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Predisposing factors for serum sodium disturbance in patients with severe traumatic brain injury (SBI)

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Aim: Disturbances in the plasma sodium level in patients with severe brain injury (SBI) is not a rare phenomenon and may cause adverse effects on prognosis and treatment outcomes. The knowledge of the prevalence of risk factors helps in early detection and good management of the serum sodium level disturbance.

Materials and methods: This is a prospective clinical trial double blind study. The target population included patients with SBI who had disturbances in their plasma sodium level and were admitted at the ICU of Kashani Hospital, Isfahan, Iran, between January and October 2006. The patients with renal insufficiency, diuretic therapy, massive transfusion, brain death, and spinal cord injury were excluded. Gender, age, the prevalence of hypo- and hypernatremia, having tracheal tube or tracheostomy, requiring mechanical ventilation support, craniotomy, type of intracranial pathology, positive history of cardiopulmonary disease, the mean time after which the disturbance occurs, and the mean time needed for the recovery from the disturbance were studied.

Results: The prevalence of hypo- and hypernatremia were 60% and 40%, respectively. Most of the patients were 21-50-year-old males with craniotomy. The mean time after which the disturbance occurs was 23 days after head trauma and the mean time needed for the recovery from sodium level disturbances was 11.5 days.

Conclusion: Hypo- and hypernatremia are common complications of intracranial lesions. Early detection of serum sodium level disturbance is important in these patients and appropriate treatment may actually improve prognosis.

Key words: Hyponatremia, hypernatremia, severe brain injury, intensive care unit

Introduction

Traumatic brain injury is an important public health issue that requires the expertise of informed neurosurgeons, neurointensivists, and other critical care practitioners (1). Electrolyte abnormalities are common in patients with head injuries, occurring at least once during the hospital course of 59% of the traumatic coma data bank (TCDB) patients (2) and disturbances in serum sodium level, both hyponatremia and hypernatremia, are among the most common. Meticulous attention should be paid to fluid administration and fluid balance (3). Serum sodium disturbances frequently occur in neurosurgical and neurologic patients and exacerbate their neurologic and general conditions. The disturbance may manifest as hypernatremia or hyponatremia. Hypernatremia usually occurs in the diabetes insipidus syndrome, whereas hyponatremia develops as a syndrome of inappropriate secretion of antidiuretic hormone (SIADH) or cerebral salt-wasting syndrome (CSWS) (4-6), and contribute to the high morbidity and mortality rates observed in these patients (7).

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SIADH is characterized by dilutional hyponatremia, and CSWS is characterized by natriuresis as a result of increased serum levels of natriuretic hormone (8). Diabetes insipidus presents itself with polyuria, serum hypernatremia and hyperosmolarity, and urine hypo-osmolarity, whereas CSWS is associated with polyuria, serum hyponatremia and hypo-osmolarity, and elevated urinary sodium and hyperosmolarity. Serum hyponatremia, serum hypo-osmolarity, urinary sodium exceeding 25 mmol/L, and euvolemia are typical findings in SIADH (9).

Disturbances of plasma sodium concentration should be seriously considered in patients with craniocerebral injuries to allow timely and appropriate therapeutic intervention and prevent possible complications that may exacerbate the patient's condition and eventually lead to death (9). Patients with significant alterations of serum sodium concentration (hypo- or hypernatremia) may have more severe brain lesions and higher mortality rates (10). So, early detection and good management of serum sodium level disturbance is important, and having knowledge about prevalence of relative risk factors helps us to reach this goal.

Methods

Patients with severe head trauma (GCS ≤ 8) (11) and serum sodium level disturbances admitted at the ICU of Kashani Hospital, Isfahan, Iran, between January and October 2006 were considered for this prospective clinical trial double blind study. Patients with renal insufficiency (acute or chronic renal failure), diuretic therapy, massive transfusion, brain death, and spinal cord injury were excluded.

The sample size was 30 patients, in the age range of 17 to 80 years and with an average age of 38.4 years (SD = 17.6). In each patient, age, gender, the time after which serum sodium level disturbance occurs, the type of serum sodium level disturbance, the time needed to improve the disturbance of serum sodium concentration, having tracheal tube or tracheostomy when the disturbance occurs, requiring mechanical ventilation support, positive history of cardiopulmonary disease, type of intracranial pathology, and having craniotomy were recorded.

Hyponatremia was defined as a serum sodium level <136 mEq/L (12) and hypernatremia was defined as serum sodium level >150 mEq/L anytime during hospitalization (13). Measurements of serum sodium concentration were performed and recorded every day. When hyponatremia was detected, sodium supplementation therapy was applied by intravenous administration of hypertonic saline. Sodium was supplemented according to the following equation: amount of sodium supplementation (mEq/d) = body weight (kg) × 0.6 × [140 - present serum sodium concentration (mEq/L)] (14). The recommended rate to increase blood sodium was controlled at 8-10 mmol/L within 24 h, to avoid central pontine myelinolysis resulting from over-quick increase in blood sodium (15). To manage hypernatremia, the patients' free water deficit was calculated and replaced. A correction rate of approximately 12 mEq/L/day is recommended to avoid rebound cerebral edema (16).

At the time of blood sampling, the following clinical parameters were measured: arterial O_2 saturation (SaO_2), end-tidal carbon dioxide, systemic blood pressure, fever, serum glucose level, and intracranial pressure (ICP).

During the stay in the ward, SaO_2 measured by an oximeter was maintained at 99% to 100%, end-tidal carbon dioxide was maintained at approximately 30 to 35 mmHg, and crystalloid and colloid solutions were used to provide euvolemia or mild hypervolemia. Some patients received sedatives and neuromuscular blockers during postoperative intensive care for ICP control. Osmotherapy with intravenous mannitol (20% solution, 3-6 times per day, 0.25-1 g/kg) was carried out whenever an acute increase in ICP was observed. If hyperglycemia was detected, the following correction factor was used to determine serum sodium concentration: a 1.6 mEq/L decrease in glucose concentration for every 100 mg/dL increase in glucose concentration (17). Fever was treated with acetaminophen and appropriate antibiotics, and an investigation for the cause of the fever was undertaken.

Patient data were collected prospectively by standard procedures. Data included the prevalence of hypo- and hypernatremia, having tracheal tube or tracheotomy, mechanical ventilation support, gender,

age, craniotomy, type of intracranial pathology, positive history of cardiopulmonary disease and mean time after which disturbance occurs, and mean time needed for recovery from the disturbance. Statistical analysis was performed by independent samples t-test. The level of significance was defined as a P value <0.05. All data were finally analyzed by SPSS (version 11.5).

Results

Out of 30 patients with severe head trauma, hyponatremia occurred in 18 (60%) and hypernatremia in 12 (40%) patients. The diagnoses of these patients were as follows: 22 patients with craniotomy (extradural hematoma, subdural hematoma, subarachnoid hemorrhage, intraventricular hemorrhage) and 8 patients without craniotomy (contusion, diffuse axonal injury). Other characteristics of the patients are summarized in Table 1.

Serum sodium concentration disturbance was most pronounced on day 4 and 16 after trauma (each one was 13.3%); 53.3% of patients presented serum sodium level disturbance within 10 days of trauma and 90% of patients within 19 days. Totally, the time range of disturbance of serum sodium level in patients with severe head trauma was variable from one to 45 days after trauma, so the mean time after which the disturbance occurs was 23 days (Figure 1).

Twenty percent of the patients died before the correction of serum sodium level or still had serum sodium level disturbance by the time they were discharged from hospital.

Serum sodium level disturbance was corrected on days 4 and 5 after its occurrence. The mean time needed for recovery from sodium disturbance was 11.5 days (Figure 2).

In our study, 33.3% (10) of patients expired and 16.7% (5) with GCS of 15, 30% (9) with GCS of 14, 13.3% (4) with GCS of 13, and 6.6% (2) with GCS of 9-10 were discharged from hospital.

Discussion

Sodium and water imbalances are the most well-known and serious complications in the acute phase of SBI, especially the traumatic ones, contributing to an increase in early morbidity observed in these patients (15,18). Several factors in these patients, such as the wide range of requiring mechanical ventilation support, tracheal tube, tracheostomy, and the history of cardiopulmonary disease, were considered in this study.

In the patients of this study, the prevalence of hyponatremia and hypernatremia was 60% and 40%, respectively. Twenty percent of the patients died before the correction of serum sodium level or still

Table 1. Characteristics of patients; data are shown as numbers (%).

Male/Female	28/2
Age	
≤20	5 (16.7)
21-30	7 (23.3)
31-40	7 (23.3)
41-50	5 (16.3)
≥51	6 (20)
Hyponatremia	18 (60)
Hypernatremia	12 (40)
Ventilator	7 (23.3)
Tracheal tube	16 (53.3)
Tracheotomy	5 (16.7)
Cardiopulmonary disease history	12 (40)
Craniotomy	22 (73.3)

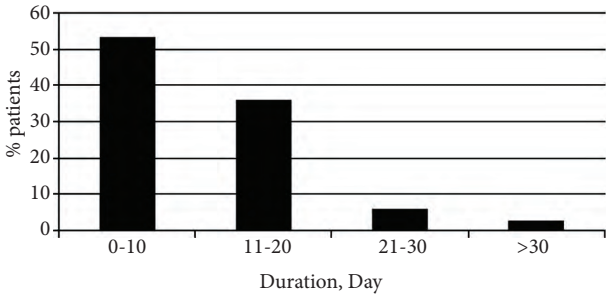

Figure 1. Timing of patients presenting serum sodium disturbance.

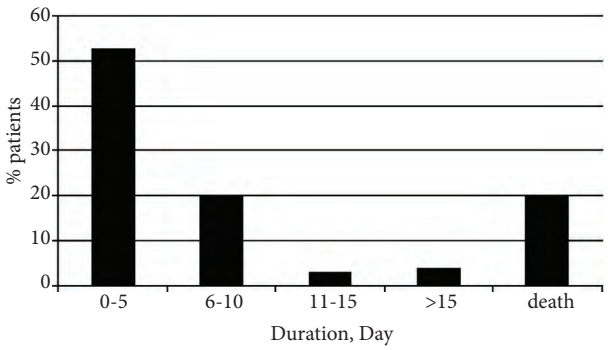

Figure 2. Timing of patients presenting serum sodium correction.

had serum sodium level disturbance in spite of all medical care. Yano et al. (19) reported that 82.4% of the expired patients with severe head injury had hypernatremia and it was more common within 3 days of injury. Hypernatremia with sodium levels >160 mEq/L was 29.4% in expired patients. Bacic et al. (9) observed polyuria with marked plasma sodium level disturbance in 39 of 224 patients with isolated craniocerebral war injuries, 21 of which had hyponatremia (sodium level <130 mmol/L) and polyuria. Thirty eight percent died within 30 days of trauma. The remaining 18 patients developed classic diabetes insipidus syndrome and 33% of them died of hypernatremia within 30 days of trauma. The mortality rate both in patients with hyponatremia and patients with diabetes insipidus was higher in those with greater disturbances of plasma sodium concentration with polyuria and those with lower GCS scores. In our study, the maximum incidence of serum sodium concentration disturbance was in the 4th and 16th days after head trauma (each one was 13.3%). Ninety percent of the patients presented serum sodium level disturbance within 10 days of trauma.

So, not only is fluid administration and fluid balance important, but also meticulous attention should be paid to repetitive and accurate checking of serum sodium concentration, especially within 10 days of head trauma.

Aiyagari et al. (20) reported that increased insensible losses due to mechanical ventilation, fever, nasogastric feeding, impaired consciousness, lack of access to free water, and underlying illnesses are some of the factors that put these patients at a higher risk for developing hypernatremia. He also suggests that hypernatremia is associated with increased mortality rates in hospitalized patients and in medical/ surgical intensive care units, but this relationship has not been studied in neurologic/neurosurgical intensive care units (NNICUs), where hypernatremia is often a component of the treatment of cerebral edema.

Our study specifically explored the relationship between the prevalence of requiring mechanical ventilation support, tracheal tube, having tracheostomy, history of cardiopulmonary disease on the one hand and the incidence of serum sodium level disturbance on the other hand in ICU patients with SBI. About 25% of the patients received mechanical ventilation, more than 50% had tracheal tube, and about 40% had cardiopulmonary disease history at the time of serum sodium level disturbances. Our study shows proportionately great prevalence of these factors at the time of serum sodium level disturbance. Studying 39 patients with neurological disorders referred to a respiratory unit, who needed artificial ventilation, Douglas et al. (21) reported that the prognosis of patients who develop acute renal failure during ventilation is poor, and that in their study half of such patients died. Inappropriate secretion of antidiuretic hormone is not infrequent in various brain disorders. They stated that in their study this complication may have occurred in 4 (possibly 6) of the patients, thus emphasizing the importance of monitoring the plasma sodium concentration in all patients with neurological disorders, particularly those affecting the brain stem, who need artificial ventilation.

For further investigation, a research study can exactly consider the relation between having these risk factors (mechanical ventilation support, tracheal tube, tracheostomy and history of cardiopulmonary disease) and serum sodium level disturbance to show the relationship between the serum sodium level and these factors.

Craniotomy surgery in 73.3% of patients in this study showed the probable relationship between craniotomy and serum sodium level disturbance, which can also be studied further.

In the end, according to the high mortality rate of patients with severe head trauma before the correction of serum sodium level disturbances and the great prevalence of mechanical ventilation, tracheal tube and positive cardiopulmonary disease history in these patients, early diagnosis and treatment of serum sodium level disturbance needs to be well considered among neurosurgeons and neurointensivists who care for patients with severe head trauma.

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