cortical activation in stroke patients. Furthermore, BIS values can be indirectly altered through cerebral hypoperfusion (4).

This study investigated the relationship between the NIHSS score and bispectral index in patients admitted to the emergency department with a first-time acute ischemic stroke. We aimed to reveal the relationship between BIS and stroke as the main outcome and the relationship between BIS and infarcted territories as the secondary outcome.

2. Materials and methods

2.1. Study design

This study was conducted prospectively after receiving the approval of the ethics committee of University of Health Sciences Fatih Sultan Mehmet Training and Research Hospital. Adult patients consecutively admitted to the emergency medicine clinic of this hospital with acute ischemic stroke symptoms were evaluated prospectively according to the inclusion criteria.

2.2. Population

University of Health Sciences Fatih Sultan Mehmet Training and Research Hospital is a tertiary hospital with 140,000 emergency admissions a year. All patients who presented to our clinic with acute ischemic stroke symptoms between February 1, 2014, and June 1, 2014 were included in the study. We excluded those with known space-occupying lesions, those with a history of clinically significant

* Correspondence: dr.serdar55@hotmail.com

cerebrovascular events, sedative drug administration or a hemorrhagic stroke, and those with altered consciousness due to metabolic causes. The patients with a severe stroke (GCS eight or less) were intubated with sedative drugs in line with the rapid sequence intubation (RSI) protocol. In severe stroke cases, we did not have enough time to seek patient consent for the study and BIS monitoring before RSI; therefore, these patients were also excluded.

2.3. Data collection and measurement

From the ischemic stroke patients, the following clinical data were collected: 1) demographics and medical histories, 2) initial vital signs at the emergency department (pulse and mean arterial pressure), 3) presence of early ischemic changes (EIC) on CT, 4) laboratory findings, 5) time from the onset of symptoms to hospital care, 6) infarcted territories, and 7) bispectral index, GCS and NIHSS scores (Table 1). The GCS and NIHSS scores were recorded by the clinician. The cerebral arterial territories were assessed on DWI and CT by a neuroradiologist blinded to the clinical histories of the patients. These territories were defined as middle cerebral artery (MCA) territory, posterior cerebral artery (PCA) territory, distal branches of MCA territory, anterior cerebral artery (ACA) territory, posterior inferior cerebellar artery (PICA) territory, and multiple arterial territories. The cerebral arterial territories were grouped as MCA, distal branches of MCA and other arterial territories.

Table 1. National Institutes of Health Strokes Scale (NIHSS) scoring

1a. Level of consciousness	
Alert	0
Not alert but arousable by minor stimulation	1
Not alert but requires repeated stimulation	2
Responds only with reflex motor or unresponsive	3
1b. LOC Questions (What is the month? What is your age?)	
Answers both questions correctly	0
Answers one question correctly	1
Answers neither question correctly	2
1c. LOC Commands (open and close the eyes and then to grip and release hand)	
Performs both tasks correctly	0
Performs one task correctly	1
Performs neither task correctly	2
2. Best Gaze	
Normal	0
Partial gaze palsy	1
Forced deviation	2
3. Visual	
No visual loss	0
Partial hemianopia	1
Complete hemianopia	2
Bilateral hemianopia	3
4. Facial Palsy	
Normal symmetrical movements	0
Minor paralysis	1
Partial paralysis	2
Complete paralysis	3
5. Motor Arm (5a. Left Arm 5b. Right Arm)	
No drift	0
Drift	1
Some effort against gravity	2
No effort against gravity	3
No movement	4
6. Motor Leg (6a. Left Leg 6b. Right Leg)	
No drift	0
Drift	1
Some effort against gravity	2
No effort against gravity	3
No movement	4
7. Limb Ataxia	
Absent	0
Present in one limb	1
Present in two limbs	2
8. Sensory	
Normal; no sensory loss	0
Mild-to-moderate sensory loss	1
Severe to total sensory loss	2
9. Best Language	
No aphasia	0
Mild-to-moderate aphasia	1
Severe aphasia	2
Mute, global aphasia	3
10. Dysarthria	
Normal	0
Mild-to-moderate dysarthria	1
Severe dysarthria	2
11. Extinction and Inattention (formerly Neglect)	
No abnormality	0
Visual, tactile, auditory, spatial, or personal inattention	1
Profound hemi-inattention or extinction to more than one modality	2

Score	
0	No stroke
1-4	Minor stroke
5-15	Moderate stroke
16-20	Moderate to severe stroke
21-42	Severe stroke

Bispectral index BIS monitoring was performed with the COVIDIEN complete monitoring system (PN / 185-0151, U.S.A) with the patient in the supine position. If the patient's condition was unstable or urgent sedative medication was required, the measurement was undertaken before the administration of medication if possible. The bispectral index monitors recorded the data for 15 minutes, and the mean value was calculated.

2.4. Statistical analysis

The Shapiro-Wilk test was used to determine normality. Descriptive statistical methods (mean, standard deviation, and frequency) were used to analyze the study data. The relationship between the bispectral index and NIHSS scores was evaluated using Spearman's correlation test. For the analysis of multiple groups, one-way analysis of variance or the Kruskal-Wallis test was used depending on the normality of data. Statistical analyses were performed using SPSS v. 20.0 (SPSS Inc., Chicago, IL, USA) in Windows, and $p<0.05$ was considered statistically significant.

3. Results

A total of 96 patients with acute ischemic stroke symptoms were admitted to our clinic between February 1, 2014, and June 1, 2014. After applying the exclusion criteria, the sample consisted of 43 patients (Fig. 1). The mean age of the included patients was 72.79 ± 11.59 years. The time from the onset of symptoms to hospital care ranged from 1 to 24 hours, with a mean of 5.07 ± 3.67 hours. The initial vital signs and comorbidities of the patients are shown in Table 1, and their laboratory data in Table 2. Twenty patients (46.5%) had EIC on CT whereas 23 (53.5%) had no EIC on CT. The mean GCS scores ranged from 9 to 15 with a mean score of 14.12 ± 1.73. Bispectral index ranged from 61 to 98, with a mean of 84.23 ± 9.50, as shown in the box plot graph presented in Fig. 2. The NIHSS scores ranged from 0 to 20, and the mean was calculated as 7.86 ± 5.72. The box plot of bispectral index value for NIHSS score is shown in Fig. 3.

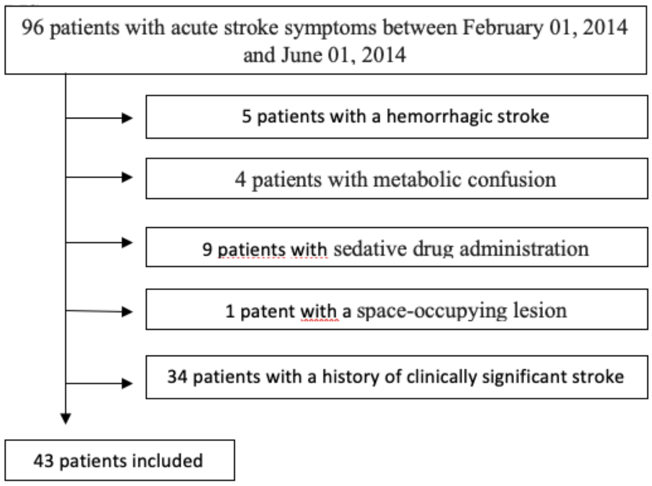

Fig.1. A flowdiagram of the study population

Table 2. Initial vital signs and comorbidities

Initialvitals	**Mean ± Standard deviation (Min-Max)**
Pulse (min)	81.40 ± 13.73 (40-112)
Mean arterial pressure	114.14 ± 17.16 (80-146.7)
Comorbidities	**n (%)**
Diabetes mellitus	17 (39.5%)
Hypertension	35 (81.4%)
Coroner artery disease	8 (18.6%)
Chronic renal failure	1 (2.3%)
Malignancy	1 (2.3%)
Atrial fibrillation	13 (30.2)
Laboratory parameters	**Mean ± Standard deviation (Min-Max)**
Leukocytes (K/uL)	9.80 ± 3.77 (4.70-21.30)
Hemoglobin (gr/dL)	13.10 ± 1.88 (7.40-16.70)
Platelets (K/uL)	247.60 ± 100.78 (141-730)
Mean platelet volume (fL)	8.14 ± 1.10 (6.6-11.8)
Troponin I (ng/ml)	0.09 ± 0.29 (0-1.74)
Glucose (mg/dL)	158.67 ± 90.91 (77-506)

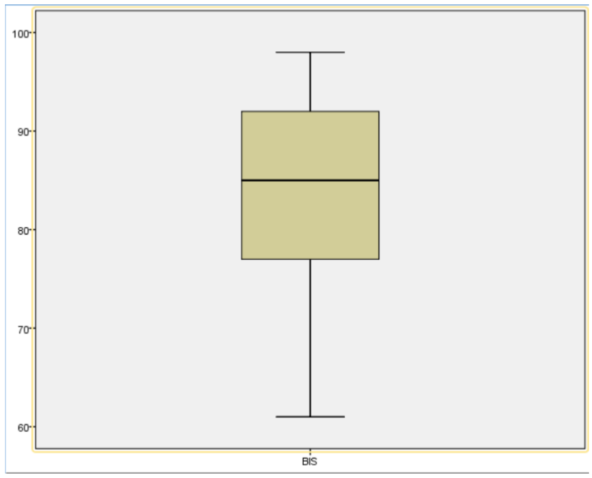

Fig. 2. The box plot of bispectral index value

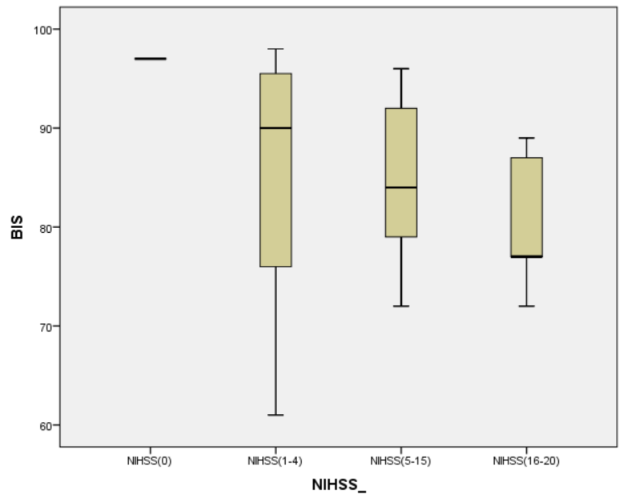

Fig. 3. The box plot of bispectral index value for NIHSS score. The NIHSS scores were categorized in 0, 1-4, 5-15, 16-20, and 21-42

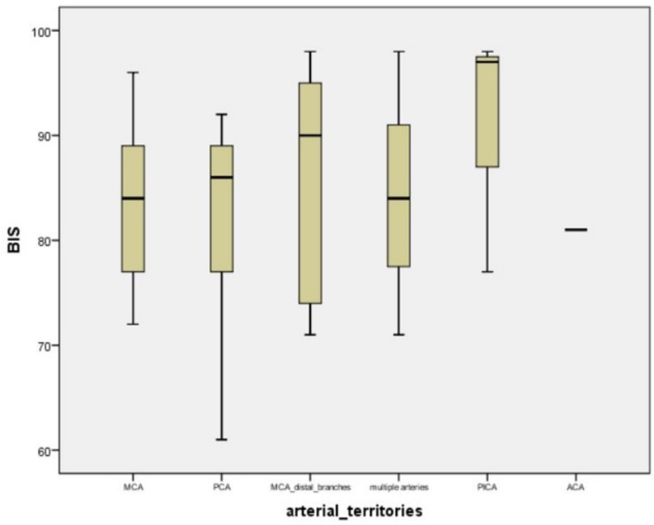

Fig.4. The box plot of bispectral index value for infarcted territories. BIS: Bispectral index; MCA: middle cerebral artery territory; PCA: posterior cerebral artery territory, MCA distal branches: distal branches of middle cerebral artery territory; multiple arteries: multiple arterial territories; PICA: posterior inferior cerebellar artery territory; ACA: anterior cerebral artery territory

The frequencies of infarcted territories were 44.2% (19 patients) for MCA territory, 11.6% (5 patients) for PCA territory, 27.9% (12 patents) for the distal branches of MCA territory, 2.3% (1 patient) for ACA territory, 7% (3 patients) for multiple arterial territories, and 7% (3 patients) for PICA territory. The box plot of bispectral index value for each territory is shown in Figure 4. There was no statistically significant relationship between the bispectral index and NIHSS scores (Spearman's correlation test, r = -0.274 p = 0.075). There was no statistically significant relationship between the grouped infarcted territories and the bispectral index and NIHSS scores (Table 3).

Table 3. Relationship between infarcted territories and NIHSS and BIS

	MCA territory	Distal branches of MCA territory	Other arterial territories	p
NIHSS	12 (2-20)	4.5 (2-12)	3 (0-16)	**0.015***
BIS	83.05 ±7.52	86.08 ± 10.65	84.25 ±11.51	**0.698**

Kruskal-Wallis test, One-wayanalysis of variance

4. Discussion

In this study, we investigated the relationship between the NIHSS score and bispectral index value in patients admitted to the emergency department with an acute ischemic stroke, and we did not determine a relationship between the two. This may be because NIHSS assesses the level of 11 clinical conditions, namely sensory deficit, coordination, language, speech, motor performance of the extremities, gaze, visual fields, facial weakness, hemi-inattention, and consciousness, of which only one is related to consciousness while the remaining ten focuses on motor, sensory and cerebellar examination (5). On the other hand, bispectral index correlates with the clinical measures of recall with high accuracy and reproducibility, sedation, and hypnosis (6). It was designed as valuable monitor of the level of sedation and loss of consciousness for sedative hypnotic drugs (7).

A second explanation for the lack of a relationship between the NIHSS score and bispectral index may be that the patients included in our study represented moderate and mild stroke cases and those with a severe stroke were excluded. The lowest bispectral index value of the patients included in the study was 61. We consider that in severe cases of stroke, lower bispectral index values may be observed. We did not determine extremely low values due to medical sedation and emergency vital interventions, such as RSI, which are required in patients with severe stroke indications and affected consciousness.

Although BIS is traditionally not designed to detect brain injuries, such as ischemic events, some previous reports attempted to address this subject, which largely remains controversial. Küsken et al. evaluated bispectral index in patients with head trauma and showed that these values were lower in patients with CT pathologies than in those without such findings (8).

In the literature, bispectral index changes due to cerebral hypoperfusion and ischemic stroke have been reported in patients undergoing preoperative bispectral index monitoring in the form of case reports (9-13). Morimoto et al. reported a case, in which the bispectral index value decreased during the arteriovenous shunt operation, which they attributed to possible cerebral hypoperfusion (9). Welsby et al. reported a patient with an unexpected bispectral index decrease during the coronary by-pass graft operation and a postoperative stroke sign. They suggested that this decrease might be due to stroke (10). In another case study, Leggat et al. observed that the bispectral index monitor recorded an acute change caused by an intraoperative stroke during the replacement of an aortic valve (11). Villacorta et al. reported another case of intraoperative stroke during the replacement of an aortic valve, which showed an unexplained, sustained fall in the bispectral index value (12). Nevertheless, Deogaonkar et al. presenting three cases, demonstrated the inability of the bispectral index monitor to detect cerebral ischemia (13).

In our study, the mean bispectral index value of the cases was 84.23 ± 9.50. All known probabilities that could affect the bispectral index values were excluded from the sample. It is possible to say that this general decrease in the bispectral index values of our patients was due to the stroke.

The ascending reticular activating system, located in the hypothalamus and brainstem, is primary responsible for consciousness (14). The cognition centers of brain are located in the prefrontal cortex, to which blood supply is provided by ACA and MCA while the branches of ACA, PCA and basilar arteries supply blood to the ascending reticular activating system (15). Therefore, multiple arterial territories are involved in consciousness, which may be the reason why we did not find any statistical difference between the grouped infarcted territories and bispectral index and NIHSS scores.

The most important limitation of this study was the exclusion of severe stroke patients. Secondly, the changes in bispectral index during the follow-up of patients could not be recorded due to early hospitalization. Therefore, we were not able to evaluate the relationship between the NIHSS scores and cognitive functions and bispectral index at the time of discharge from hospital. Finally, the number of patients with the same infarcted territories was not sufficient to investigate their relationship with bispectral index.

In this study, bispectral index decreased due to ischemic stroke, but there was no significant relationship between the bispectral index and NIHSS scores. The results should be reevaluated in studies conducted with larger series to reveal the relationship between infarcted territories, NIHHS score, bispectral index, and GCS score.

References

1. Lloyd-Jones DM, Hong Y, Labarthe D, Mozaffarian D, Appel LJ, Van Horn L, et al. Defining and setting national goals for cardiovascular health promotion and disease reduction: the American Heart Association's strategic Impact Goalthrough 2020 and beyond. Circulation. 2011; 121:586-613.
2. Heldner MR, Zubler C, Mattle HP Schroth, G, Weck A, Mono, M. L, et al. National Institutes of Health stroke scale score and vessel occlusion in 2152 patients with acute ischemic stroke. Stroke. 2013; 44:1153-7.
3. Arbour R. Continuous nervous system monitoring, EEG, the bispectral index, and neuromuscular transmission. AACN ClinIssues. 2003; 14:185-207.
4. Guerrier G, Gianni MA. Bispectral index versus standard monitoring in sedation for endoscopic procedures: a systematic review and meta-analysis. J Clin Anesth. 2019; 58:100-4.
5. Ortiz GA, Sacco RL. National Institutes of Health Stroke Scale (NIHSS). Wiley Encyclopedia of Clinical Trials. 2008.
6. Agrawal D, Feldman HA, Krauss B, Waltzman ML. Bispectral index monitoring quantifies depth of sedation during emergency department procedural sedation and analgesia in children. Ann Emerg Med. 2004; 43:247-55.
7. Barbato M, Barclay G, Potter J, Yeo, W., Chung, J. Correlation between observational scales of sedation and comfort and Bispectral Index scores (BIS). J Pain Symptom Manag. 2017; 54:186-93.
8. Kusken O, Ozturk TC, Hunuk A, Akoglu EU, Ak R, Turan CA, et al. Relationship between brain computed tomography findings and bispectral index score in patients presenting with head trauma. North Clin Istanb. 2019; 6:219–25.
9. Morimoto Y, Monden Y, Ohtake K, Sakabe T, Hagihira S. The detection of cerebral hypoperfusion with bispectral index monitoring during general anesthesia. AnesthAnalg. 2005; 100:161.
10. Welsby IJ, Ryan JM, Booth JV, Flanagan E, Messier RH, Borel CO. The bispectral index in the diagnosis of perioperative stroke: a case report and discussion. AnesthAnalg. 2003; 96:435-7.
11. Leggat CS, Fischer GW. Early detection of an acute cerebral event during cardiopulmonary bypass using a bispectral index monitor. Semin CardiothoracVascAnesth. 2008; 12:80-2.
12. Villacorta J, Kerbaul F, Collart F, Guidon C, Bonnet M, Guillen JC, et al. Perioperative cerebral ischaemia in cardiac surgery and BIS. Anaesth Intensive Care. 2005; 33:514-7.
13. Deogaonkar A, Vivar R, Bullock RE, Price K, Chambers I, Mendelow AD. Bispectral index monitoring may not reliably indicate cerebral ischaemia during awake carotid endarterectomy. Br J Anaesth. 2005; 94:800–4.
14. Kovalzon VM. Ascending reticular activating system of the brain. TranslNeurosci Clin. 2016; 2:275–85.
15. Ott T, Nieder A. Dopamine and cognitive control in prefrontal cortex. Trends Cogn Sci. 2019;23(3):213–34.