DOI: 10.5137/1019-5149.JTN.25177-18.1
Received: 28.10.2018 / Accepted: 20.11.2018
Published Online: 27.11.2018

Turk Neurosurg, 2018

Original Investigation

The Relationship Between Vasoactive-Inotropic Score and Mortality in Adult Patients with Traumatic Brain Injury

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ABSTRACT

AIM: To assess the feasibility of the vasoactive-inotropic score (VIS) in determining the amount of vasoactive support and its relationship with the mortality rate and characteristics of the patients with traumatic brain injury (TBI).

MATERIAL and METHODS: This study was conducted with a retrospective design involving the years 2013-2018 in a university hospital which provides tertiary intensive care service. A total of 102 patients who were admitted in the ICU with the diagnosis of severe TBI, and also were followed by neurosurgery service and who received vasoactive and inotropic support were analyzed concerning VIS value.

RESULTS: The median age of the patients was 34 years, and 69.6% of the patients were male. Mortality rate was 43.1%. In the group with mean VIS≥10, the admission duration in the ICU and hospital were shorter ($p<0.0001$) whereas mortality rates were higher (81.1% vs 21.5% and $p<0.0001$). Besides, the number of patients with a VIS score of ≥10, ≥15 and ≥20 were higher in the group of patients who died ($p<0.0001$). The results of the multivariate analysis such as VIS≥10 were significant.

CONCLUSION: We can conclude that VIS, which is used to determine the amount of vasoactive and inotropic medicines during cardiac surgery and in sepsis patients, may be useful in predicting mortality in TBI patients.

KEYWORDS: Traumatic brain injury, Vasoactive-inotropic score, Mortality, Intensive care unit

INTRODUCTION

It is expected that approximately eight million people would die due to injury in the year 2020 worldwide (10). Head trauma and severe traumatic brain injury (TBI) which has an important place among all the trauma patients, affect annually approximately 5.48 million people worldwide. TBI, also termed as "the silent epidemic" is the traumatic injury which leads to the highest mortality and morbidity. TBI as one of the preventable death causes also has an essential place among mortality and disability reasons in the patient population aged below 40 years old (3,11).

The patients with TBI are usually managed in the Intensive Care Unit (ICU). The sensitive balance between ensuring adequate cerebral perfusion pressure and fluid overload is very crucial. At this stage, the administration of the vasopressor and inotropic drugs orientates the treatment process. It is controversial how fluid replacement and administration of the vasoactive medications should be managed in case of hypotension in the patients with TBI (10). Vasoactive-inotropic score (VIS) which is evaluated mostly in cardiac surgery patients in recent years is based on the calculation of the amounts of the administered vasoactive drugs. This calculated score can be used in predicting mortality rates in patients with TBI followed in the ICU (5,6,13,22).

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We aimed to assess the feasibility of VIS in predicting the outcome of TBI patients receiving vasoactive supplementation in the early term who are managed in the ICU.

MATERIALS and METHOD

The present study was approved by The Ethics Committee of Selcuk University Medical Faculty (Date:12.09.2018, Number: 2018/314). Archive and data processing system of the hospital was used. In this study, the 102 patients who were admitted in the ICU with diagnosis of TBI, and also follow up by neurosurgery and who were receiving vasoactive and inotropic support were evaluated for their VIS value. The files of the patients with head injury who were admitted in the anesthesiology and reanimation ICU between January 2013 to July 2018 were analyzed retrospectively. Data such as demographic characteristics of the patients, type of head injury, medical and surgical interventions, duration of hospital and ICU stay and outcomes were recorded. Mean VIS values of the patients in the first 48 hours were calculated and the patients were divided into two groups as subjects with a VIS of <10 and ≥10. The parameters associated with VIS were analyzed. The patients were divided into two groups as dead and survivors and were statistically analyzed concerning general characteristics and VIS.

Patients admitted to the ICU with a history of head injury, older than 18 years of age who received vasopressor or inotropic support within the first 48 hours of admission were included in the study. Patients with uncontrolled hemorrhagic shock, coagulopathy, and spinal cord injury were excluded.

Calculation of VIS

The doses of adrenaline, noradrenaline, dopamine, dobutamine, milrinone, and vasopressin of the patients within the first 0^{th}, 6^{th}, 12^{th}, 24^{th} and 48^{th} hours beginning from admission to the ICU were recorded. Overall VIS values were obtained by using the mean value of each agent. The following Formula was used to calculate the VIS value (Figure 1) (5,22).

Statistical Analysis

Data were statistically analyzed using SPSS Version 22.0 (Statistical Package for the Social Sciences Inc., Chicago, IL, USA). Data were tested for normality with Kolmogorov–Smirnov (with Lilliefors correction) and Shapiro–Wilk tests. Descriptive statistics were performed in all the patient groups; numerical data were expressed as median (quarter intervals) while categorical data were given as percentages. Patients were classified according to mean VIS (VIS<10 or VIS≥10), and ICU outcomes (dead or survive). Patient features were compared using Chi-Square or Fisher's Exact Test for categorical variables and Mann-Whitney U Test for numerical variables. $p<0.05$ value was accepted as statistically significant. To identify any independent risk factor associated with mortality, among the significant parameters of univariate analysis, the ones which were not associated with each other were entered into the multivariate linear regression analysis. ROC analysis was performed.

RESULTS

General Characteristics of the TBI Patients

During the study period, a total of 194 patients with traumatic brain injury were admitted and treated in the ICU. Data of 102 patients with TBI which met the inclusion criteria were analyzed. The median age of the patients were 34 (range: 23-51) years, and 69.6% (n=71) of the patients were male. Median Acute Physiology and Chronic Health Evaluation II (APACHE II) and Glasgow Coma Scale (GCS) values were 20 (18-24) and 5 (3-8), respectively. The rate of patients on mechanical ventilation support was 86.3% (n=88). The incidence of isolated head injury was 20.6% (n=21). Of the patients; 22.5% (n=23) underwent neurosurgical procedures whereas 22.5% (n=23) were operated for non-cerebral events. The median duration of ICU and hospital stay were 6 (2.75-18) and 10 (3-23) days, respectively. The mortality rate of the patients was 43.1% (n=44) (Table I).

Head Trauma and Diagnoses

All head trauma patients were evaluated in the emergency department by the physicians of the neurosurgery service. TBI patients we transferred to the anesthesia and reanimation ICU for postoperative management after neurosurgical interventions. The rates of TBI between in-vehicle traffic accidents and fall injuries were 38.2% (n=39) and 24.5% (n=25), respectively. On the other hand, the rates of motorcycle accidents and non-vehicle traffic accidents were 18.6% (n=19) and 13.7% (n=14), respectively. The incidence of TBI due to other reasons such as occupational accidents, explosions, and gunshot injuries was 4.9% (n=5). Overall the admission rate of the patients after traffic accidents was 70.6% (n=72).

The most common diagnosis for admission to the ICU was subarachnoid hemorrhage and skull fractures (i.e.: compression fracture) (53.9% and 44.1%, respectively) (Table I).

Patients and Vasopressor Medications

The number of patients who received noradrenaline, adrenaline, dopamine, and dobutamine and the median doses were 5 (2-10) µg/kg/min in 99 patients, 5 (4.25-7) µg/kg/min in 20 patients, 6.5 (3-10.25) µg/kg/min in 34 patients and 15 (12.5-15) µg/kg/min in 5 patients, respectively. No patient received vasopressin or milrinone (Table I).

The Patient Characteristics in Terms of Mean VIS

The patients in the group with mean VIS≥10 were older and had lower GCS values ($p=0.005$ and $p=0.013$ respectively).

Vasoactive-Inotropic Score = **dopamine dose** (µg/kg/min) + **dobutamine dose** (µg/kg/min) + **100 xadrenaline dose** (µg/kg/min) + **100 x noradrenaline dose** (µg/kg/min) + **10 x milrinone dose** (µg/kg/min) + **10.000 x vasopressin dose** (U/kg/min)

Figure 1: Vasoactive-inotropic score (VIS) formula.

Table I: General Characteristics of Traumatic Brain Injury Patients

Variable	Total Patients (n= 102) Median (IQR), n (%)
Age (years)	34 (23.75-51)
Gender (male)	71 (69.6%)
APACHE II score	20 (18-24)
GCS score	5 (3-8)
Mechanical ventilation	88 (86.3%)
Isolated head injury	21 (20.6%)
Neurosurgical intervention	23 (22.5%)
Other surgical interventions	23 (22.5%)
Hemoglobin (gr/dl)	10.5 (9.7-12.4)
Red Blood Cell replacement	49 (48%)
Number of Red Blood Cell (Unit)	2 (2-3)
Fresh Frozen Plasma replacement	35 (34.7%)
Number of Fresh Frozen Plasma (Unit)	1 (1-2)
Volume balance (ml/day)	544 (254-850)
Length of ICU stay (day)	6 (2.75-18)
Length of hospital stay (day)	10 (3-23)
Outcome (Death)	44 (43.1%)
Type of trauma	
Traffic accident (inside the vehicle)	39 (38.2%)
Traffic accident (outside the vehicle)	14 (13.7%)
Fall injury	25 (24.5%)
Motorcycle accident	19 (18.6%)
Others (Explosion, work accident, penetrating head injury)	5 (4.9%)
Diagnosis of hospitalization	
Cerebral edema	30 (29.4%)
Subdural hemorrhage	25 (24.5%)
Epidural hemorrhage	17 (16.7%)
Intracerebral hemorrhage	12 (11.8%)
Subarachnoid hemorrhage	55 (53.9%)
Pneumocephalus	4 (3.9%)
Cerebral contusion	12 (11.8%)
Diffuse axonal injury	5 (4.9%)
Skull fractures	45 (44.1%)
Skull base fractures	37 (36.3%)
Others	2 (2%)
Supportive treatment	
Noradrenaline (µg/kg/min), (n= 99)	5 (2-10)
Adrenalin (µg/kg/min), (n= 20)	5 (4.25-7)
Dopamine (µg/kg/min), (n= 34)	6.5 (3-10.25)
Dobutamine (µg/kg/min), (n= 5)	15 (12.5-15)

APACHE II: *Median acute physiology and chronic health evaluation II,* ***GCS:*** *Glasgow coma scale,* ***ICU:*** *Intensive care unit.*

The duration of stay in the ICU and hospital were shorter in the group with a mean VIS of ≥10 (p<0.0001). A significantly higher mortality rate was found in this group (81.1% vs 21.5% and p<0.0001). In the group with a mean VIS of ≥10 demonstrated a higher rate of diagnosed subarachnoid hemorrhage and a lower rate of skull fractures (67.6% vs. 46.2%; p=0.042 and 29.7% vs. 52.3%; p=0.038 respectively) (Table II).

The Patient Characteristics in Terms of Mortality

In the group of patients who died, GCS value (3 vs. 6; p<0.0001) was lower, whereas higher mechanical ventilation rates (100% vs 75.9%; p<0.0001) and APACHE II values were encountered (22.5 vs. 20; p=0.027). The rate of the non-cerebral surgeries was found higher in the survivor group (31% vs. 11.4%; p=0.030). The group of patients who died had a shorter duration of stay both in the ICU and the hospital (2.5 vs 14 and 2.5 vs 18.5; p<0.0001, respectively). In this group, the number of patients with a VIS of ≥10, ≥15 and ≥20 were significantly higher (p<0.0001). The group also had higher rates of subarachnoid hemorrhage (77.3% vs 36.2%; p<0.0001) whereas incidence of epidural hemorrhage and skull fractures were lower (6.8% vs 24.1%; p=0.030 and 29.5% vs 55.2%; p=0.015) (Table III).

The parameters with significant results according to univariate analysis were evaluated with multivariate analysis. The parameters such as VIS≥10 [OR 157.2, 95% CI 4.3-5709.8, p=0,006], duration of ICU stay [OR 2.45, 95% CI 1.37-4.40, p=0,003], duration of hospital stay [OR 0.33, 95% CI 0.17-0.63, p=0.001], non-cerebral surgeries [OR 0.31, 95% CI 0.001-0.86, p=0.041] and presence of skull fractures [OR 0.041, 95% CI 0.003-0.631, p=0.022] were determined as independent risk factors (Table III).

The Correlation Between Mean Cutoff VIS value and Mortality

The cut-off value of mean VIS values according to the ROC analysis performed to predict mortality rate was found as 7.5 (Figure 2). The sensitivity and specificity values for the VIS=7.5 cut-off value were 72.7% and 74.1%, respectively. Positive predictive value, negative predictive value and overall consistency values were found as 68.1%, 78.2% and 73.5%, respectively [AUC 0,863 and 95% CI 0.794-0.931, p<0.0001] (Table IV).

■ DISCUSSION

To the best of our knowledge, this is the first study in the literature to assess the patients with TBI in respect of VIS. According to the outcomes of our patients, a VIS value of ≥10 was found to be associated with increased mortality. Additionally, mortality rates progressively increased with the increase in VIS, and it was consequently noticed that no patient with a VIS of ≥20 survived.

TBI is one of the principal causes of mortality in the age group below 40 years old (11). Mean age was 34 years while male patients made 69.6% of the study population in our study. The ages and gender ratios of the patients with severe TBI in a retrospective study were compliant with the results of our

Table II: The Patient Characteristics in Terms of Mean VIS

	Univariate Analysis			LR
	Vasoactive-Inotropic Score		p	
Variable	**Mean VIS <10 n= 65 (63.7%) median (IQR) n (%)**	**Mean VIS ≥10 n= 37 (36.3%) median (IQR) n (%)**		
Age (years)[a]	31 (23-44)	40 (27.5-63)	**0.005**	NS
Gender (male)	45 (69.2%)	26 (70.3%)	1.000	
APACHE II score	20 (17.5-22)	22 (18-26)	0.052	
GCS score [a]	6 (3-8)	3 (3-7.5)	**0.013**	NS
Mechanical ventilation	53 (81.5%)	35 (94.6%)	0.078	
Isolated head injury	16 (24.6%)	5 (13.5%)	0.212	
Neurosurgical intervention	18 (27.7%)	5 (13.5%)	0.139	
Other surgical interventions	15 (23.1%)	8 (21.6%)	1.000	
Hemoglobin (gr/dl)	10.5 (9.7-12.5)	10.2 (9.7-12)	0.524	
Red Blood Cell replacement	29 (44.6%)	20 (54.1%)	0.413	
Number of Red Blood Cell (Unit)	2 (2-3)	2 (2-3)	0.920	
Fresh Frozen Plasma replacement	19 (29.7%)	16 (43.2%)	0.196	
Number of Fresh Frozen Plasma(Unit)[a]	1 (1-2)	2 (1-5)	**0.022**	NS
Volume balance (ml/day)	549 (258-850)	510 (250-750)	0.374	
Length of ICU stay (day) [a]	9 (4-21.5)	2 (1-8)	**<0.0001**	NS
Length of hospital stay (day) [a]	12 (6-26)	2 (1-16)	**<0.0001**	NS
Outcome (death)[a]	14 (21.5%)	30 (81.1%)	**<0.0001**	NS
Type of trauma				
Traffic accident (inside the vehicle)	22 (33.8%)	17 (45.9%)	0.290	
Traffic accident (outside the vehicle)	10 (15.4%)	4 (10.8%)	0.766	
Fall injury	17 (26.2%)	8 (21.6%)	0.642	
Motorcycle accident	13 (20%)	6 (16.2%)	0.920	
Others	3 (4.6%)	2 (5.4%)	1.000	
Diagnosis of hospitalization				
Cerebral edema	14 (21.6%)	16 (43.2%)	0.155	
Subdural hemorrhage	18 (27.7%)	7 (18.9%)	0.351	
Epidural hemorrhage	14 (21.5%)	3 (8.1%)	0.101	
Intracerebral hemorrhage	10 (15.4%)	2 (5.4%)	0.203	
Subarachnoid hemorrhage [a]	30 (46.2%)	25 (67.6%)	**0.042**	NS
Pneumocephalus	2 (3.1%)	2 (5.4%)	0.620	
Cerebral contusion	8 (12.3%)	4 (10.8%)	1.000	
Diffuse axonal injury	5 (7.7%)	0 (0%)	0.156	
Skull fractures [a]	34 (52.3%)	11 (29.7%)	**0.038**	NS
Skull base fractures	22 (33.8%)	15 (40.5%)	0.527	
Others	2 (3.1%)	0 (0%)	0.533	

The parameters in bold indicate the significant ones in univariate analysis. ***VIS:*** *Vasoactive-inotropic score,* ***LR:*** *Logistic regression,* ***NS:*** *Non-significant,* ***APACHE II:*** *Median acute physiology and chronic health evaluation II,* ***GCS:*** *Glasgow coma scale,* ***ICU:*** *Intensive care unit. [a] Marked parameters which were significant in univariate analysis and not associated with each other were included in the multivariate analysis*

Table III: The Patient Characteristics in Terms of Mortality

	Univariate Analysis			Multivariate analysis	
	Vasoactive-Inotropic Score		p	OR	p
Variable	**Survive group n= 58 (56.9%) median (IQR) n (%)**	**Death group n= 44 (43.1%) median (IQR) n (%)**			
Age (years)	34 (23-49)	35 (24-55.75)	0.763		
Gender (male)	37 (63.8%)	34 (77.3%)	0.193		
APACHE II score [a]	20 (18-21.25)	22.5 (17.25-26)	**0.027**		
GCS score [a]	6 (4-12)	3 (3-5)	**<0.0001**		
Mechanical ventilation [a]	44 (75.9%)	44 (100%)	**<0.0001**		
Isolated head injury	14 (24.1%)	7 (15.9%)	0.336		
Neurosurgical intervention	13 (22.4%)	10 (22.7%)	1.000		
Other surgical interventions	18 (31%)	5 (11.4%)	**0.030**	0.31 (0.001-0.86)	**0.041**
Hemoglobin (gr/dl)	10.5 (9.6-12.4)	10.4 (9.7-12.3)	0.987		
Red Blood Cell replacement	27 (46.6%)	22 (50%)	0.842		
Number of Red Blood Cell (Unit)	2 (2-3)	2 (2-3)	0.750		
Fresh Frozen Plasma replacement	20 (34.5%)	15 (34.9%)	1.000		
Number of Fresh Frozen Plasma (Unit)	1 (1-2)	2 (1-5)	0.167		
Volume balance (ml/day)	544 (263-850)	450 (250-850)	0.214		
Length of ICU stay (day)	14 (5-29)	2.5 (1-5.75)	**<0.0001**	2.45 (1.37-4.40)	**0.003**
Length of hospital stay (day)	18.5 (9.75-34)	2.5 (1-5.75)	**<0.0001**	0.33 (0.17-0.63)	**0.001**
Mean VIS [a]	3 (1-8)	15.5 (6.25-31.75)	**<0.0001**		
Mean VIS ≥10	7 (12.1%)	30 (68.2%)	**<0.0001**	157.2 (4.3-5709.8)	**0.006**
Mean VIS ≥15 [a]	3 (5.2%)	23 (52.3%)	**<0.0001**		
Mean VIS ≥20 [a]	0 (0%)	19 (43.2%)	**<0.0001**		
Type of trauma					
Traffic accident (inside the vehicle)	23 (39.7%)	16 (36.4%)	0.838		
Traffic accident (outside the vehicle)	5 (8.6%)	9 (20.5%)	0.144		
Fall injury	17 (29.3%)	8 (18.2%)	0.248		
Motorcycle accident	10 (17.2%)	9 (20.4%)	0.443		
Others	3 (5.2%)	2 (4.5%)	0.632		
Diagnosis of hospitalization					
Cerebral edema	16 (27.6%)	14 (31.8%)	0.785		
Subdural hemorrhage	15 (25.9%)	10 (22.7%)	0.818		
Epidural hemorrhage [a]	14 (24.1%)	3 (6.8%)	**0.030**		
Intracerebral hemorrhage	6 (10.3%)	6 (13.6%)	0.758		
Subarachnoid hemorrhage [a]	21 (36.2%)	34 (77.3%)	**<0.0001**		
Pneumocephalus	1 (1.7%)	3 (6.8%)	0.189		
Cerebral contusion	8 (13.8%)	4 (9.1%)	0.547		
Diffuse axonal injury	3 (5.2%)	2 (4.5%)	0.885		
Skull fractures	32 (55.2%)	13 (29.5%)	**0.015**	0.041 (0.003-0.63)	**0.022**
Skull base fractures	20 (34.5%)	17 (38.6%)	0.683		
Others	1 (1.7%)	1 (2.3%)	0.843		

The parameters in bold indicates the significant ones in univariate and multivariate analysis. ***VIS:*** *Vasoactive-Inotropic Score,* ***APACHE II:*** *Median Acute Physiology and Chronic Health Evaluation II,* ***GCS:*** *Glasgow Coma Scale,* ***ICU:*** *Intensive Care Unit.* [a] *Marked parameters which were significant in univariate analysis and not associated with each other were included in the multivariate analysis.*

study where 83.2% of the patients were admitted due to traffic accidents (17). According to literature data, the most common cause of TBI is traffic accidents in the low and moderate-income countries while the frequency of fall injuries increases depending on increased population of elderly subjects (3,11). In our study, 70.6% of the TBI cases occurred due to traffic accidents while fall injuries were the second most common cause. These patients were admitted most frequently associated subarachnoid hemorrhage.

The TBI patients are usually referred to the intensive care unit following first medical intervention after injury. In the ICU, secondary brain injury which may develop due to increased intracranial pressure is avoided while the most appropriate intervention is performed to recover the initial damage. The vasopressor drugs in presence of risk for cerebral edema which may develop in the clinical course of refractory shock or transfusion of fluids and blood components are added to the fluid replacements. Because hypotension is commonly observed after TBI and it may affect survival (9,12,20). Mortality rate was found at 43.1% in this patient group in the present study.

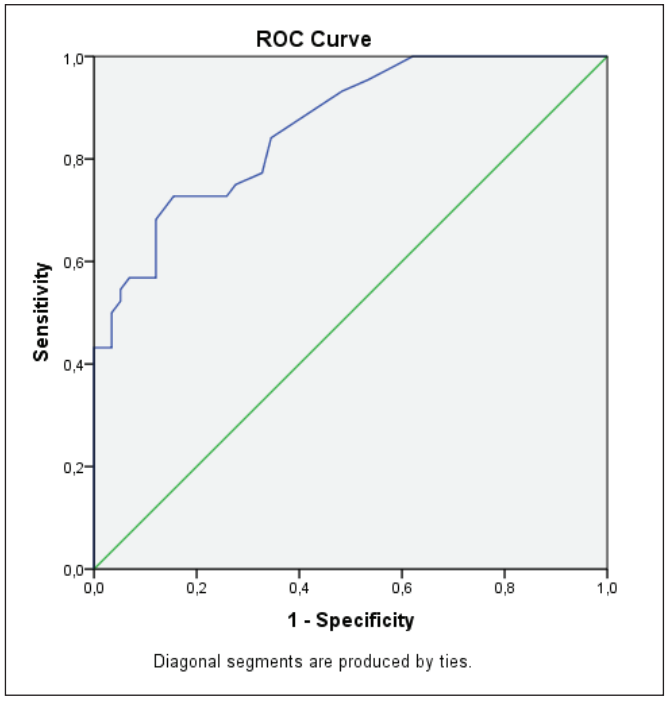

Figure 2: Receiver Operating Characteristic (ROC) curve for mean Vasoactive-inotropic score (VIS).

Various scoring systems are used in prediction of mortality rates in the TBI patients who are admitted to the ICU (15). In some cases, many laboratory techniques may be needed to calculate these scores. New scoring systems to achieve this goal are frequently introduced to clinical practice (21). Use of VIS is distinct which has been used in a limited number of studies in recent years. These studies have been carried out in especially postoperative pediatric cardiac patients (5,6,13). There are also studies on VIS in pediatric sepsis patients (8,14). Recently, VIS was used in the adult cardiac surgery patients (22). Our study has assessed the use of VIS in the TBI patients who were managed in a tertiary intensive care unit which received vasoactive drug support.

Similarly, with the study which evaluated VIS in 71 pediatric patients in the clinical picture of refractory septic shock, our mortality rate was found to be 100% in patients with a VIS of >20 (8). Another study has evaluated VIS as a prognostic scoring system in the adolescents (10-18 years) who underwent cardiac surgery. It was stated that VIS correlated with the duration of hospital stay and duration to extubation. As a result, VIS has been recommended as an easy, relevant and accurate prognostic indicator (7). An editorial letter has evaluated the data of 390 patients who received preoperative vasopressor supplementation out of 711 patients who underwent cardiac transplantation for heart failure. The complication and mortality rates after cardiac transplantation were found significantly higher in the patients with preoperative VIS>20 (1). Another study has evaluated VIS in the cardiogenic shock patients. The 493 patients were divided into five groups based on VIS values (VIS: 1 to 10, 11 to 20, 21 to 38, 39 to 85, and > 85). Mortality rates were discovered as 8.2%, 14.1%, 21.1%, 32.0%, and 65.7% (p<0.001), respectively. As a consequence, high VIS values within the first 48 hours in the clinical course of cardiogenic shock was found to be associated with a nincreased mortality rate. The increased VIS values were also

Table IV: Receiver Operating Characteristic Analysis for the Prediction of Mortality. Cut-Off for Survive Group Versus Death Group Mean VIS Based on ROC Analysis

		AUC		p value	Asymptotic 95 % confidence intervals lower bound-upper bound	Cut-off value
Mean VIS		0.863		<0.0001	0.794-0.931	≥7.5
		Outcome: death				
		Yes	No	Total	Sensitivity	32/44=%72.7
	Yes	32	15	47	Specificity	43/58=%74.1
Mean VIS=7.5	No	12	43	55	Predictive value of positive test	32/47=%68.1
	Total	44	58	102	Predictive value of negative test	43/55=%78.2

ROC: *Receiver operating characteristic,* ***AUC:*** *Area under the curve,* ***VIS:*** *Vasoactive-inotropic score.*

associated with cardiac arrest, reduced pH, APACHE II Score, and increased lactic acidosis (16). In the present study, VIS values were higher in the patients diagnosed with subarachnoid hemorrhage who had significantly higher mortality rates. Similarly, low GCS value was associated with both increased mortality and high VIS values.

Another study analyzed VIS in sepsis patients aged between 2 months and 18 years. The admission duration in the ICU, rates of mechanical ventilation and mortality were found to be associated with VIS (14). The predictive strength of VIS for mortality and morbidity was assessed in 129 patients who underwent cardiopulmonary by-pass surgery. It reported that a high level of VIS value was effective in predicting mortality and morbidity. In addition, the patient group with high VIS level received longer duration of mechanical ventilation support and duration of stay in the ICU (22). Contrarily, the patients with higher VIS values had a significantly shorter duration of stay both in the ICU and the hospital in our study. In our study, shorter duration of stay was due to increased mortality accompanied with increased VIS values within the first 48 hours in the ICU.

There is a long-standing debate on the fact how hemodynamic balance will be achieved and how fluid treatment and vasopressors will be administered (10,12). There are a few studies which compared the efficacy of the vasopressors commonly used in the treatment of TBI and the outcomes of these studies are controversial (19). Besides, there is only a limited number of studies which investigated the use of vasopressors during the early stage of the resuscitation period in the traumatic brain injury patients with very high mortality rate (9). In the present study, the early stages of the TBI patients involving the first 48 hours in the ICU were analyzed. It was observed that use of vasopressors during this period might be ineffective when administered over optimal levels. According to the outcomes of our study, VIS may be preferred conveniently in predicting the adequate level of this support. As a matter of fact, a study carried out in the cardiac intensive care units has suggested that the patients who have received three or more vasoactive drugs usually did not survive. It has been reported that addition of third and fourth vasoactive drug without percutaneous intervention or revascularization surgery which can reverse the shock in these patients is ineffective (18). The available evidence does not support preferring any vasopressor to another (2). In this sense, this score calculated by total values of the drugs used in VIS presents an overall value independent from the fact which vasopressor was used. Although, some authors recommended the addition of drugs such as levosimendan to the VIS score, the calculations made by the addition of the drugs which are more commonly used drugs in clinical practice can be more effective (4). Accordingly, we have preferred the more commonly used agents in the treatment of TBI patients such as noradrenaline, dopamine, adrenaline, and dobutamine. Vasopressin and milrinone were not used in our study since the other studies on VIS involving administration of these drugs were carried out with the cardiac or sepsis patients. Besides, the cut-off value of VIS was found 7.5 in prediction of mortality according to the ROC analysis.

Limitations

The present study has several limitations. First of all, we had no previously determined criteria on the facts such as combinations of the vasoactive drugs, dose adjustments and targeted blood pressure since our study was performed retrospectively. A second limitation was the relatively small number of patients since our study was a single-center study that were carried out in a single ICU. Finally, another limitation of our study was the fact that milrinone and vasopressin were not used in the treatment of hypotension in the analyzed patient group and that VIS value was calculated without the addition of these drugs.

■ CONCLUSION

Profit and loss should be taken into consideration when administering high doses of vasopressor or inotropic drugs to TBI patients. VIS is easy to calculate and is an effective method for the prediction of mortality. We have concluded that it may be used in ICU patients treated for TBI.

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