

Hyponatremia in Traumatic Brain Injury

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Abstract

Hyponatremia is a well known complication of traumatic and nontraumatic cerebral injury, often related to the syndrome of inappropriate antidiuretic hormone secretion (SIADH). This hyponatremia is mostly responsible for neuronal death and its consequence.

Here our aim is to study the electrolyte changes especially that of serum sodium levels following various traumatic brain injury (TBI). Patients having TBI of varying severity was evaluated. Along with the incidence and etiology, the fluid and electrolytes study was done in every case.

In result hyponatremia was found to be more common with patient of chronic alcoholism. All patients with Na⁺ value < 125 treated with 3% sodium chloride and got improved. Our observation revealed early enteral feeding with salt replacement in each feed reduced the chance of hyponatremia. We did find an association between chest infection and increased incidence of hyponatremia in this series. In our study the increased incidence of hyponatremia in patients with diffuse axonal injury (DAI) with severe brain edema was attributed to both cerebral factors as well as combined use of osmotic & loop diuretic.

The neurointensivist and every neurosurgeon must recognize the inter-relationship between the primary neurological illness and the electrolyte imbalance so that they can be addressed promptly and in a systematic manner – at the correct time to have a better outcome for the patients.

Key words: Hyponatremia, electrolytes, TBI, SIADH, sodium chloride

Introduction

Hyponatremia is a well known complication of traumatic and nontraumatic cerebral injury, often related to the syndrome of inappropriate antidiuretic hormone secretion (SIADH). Nonetheless, it also can be associated with a different entity, known as cerebral salt wasting (CSW) syndrome. This hyponatremia is mostly responsible for neuronal death and its consequence [1]. Acute onset of severe hyponatremia, is associated with either death or poor neurologic outcome, especially in children, in whom a sudden onset of seizures, followed by coma, apnea, and brain stem compression may occur. Successful treatment will depend on a correct diagnosis of the underlying problem. Various pathophysiologic mechanisms can be at its origin. The most

important differential diagnosis of acute hyponatremia includes SIADH, CSW, and acute adrenocortical insufficiency.

However, the etiology of CSW and the pathophysiologic mechanisms leading to this syndrome remain up to date somewhat unclear. The atrial natriuretic peptide (ANP) is a hormone with natriuretic and aldosterone-inhibiting characteristics released from the heart in response to atrial stretch. Neurons containing ANP have been identified in the brain; however, the concentration of this hormone in the brain consistently is lower than in the heart, making it unlikely that cerebral secretion of this hormone is responsible for renal salt wasting. Although atrial stretch is the principal mechanism for the release of atrial natriuretic peptide, evidence has accumulated to suggest that the central nervous system modulates the cardiac secretion of this hormone. Thus, cerebral diseases may lead to a disturbance of the control over atrial natriuretic peptide secretion and to subsequent excessive secretion. The proportion of patients with hyponatremia caused by SIADH and CSW has been extensively debated in the medical literature without a definite consensus. [1-5] Further review of the literature takes the reader into the gray zone of differentiation between CSW and SIADH with panels of laboratory and clinical tests, none of which are conclusive. [4,5,6] Measurement of ADH levels is not available at most hospitals that manage head injury. Given that the fluid management strategies in these two conditions are completely divergent, the result is a serious clinical dilemma. Fluid restriction is a less than ideal option when the clinical consequences of dehydrating a TBI patient are considered, especially in a tropical climate.

Therefore, it is of crucial importance to determine the exact cause of hyponatremia in patients with acute cerebral disease—dilutional in SIADH, or the result of a negative sodium balance in CSW—because failure to do so can lead to inappropriate treatment and fluid restriction in patients with CSW and subsequent fatal hyponatremia and hypovolemia. Taking these fact in to account our aim here is to find out the incidence of various electrolyte imbalance particularly hyponatremia in TBI patients that may leads towards diagnosis and correction of hyponatremia in traumatic brain injury patients.

Material and methods

In the present study, an attempt has been made to study the electrolyte changes especially that of serum sodium levels following various TBI and its implication in the principle of replacement therapy. So meticulous attention should be paid to fluid and electrolyte balance. Special attention has been paid to the changes in electrolytes in relation to the severity of head injury, surgical procedures and pre-operative factors. Patients having TBI of varying severity will be evaluated. Fluid and electrolytes study will be done in every case. The incidence and aetiology will be studied. Assessment of neurobehavioural sequelae and neurologic deficits in head injury with hyponatremia was done by Glasgow outcome scale (GOS).

Patient Selection Criteria

All patients of head injury with Glasgow coma scale (GCS) between 3 to 15 will be included in the study.

Exclusion criteria

1. Patient who died or left the hospital before any therapeutic measure excluded from the study.
2. Patients having hypertension, renal diseases, heart diseases, endocrine disorders which could possible influence the serum electrolytes were excluded.

Timing of Investigation

Each patient's blood is investigated for electrolyte pattern during the period of hospital stay (after 3-4 days of admission and daily). Normal range of serum Na^+ is 136 – 142 mEq/L. High serum Na^+ value is > 142 mEq/L, low serum Na^+ value is < 136 mEq/L.

Result

This study was compiled in the Department of Neurosurgery of IMS & SUM Hospital, Bhubaneswar during January to December 2020. The biochemical work was carried out in Central Research Laboratory attached to the Department of Biochemistry. The study comprises a total of 100 cases of TBI out of 120 cases after excluding 20 cases (according to exclusion criteria). 100 valid cases were taken for statistical evaluation.

The maximum number of head injury cases was in the age group of 31-40 yrs (33%). Minimum numbers of head injury cases were found in the age group of 51-60 yrs (18%) (Table 1).

Table 1: Age distribution of head injury cases

Age group (yrs)	No. of cases	Percentage (%)
20 – 30	21	21%
31 – 40	33	33%
41 – 50	28	28%
51 – 60	18	18%
TOTAL	100	100%

The maximum number of male cases was in the age group of 31-40 yrs (93.93%) and minimum number of male cases was in the age group of 51-60 yrs (61.11%). Maximum number of female cases was in the age group of 51-60 yrs (38.88%) and minimum number of female cases was in the age group of 31-40 yrs (6.06%). We also found road traffic accident was most common cause of head injury in all age groups. The least common cause of head injury was fall from height in all age groups. In the age group of 20-30 yrs road traffic accident accounts 46.87%. (Table 2)

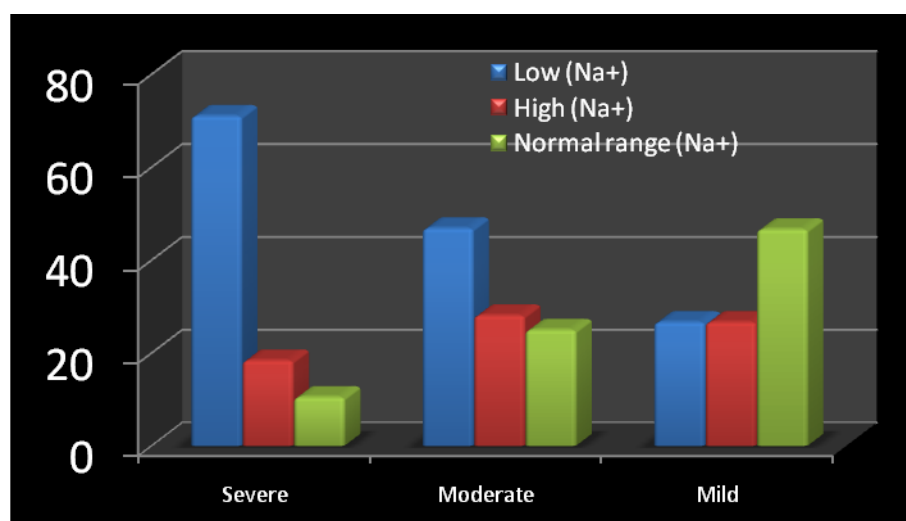
Table 2: Age wise distribution of cases in different types of head injury

MODE OF INJURY	Total No. of cases	AGE GROUP			
		20-30	31-40	41-50	51-60
Road Traffic Accident	64	30 (46.87%)	20 (31.25%)	15 (35.73%)	4 (6.25%)
Fall from height	16	4 (25%)	3 (18.75%)	6 (37.5%)	3 (18.75%)
Physical Assault	20	8 (40%)	6 (30%)	4 (20%)	2 (10%)

We showed that mostly males (93.75%) had head injury due to road traffic accident. Females (45%) had head injury due to physical assault. Due to fall from height the head injury incidence was (81.25%) in males. Most of the head injury cases belonged to the severe variety of head injury (38%), while the mild (30%) and moderate (32%) head injury cases were quite less (Table 3).

Table 3: Cases associated with type of head injury (GCS score)

GCS Score	Type of Head injury	No. of cases	Percentage (%)
3 – 8	Severe	38	38
9 – 12	Moderate	32	32
13 – 15	Mild	30	30
Total		100	100

**Fig 1:** Serum Na⁺ value according to GCS score

This figure shows that the head injury cases with low serum Na^+ level were 50 in number. The cases of severe head injury with low serum Na^+ level were 71% of total and of mild head injury were 26.66% of total (Fig 1).

We also found that most CT findings were brain contusion which was 52% of total number of cases. Diffuse axonal injury (DAI), the second most common CT finding was 30%. Extradural haematoma (EDH) was the least common CT finding and that was 8% of total cases in the study (Table 4).

Table 4: Type of lesion in correlation with CT scan findings

CT scan finding	No. of cases	Percentage (%)
Contusion	52	52
Extradural haematoma	8	8
Acute Subdural haematoma	10	10
Diffuse axonal injury	30	30
Total	100	100

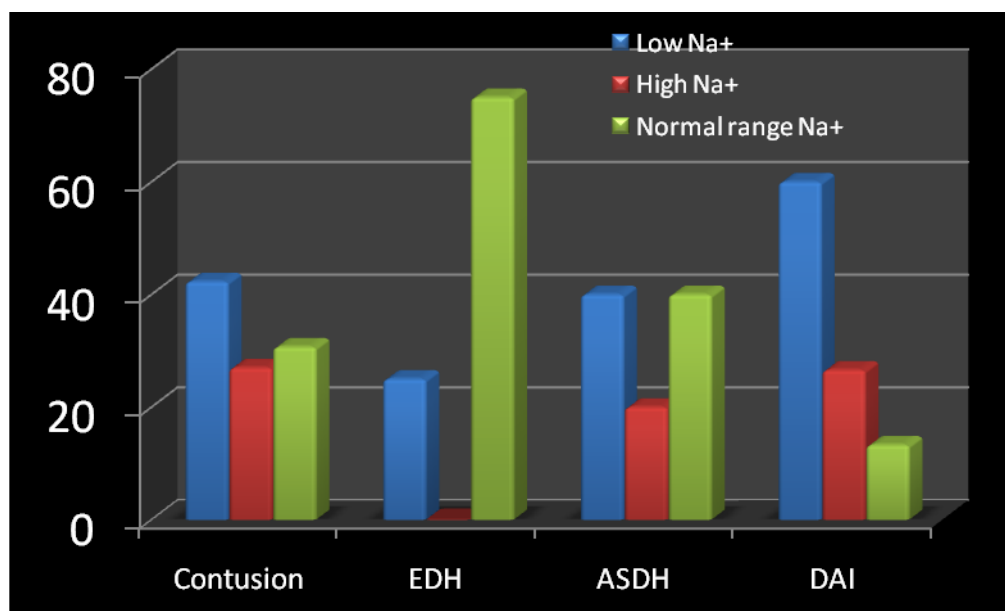


Fig 2: Correlation of serum Na^+ value with intracranial lesions

This Figure showed that low serum Na^+ level was commonly found in diffuse axonal injury (60%) and in contusion (42.3%) (Fig 2).

The outcome of head injury cases after treatment in the different age groups was found. It shows that in severe head injuries (GCS score 3-8), 100% cases recovered in the age group of 20-30 yrs. It also shows that there was better recovery in the mild head injury case (13-15 GCS scoring) (Table 5).

Table 5: Outcome of cases according to age in severity of head injury

GCS score	Total No. of cases	Age group (yrs)	No. of cases	No. of cases recovered	Death
3 - 8	38	20-30	5	5 (100%)	Nil
		31-40	17	14 (82.3%)	3 (17.7%)
		41-50	12	10 (83.4%)	2 (16.6%)
		51-60	4	1 (25%)	3 (75%)
9- 12	32	20-30	11	11 (100%)	Nil
		31-40	8	8 (100%)	Nil
		41-50	6	5 (83.4%)	1 (16.6%)
		51-60	7	5 (71.4%)	2 (28.6%)
13-15	30	20-30	6	6 (100%)	Nil
		31-40	6	6 (100%)	Nil
		41-50	10	10 (100%)	Nil
		51-60	8	8 (100%)	Nil

Table 6: Outcome of cases according to sex distribution in severity of head injury

GCS score	Total No. of cases	Sex	No. of cases	No. of cases recovered	Death
3 - 8	38	Male	35	30 (85.7%)	5 (14.2%)
		Female	3	Nil (0%)	3 (100%)
9- 12	32	Male	29	27 (93.1%)	2 (6.8%)
		Female	3	2 (66.6%)	1 (33.3%)
13-15	30	Male	20	20 (100%)	Nil
		Female	10	10 (100%)	Nil

This table shows outcome of head injury cases after treatment in regards to sex. Male cases in all categories had a better recovery and lower mortality than their female counterpart. All the female cases of severe head injury did not recover in the study (Table 6).

We also related hyponatremia with mortality in head injury cases according to type of head injury. It showed that low serum Na^+ value had higher mortality rate (26%) in severe head injury (Fig 3)

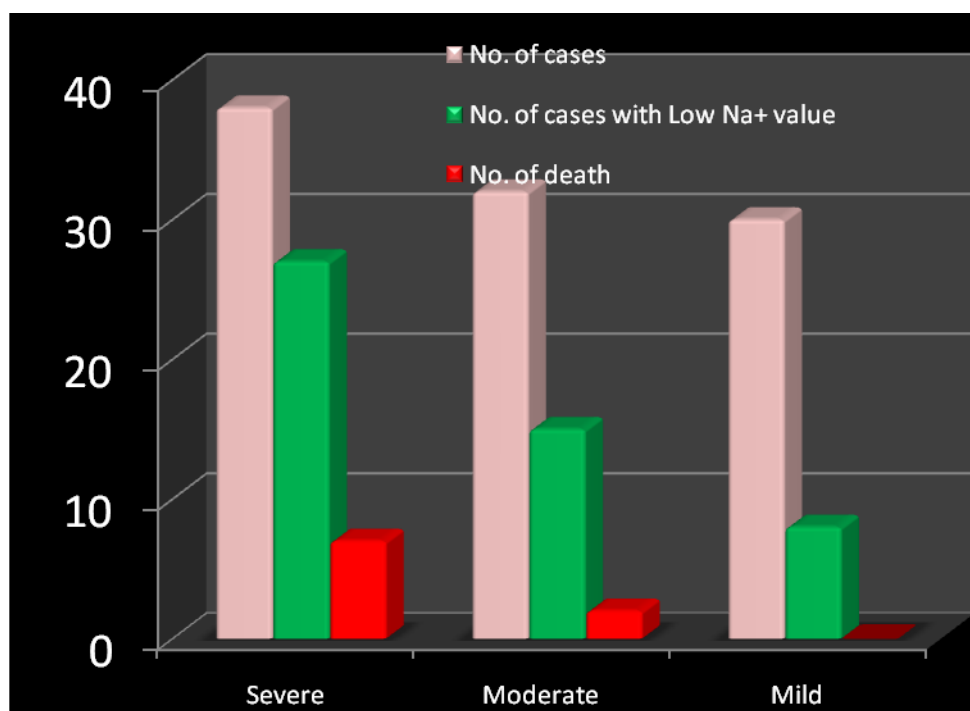


Fig 3: Relation between LOW SERUM Na⁺ value and mortality in head injury cases

Discussion

Patients of 20-60 yrs of age and both sexes were studied. Maximum number of cases were found in the age group of 31-40 yrs and 41-50 yrs, males were predominant (84%) than females (16%).

The incidence of head injury in males is 84% in all age group and in females, it is 16%. This is in accordance with the reports of Goldstein FC & Levin HS (1987) [7] who found that approximately 2/3rd of head injury occur in males, because males are involved in more outward activities and drive the vehicles.

Road traffic accident (RTA) is the most common mode of head injury (64%). This is nearly similar to the reports of DuAcan et al. (1989) [8] who found that RTA represent 60-80% of head injury in adults. It is also in accordance with the findings of Annerggers (1980) [9]. 56-60% of patients with GCS score ≤ 8 as per Mark Simon and Schuster (2015) [10]. Rosman NP (1994) [11] reported the incidence of mild head injury to be 80%, moderate & severe head injury to be 15%. This is due to increase in number of population, use of more vehicles, un-development of roads, stressful and hurry lifestyle.

In the present study, the incidence of severe, moderate & mild head injuries are 38%, 32% and 30%. This indicates a higher incidence of severe & moderate head injuries in the present study. The cause may be that due to lack of adequate transport facilities, unawareness, poverty & fear for higher treatment cost of referral centres. Most of the cases are primarily treated at local hospitals & only when the cases deteriorates then he is brought to the referral centre.

Types of lesion correlation with CT findings in present study shows that cases of contusion which is the most common traumatic brain lesion (52%) followed by Diffuse Axonal Injury (DAI) is 30%. According to Lindsey et al. 2006 [12], the incidence of contusion is 36%. According to Kumar and Mahapatra (2009) [13] the occurrence of cerebral contusion has varied from 30-40%. The incidence of extradural haematoma (EDH) is found in 8% of head injured cases. This is in accordance with the finding of Kumar and Mahapatra (2009) [13] who reported the incidence to be 9%. 30% of cases belong to acute subdural haematoma (ASDH) in our study which is nearly similar to the findings of Kumar and Mahapatra (2009) [13] which varies from 10-30%.

Hyponatremia is associated with different type of intracranial lesion i.e. cerebral contusion (42.3%), EDH (25%), ASDH (40%) & DAI (60%). According to Kumar and Mahapatra (2009) [13] significant hyponatremia is relatively common after the head injury occurring in about 8% to 15% of patients with moderate and severe head injuries. As per Lolin K et al. (1992) [14] the incidence of hyponatremia increases in the presence of severe head injuries, cerebral contusion, DAI & ASDH. Hyponatremia is a common complication of several intracranial diseases and is often associated with the worsening of the patient's neurological status. According to Palmer BF (2003) [15], three explanation have been suggested for the cause of hyponatremia in patients with cerebral disorders. Hyponatremia associated with hypernatremia caused by inhibition of Na^+/K^+ ATPase, the syndrome of inappropriate secretion of ADH which results in dilutional hyponatremia ; cerebral salt wasting syndrome characterized with renal sodium wasting, decrease in extracellular fluid volume, hyponatremia and sodium balance.

It is seen that cases with GCS scoring (13-15) i.e. mild head injury has 100% recovery. Male cases being more stronger could withstand the traumatic head injury in a better way than the females, because the physiologic mechanisms may be weaker in females, so the female cases succumbed or recovered less after head injury.

When the GCS score is low (3-8), mortality is high (21.2%) this corroborates with the finding of Goldstein FC & Levin HS (1987) [7] who reported a (20%) mortality in severe head injured patients. According to his study in male cases recovery rate is better than female head injury cases. In moderate head injury (GCS 9-12) the mortality rate is (9.4%). This also corroborates with the finding of Goldstein FC & Levin HS (1987) [7] who reported 10% mortality in moderate head injury.

Conclusion

The present study is basically a clinical study which is based upon the correlation between clinico-radiological data and serum sodium value. The hyponatremic patients could not be categorized or classified in this study. However it was established that the disturbance of sodium homeostasis is a common phenomenon in traumatic brain injury patients compounding the neurological disability and ultimately affecting the outcome. The neurointensivist and every neurosurgeon must recognize the inter-relationship between the primary neurological illness and

the electrolyte imbalance so that they can be addressed promptly and in a systematic manner – at the correct time to have a better outcome for the patients.

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