Original Article

The Level of Serum Osmolarity at Admission in Prognosis of Nosocomial Mortality in Patients with Severe Brain Trauma

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Abstract

Background: Traumatic brain injury (TBI) is a leading cause of death among patients in developed countries. The patients' prognosis depends on the trauma-induced primary damage as well as the secondary brain damage, including electrolyte disturbances. Therefore, prevention, diagnosis, and timely treatment lead to better prognosis. Herein, the aim is to prognosticate about the mortality in patients with TBI through serum osmolarity at admission.

Materials and Methods: In this cross-sectional study, 141 patients with TBI were assigned through convenience sampling. The level of serum osmolarity was examined once the patients were admitted to emergency department and later, the outcome was recorded. Finally, we analyzed the relationship between osmolarity level and patient outcome in age groups.

Results: The mean serum osmolarity in the age group of under 18 years, 18 to 60 years, and more than 60 years was equal to 295.3 ± 10.02 mOsm/L, 297.2 ± 6.5 mOsm/L, and 301.6 ± 7.6 mOsm/L, respectively (P-value <0.001). Osmolarity with a cut-off point of more than 298.90 and sensitivity and specificity of 70.49 and 62.86, respectively, had appropriate diagnostic value for predicting mortality in these patients (P-value <0.001).

Conclusion: According to the results of this study, serum osmolarity can have an appropriate diagnostic value in predicting mortality in patients with TBI. In addition, in different age categories, the osmolarity serum in the mortality of these patients was significantly different. Therefore, due to the high importance of serum osmolarity in the mortality of patients, careful monitoring of fluid therapy status of trauma patients should be implemented to prevent the development of hyperosmolarity for the patient with irreversible outcomes.

Keywords: Concussion, Glasgow coma scale, mortality, osmolarity

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Introduction

Traumatic brain injury (TBI) involves dysfunction of the brain following an external shock.[1-3] This injury is the major cause of death in developed countries and is increasing in low-income countries. Brain injuries include primary and secondary injuries. Primary injury includes mechanical injuries that occur during a head injury and include brain laceration, hemorrhage, cantogensis, and tissue rupture from the brain, which on microscopic examination is characterized by cell destruction and destruction of very small cerebral vessels. Secondary damage includes a series of intracellular and extracellular disorders (such as hypotension, hypoxia, hyperglycemia, anemia, etc.) that occur at any time of trauma and lead to ion shift and severe depolarization of brain cells.[3,4]

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Patients with brain trauma have different prognoses depending on the severity of the injury. Studies show that the prognosis of these patients depends not only on the primary injury caused by the trauma but also on the secondary brain damage that occurs following the primary injury and sometimes in the course of treatment. In other words, management in the acute phase of the disease and interventions that prevent secondary injuries have significantly reduced the mortality of brain trauma compared with previous decades.[5] It should be noted that only part of the trauma to the skull is due to primary injuries that are not predictable, but most injuries are due to secondary injuries and can be predicted and treated.[6] Given that there are no comprehensive and accurate studies on the frequency of mortality in patients with brain trauma and its relationship with serum osmolarity and the available information is inconsistent, this study aims to investigate the level of serum osmolarity at admission. The prognosis of nosocomial mortality in patients with severe brain trauma was performed during 2017 to 2018.

Materials and Methods

This study was a cross-sectional study following a diagnostic value approach. The statistical population included all patients with TBI that referred to emergency department (ED) of Khatam al-Anbia Hospital in Zahedan Hospital from March 2017 to March 2018. The sample size of 141 patients was selected from the mentioned population at the confidence interval of 95%, test power of 80%, and based on the results of previous studies[7] indicating the sensitivity of 76%, matching ratio (P) equal to 0.45, and the error level of 0.15. This sample was selected from the target population using the convenience non-probability sampling method.

Patients with isolated brain trauma, those with multiple trauma, and primary head trauma, as well as those with a Glasgow coma scale above 8 were included. Not-inclusion criteria included history of cardiopulmonary disease, renal failure and metabolic disorders, liver disease and coagulopathy, brain disease, use of opium/alcohol and toxication, casualties who presented 6 h after the accident, casualties in the early hours and before 6 h of hospitalization die, the injured ones who have life-threatening trauma to other organs in addition to head trauma, and patients who received normal saline before ED admission.

Due to the fact that some patients usually received intravenous normal saline using fluid therapy before entering the hospital by Emergency medical services, the patient's sodium was not considered primary sodium at admission and it is pre-determined to enroll patients in investigation who have taken pre-hospital normal saline and, secondly, a test from a vein at the farthest point from the patient's serum therapy site.

After approving the code of ethics from the Ethics Committee of Zahedan University of Medical Sciences (number approved: IR.ZAUMS.REC.1396.122) and obtaining written consent from the patient (if was conscious) or patient attendant, first the demographic characteristics of patients including age, sex, serum osmolarity, blood sodium, blood urea nitrogen, and blood sugar were recorded at emergency room. Finally, the number of days of hospitalization and the patient's outcome (death or survival) were registered.

It should be noted that, because serum osmolarity values and response to treatment (resulting in mortality rate) may vary in people under 18 years and over 60 years of age, subjects were assigned to three age groups.

The data were eventually analyzed by SPSS software (version 25, IBM Corporation, Armonk, NY). According to the result of Kolmogorov–Smirnov test for abnormal data distribution, Spearman correlation coefficient and Mann–Whitney test were used. ROC analysis was used to evaluate the diagnostic value of osmolarity in predicting mortality of patients with TBIs. The area under the curve indices, sensitivity and specificity, positive and negative predictive values (PPV and NPV), and positive and negative likelihood ratios (+LR and −LR) were reported. Significance level was also considered less than 0.05.

Result

Among the 141 patients studied, 100 (70.9%) were male and 41 (29.1%) were female with a mean age of 25.4 ± 16.4 years (ranging in age from 1 to 82 years).

At ED, the mean serum osmolarity levels were 295.3 mOsm/l in under 18-year-old patients, 297.2 mOsm/l in 18- to 60-year-old patients, and 301.6 mOsm/l in over 60 years old ones with TBIs. Table 1 shows the serum osmolarity, blood sodium, urea nitrogen, and blood sugar in terms of different age groups.

In addition, there was no statistically significant difference between the days of hospitalization of patients with TBIs and serum osmolarity at admission according to Spearman test in the age group of under 18 years (r = −0.132, P = 0.38). Also, this difference was not significant in the age groups of 18 to 60 years (r = −0.102, P = 0.34) and over 60 years (r = 0.46, P = 0.29).

Moreover, the evaluation of the relationship between mortality of patients with TBIs and serum osmolarity in terms of the age of patients showed that 19.6% of patients died under the age of 18 years, 37.5% between the ages of 18 and 60 years, and 28.6% over the age of 60 years. The mean osmolarity in patients under 18 years and 18 to 60 years of age in patients who had died was significantly higher than ones who were alive (P value < 0.001); while in over 60 years old patients,

Table 1: Frequency distribution of laboratory values in terms of age groups

Age group Variable	Under 18 years	18-60 years	Over 60 years
Serum osmolarity; mOsm/L	295.3±10.02	297.2±6.5	301.6±7.6
Blood sodium; mmol/l	141.1±3.5	141.3±3.5	141.6±3.9
Blood urea nitrogen; mg/dL	14.8±4.3	16.4±4.7	21.1±5.9
Blood sugar; mg/dL	144.7±58.3	160.7±56.3	171±23.6

the mean osmolarity in dead patients was significantly lower than in living patients (296.7 ± 12.9 mOsm/L vs 303.7 ± 5.2 mOsm/L; *P* value <0.001) [Table 2 and Figure 1].

The cutoff point of osmolarity level in predicting mortality of patients with TBIs was more than 298.90 mOsm/L and the sensitivity and specificity were 70.49% and 62.86%, respectively. Its positive and negative predictive values were 76.81% and 55.00%, respectively (Area under the ROC curve = 0.722, *P* value <0.001) [Table 3 and Figure 2].

Discussion

Electrolyte disturbances are common in patients with concussion,[7,8] which in turn is an important and controllable cause of nerve damage. Most common disorders are seen in the first week of injury.[1]

This study was performed to determine the relationship between serum osmolarity at admission to the hospital and to predict the hospital mortality of patients with TBIs.

According to the findings, the mean serum osmolarity at the ED was very considerable in under 18 years of age patients with TBIs; because people in this age group have a high risk of mortality if they are hyperosmolar. Prevention of brain injury in this study group is more important than the other two groups, because brain damage in the early stages of life causes irreversible damage to the person and can make it very difficult for them to continue living. Therefore, it is necessary to take special care of this group. Also, in over 60-year-old patients with TBIs, the average serum osmolarity at the ED and their blood sodium are higher than other age groups, which indicates the importance of attention and the need for more care for patients in this age group.

Jabalameli[9] in his study of brain trauma patients in the age group of 3 to 80 years showed that the mean osmolarity was not significantly associated with the severity of brain injury. The minimum and maximum osmolarity in this study was 285 to 274 mOsm/L.

Also according to the results of a study by Balak *et al.*,[10] in the age group of 1 to 30 years, the mean osmolarity level of patients with minor head trauma and patients with minor trauma in an extremity was not significantly different. But in the age group over 30 years, the mean osmolarity level in patients with minor trauma in an extremity was significantly higher than patients with minor head trauma.

Other studies have recommended that serum osmolarity in brain lesions be kept above the normal range of 285 to 295 mOsm/L[11,12] which is in agreement with the current study. This can lead to decreased brain fluid and cerebral edema in patients with TBIs and has a better prognosis.[13] However, it should be noted that osmolarity of 260 mOsm/L increases the risk of cerebral edema and Osmotic Demyelination Syndrome, and osmolarity of more than 320 mOsm/L causes cerebral blood vessel disorders and should be treated immediately.[14]

Some studies have suggested that hyponatremia is a common finding in patients with TBIs,[15,16] which has not been the case in this study. Another study has shown that sodium concentration has no effect on the prognosis of these patients,[17,18] but studies have shown that administration of hypertonic saline in patients with changes in cranial pressure can reduce cerebral edema and improve the prognosis while keeping plasma sodium higher.[19]

Table 2: Comparison of mean osmolarity level a in terms of outcome of patients with TBI by age categories

Age group	Outcome	Frequency (%)	Osmolarity level	*P*
Under 18 years	Alive	37 (80.4%)	292.5±8.3	<0.0001
	Dead	9 (19.6%)	306.8±8.2	
18-60 years	Alive	55 (62.5%)	295.3±5.9	<0.0001
	Dead	33 (37.5%)	300.4±6.3	
Over 60 years	Alive	5 (71.4%)	303.7±5.2	<0.0001
	Dead	2 (28.6%)	296.7±12.9	

Table 3: Diagnostic value of osmolarity level in predicting mortality of patients with TBIs

	Osmolarity
Survival	
Alive (*n*=97)	297.96±5.71
Dead (*n*=44)	300.54±6.15
Parameters of ROC analysis	
Cutoff Point	298.90
AUC [95%CI]	0.722 [0.615-0.83]
P	0.0001
Sensitivity, % [95% CI]	70.49 (57.4-81.5)
Specificity, % [95% CI]	62.86 (44.9-78.5)
PPV, % [95% CI]	76.81 (63.6-87.0 ()
NPV, % [95% CI]	55.00 (38.5-70.7)
−LR, % [95% CI]	0.47 (0.3-0.7)
+LR, % [95% CI]	1.90 (1.2-3.0)

AUC: Area under the curve, PPV: Positive predictive value, NPV: Negative predictive value, −LP: Negative Likelihood ratios, +LR: Positive Likelihood ratios, CI: Confidence Interval

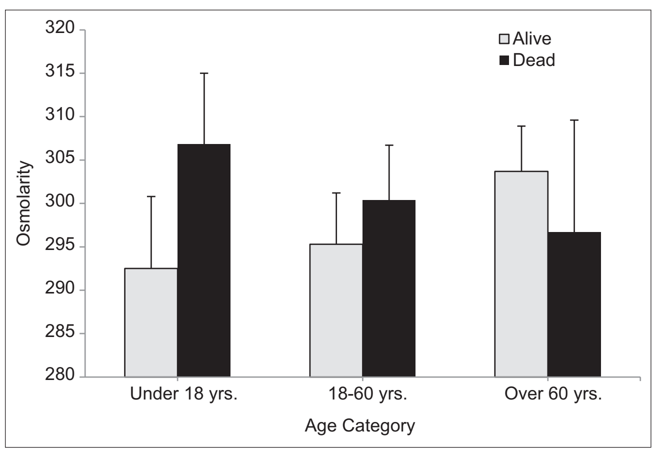

Figure 1: Mean osmolarity level in terms of outcome of patients with TBI in different age categories

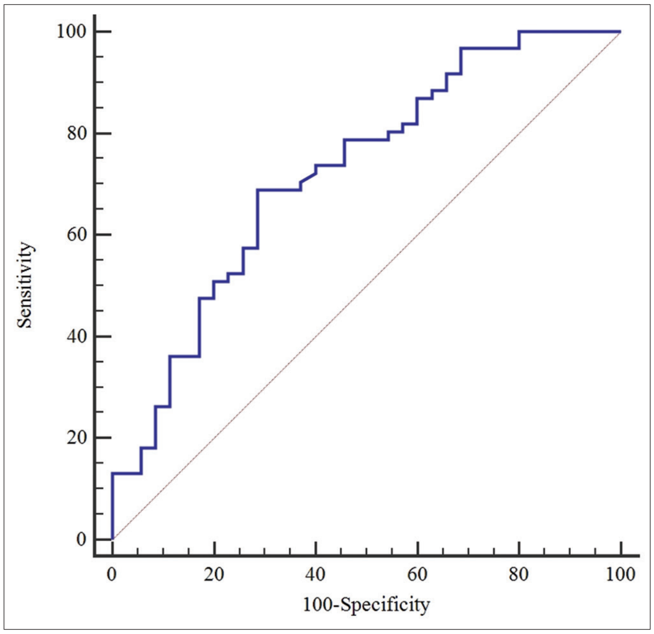

Figure 2: ROC curve in the diagnosis of osmolarity level in predicting mortality of patients with TBIs

In addition, according to the results of this study, osmolarity with a cut-off point of 298.9 mOsm/L and a sensitivity and specificity of 70.49 and 62.86, respectively, had an appropriate diagnostic value in predicting mortality in patients with TBI. Consistent with this study, in the study of Holtfreter *et al*.,[7] the cut-off point of osmolality was 298 mOsm/kg with sensitivity and specificity of 76.40 and 61.30, respectively, to predict the mortality of patients admitted to the ICU due to trauma (multiple, brain, chest, or abdominal), surgery (abdominal, chest, or neurosurgery), and other diseases (pulmonary or cardiac decompensation and other disease). In addition to osmolarity, they also evaluated the diagnostic value of other factors such as APACHI II score, SOFA score, sodium, glucose, creatinine, urea, lactate, and procalcitonin in predicting mortality in these patients. However, these factors were not evaluated in present study and could be one of our weaknesses.

According to our findings, in the age groups of under 18 years and 18 to 60 years, the mean osmolarity in the surviving patients was lower than the deaths and this difference was significant. This can indicate the important role of the physician in prescribing the correct fluid therapy and not to increase the serum osmolarity too much in patients with TBIs. High accuracy should be used in regulating the patient's osmolarity and this amount should be monitored with tests to prevent hyperosmolar complications such as severe neurological disorders, acute poisoning, and disorders of the blood-brain barrier. Also, the most important factor in increasing osmolarity in these patients was their high blood sugar during trauma. Therefore, monitoring blood sugar during emergency admission and controlling it can play a vital role in the course of treatment.

Due to some limitations in conducting this study, it is suggested to further increase the reliability of the results; similar study should be conducted with a sample size of over 300. Considering that the status of patients in the present study was followed only in the hospital until their discharge, it is suggested that in future studies, more accurate follow-up be performed on these patients after discharge to determine the possible complications and consequences of the disease. Also, due to the high importance of primary blood sugar in patients with TBIs, blood sugar checks should be added to routine tests of these patients.

Conclusion

Higher osmolarity resulted in higher mortality in both age groups in this study. The results indicated that due to the high importance of serum osmolarity in patients' mortality, careful monitoring of fluid therapy status of trauma patients should be performed to prevent hyperosmolarity for the patient because it causes irreversible consequences. The treatment team should pay attention to different electrolytes and indicators while maintaining the hemodynamics of the injured person so that they can provide appropriate prognostic care to the patient with TBIs.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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