Original Article

Association between serum sodium level and outcome of traumatic brain injury among Sudanese patients

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Abstract 

Background: Traumatic brain injury (TBI) is defined as an alteration in brain function caused by an external force; it is responsible for high mortality around the world. Hypernatremia is a common electrolyte disturbance in patients with TBI and associated with early mortality after TBI. The aim of this study is to examine the relationship between hypernatremia and outcome after TBI in Sudanese patients.

Methods: This is a cross-sectional study conducted at the National Center for Neurological Sciences from October 2015 to October 2018; blood specimens were obtained from 210 TBI patients and processed for serum sodium measurement.

Results: In the present study measurement of sodium revealed that sodium level <135 mmol/l was detected in 9.0% of patients, while sodium level >145 was detected in 16.7% of patients. Moreover, in this study, the

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mortality rate was increased in the patients with sodium level >145 mmol/L.

**Conclusion:** There was an association between hypernatremia and poor outcome after TBI.

**Keywords:** Traumatic brain injury, hypernatremia, outcome, mortality, Sudanese patients.

**Introduction**

Traumatic brain injury (TBI) is the major cause of disability, morbidity, and mortality among individuals younger than 45 years and is responsible for a significant proportion of all traumatic deaths in the United States (US) and other developed nations.\(^1\,^2,^3\) Traumatic brain injury is a critical public health and socio-economic problem throughout the world.\(^4\) Although high-quality prevalence data are scarce, it is estimated that in the US, around 5.3 million people are living with a TBI-related disability,\(^5\) and in the European Union, approximately 7.7 million people who have experienced a TBI have disabilities.\(^4\,^6\) Hypernatremia is a water balance disorder encountered in about 6–9% of critically ill patients and associated with an increased risk of death.\(^7\) Hypernatremia is a common electrolyte disturbance in patients with TBI.\(^8\) Patients with severe TBI has a high risk of developing hypernatremia over the course of their ICU stay, due to insensible water losses, inadequate provision of free water, excess sodium administration, the development of central diabetes insipidus and other coexisting predisposing neurological conditions.\(^9\,^10\)

The relationship between hypernatremia and TBI is complex, and there is considerable heterogeneity in prior studies evaluating hypernatremia in patients with TBI.\(^11\) The aim of this study was to examine the relationship between hypernatremia and outcome after TBI in Sudanese patients.

**Materials and Methods**

This was a cross-sectional hospitalized-based study conducted in the National Center for Neurological Sciences (NCNS) in Khartoum state, during the period from October 2015 to October 2018. Two hundred and ten Sudanese patients with TBI attending NCNS were enrolled in this study. The data were collected using a pre-designed interview questionnaire. Venous blood sample was collected from all participants, in sterile plain container for sodium measurement. Verbal and written consent from each participant was obtained. Sodium concentrations were obtained by using the full automated Easylyte instrument (Na/K analyzer). Data were analyzed using Microsoft office Excel 2007 and Statistical Package for Social Sciences (SPSS) version 21 software program with the p-value of <0.05 considered as statistically significant by using the Chi-square test.

**Results**

This study was conducted among two hundred and ten TBI patients attending the NCNS. Males were 191 (91.0%) and females were 19 (9.0%). The most affected age group was ranging between 19–34 years, followed by the age group (51–66 years) in 19.0%. (Table 1)

<table>
<thead>
<tr>
<th>Age in group/years</th>
<th>Frequency</th>
<th>Percentage %</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 to 18</td>
<td>30</td>
<td>14.3%</td>
</tr>
<tr>
<td>19 to 34</td>
<td>75</td>
<td>35.7%</td>
</tr>
<tr>
<td>35 to 50</td>
<td>37</td>
<td>17.6%</td>
</tr>
<tr>
<td>51 to 66</td>
<td>40</td>
<td>19.1%</td>
</tr>
<tr>
<td>67 to 82</td>
<td>24</td>
<td>11.4%</td>
</tr>
<tr>
<td>83 to 98</td>
<td>4</td>
<td>1.9%</td>
</tr>
<tr>
<td>Total</td>
<td>210</td>
<td>100%</td>
</tr>
</tbody>
</table>

The majority of the patients had no significant past medical illness (92.9%), but hypertension was encountered in 9.4% of the patients, and diabetes in 1.9%. Finally, most of the patients were discharged from hospital constituting (88.0%), while about 12% of the patients have died. The frequency of sodium levels revealed that sodium level of 135–145 mmol/L was found in 74.3% of patients. (Table 2) The findings of this study showed that the mortality rate was increased in the patients with sodium level >145 mmol/L, \(P = 009\). (Table 3)
Table 2: Shows the frequency of sodium results in traumatic brain injury patients.

<table>
<thead>
<tr>
<th>Sodium (mmol/L)</th>
<th>Frequency</th>
<th>Percentage %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 135</td>
<td>19</td>
<td>9.0%</td>
</tr>
<tr>
<td>More than 145</td>
<td>35</td>
<td>16.7%</td>
</tr>
<tr>
<td>135 to 145</td>
<td>156</td>
<td>74.3%</td>
</tr>
<tr>
<td>Total</td>
<td>210</td>
<td>100%</td>
</tr>
</tbody>
</table>

Table 3: Shows cross-tabulation and the odd ratio of sodium and outcome when the comparison is to sodium less than 135.

<table>
<thead>
<tr>
<th>Sodium</th>
<th>Outcome</th>
<th>P-value</th>
<th>OR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Discharge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than 135</td>
<td>18</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>% within Outcome</td>
<td>9.8%</td>
<td>4.0%</td>
<td></td>
</tr>
<tr>
<td>More than 145</td>
<td>18</td>
<td>17</td>
<td>.009</td>
</tr>
<tr>
<td>% within Outcome</td>
<td>9.8%</td>
<td>68.0%</td>
<td></td>
</tr>
<tr>
<td>135 to 145</td>
<td>149</td>
<td>7</td>
<td>.883</td>
</tr>
<tr>
<td>% within Outcome</td>
<td>80.4%</td>
<td>28.0%</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>185</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>% within Outcome</td>
<td>100%</td>
<td>100%</td>
<td></td>
</tr>
</tbody>
</table>

a. Type = Case

The power of the model = 33.3%

Discussion

Traumatic brain injury occurs when a traumatic event causes the brain to move rapidly within the skull, leading to damage.\(^{(12)}\)

A TBI occurs every 15 seconds in the US, generating 1.7 million new head injury victims per year.\(^{(12,13)}\) Primary brain damage and secondary brain damage are the main two types of TBI.\(^{(14-16)}\) Moreover, TBI is a major cause of mortality and disability in Europe and the US, as well as in under developing countries as 2.5 million of people in the US is suffering from the bad outcome. Many head-injured patients die or survive with severe brain damage, even after mild or moderate head injury.\(^{(17,18)}\)

The findings of this study showed that among 210 patients, males were 191 with the male to female ratio 10:1, several studies showed similar results to our study.\(^{(19-22)}\) However, a study was done by Kumar et al. Showed that among 216 patients, 154 patients were males and females were 62, with a male to female ratio 2.5:1.\(^{(19)}\)

The distribution of the ages of the studied material revealed that most affected age group was ranging between 19–34 years. A study was done by Mustafa, et al, revealed that males between the ages of 14–24 years seem to be the group most commonly affected by TBI.\(^{(23)}\) The findings of this study did not differ from the international studies of TBI among age groups.\(^{(19,24-27)}\) In this study, the majority of the patients had no previous medical illness, which is similar to several studies from the literature.\(^{(19,30)}\) The findings of the present study revealed that most of the patients in the study were discharged from hospital constituting 88%. Studies done by Kumar et al.\(^{(19)}\), Thelin et al.\(^{(29)}\). showed similar findings to our results.

Hypernatremia was independently associated with early mortality after severe TBI and demonstrates a complex relationship with TBI.\(^{(31,32)}\) In the present study, 16.7% of the patients presented with hypernatremia. Similar results to our findings were reported by different studies.\(^{(33-36)}\) A study from India showed that seventeen of 50 patients of TBI group had a Na+ level of 135mmol/L or lower, and hypernatremia Seven of 50 in TBI group.\(^{(36,37)}\) In the present study, regarding the outcome and sodium, there was a significant association between hypernatremia
and death among TBI patients (p = 0.009). Studies done by others showed similar findings to our result.

In the study done by Li et al. showed that the mortality rate for patients with sodium level of >150 mmol was 67.4% and severe hypernatremia is an independent risk factor with extremely high odds ratio for death in patients with TBI who are admitted to the NICU.

In conclusion, in this study we concluded that there was a strong association between hypernatremia and an increased rate of mortality in Sudanese patients with TBI.

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Informed consent: Obtained.

Ethical Clearance: Obtained.

References
