Hyponatremia is a common electrolyte disorder encountered in patients of neurological disorders such as stroke, subarachnoid hemorrhage, and meningitis, which is usually either due to inappropriate secretion of antidiuretic hormone (SIADH) or cerebral salt wasting syndrome (CSWS). We conducted this study in a tertiary care hospital to determine the incidence and etiology of hyponatremia in patients of stroke admitted in the hospital.

**Materials and Methods:** It was a prospective study done over a period of two years that included established cases of stroke diagnosed on the basis of clinical history, examination and neuroimaging. 1000 stroke patients were evaluated for hyponatremia (serum sodium <130 meq/l). The data was analysed using Chi-square test using SPSS (Statistical package for social science) software.

**Results:** Out of 1000 patients, 353 patients had hyponatremia. Out of this 353 patients, 238 (67%) had SIADH and 115 (33%) had CSWS. SIADH was seen in 83 patients who had ischemic stroke and 155 patients of hemorrhagic stroke. CSWS was found in 38 patients with ischemic stroke and 77 patients with hemorrhagic stroke. Statistical analysis revealed that hyponatremia significantly affects the outcome of stroke especially when it is due to CSWS rather than SIADH.

**Conclusion:** Incidence of hyponatremia in our study population was 35%. In patients of hyponatremia 67% were having SIADH and 33% were having CSWS. Overall hyponatremia affected the outcome of stroke especially when caused by CSWS. Therefore close monitoring of serum sodium must be done in all patients who are admitted with stroke and efforts must be made to determine the cause of hyponatremia, in order to properly manage such patients thereby decreasing the mortality rate.

**Key Words**

Hyponatremia, stroke, syndrome of inappropriate antidiuretic hormone

**Introduction**

Hyponatremia is a common electrolyte disorder encountered in patients of neurological disorders such as stroke, subarachnoid hemorrhage, and meningitis, which is usually either due to syndrome of inappropriate secretion of antidiuretic hormone (SIADH) or cerebral salt wasting syndrome (CSWS).

Antidiuretic hormone (ADH) is a hormone stored in posterior pituitary gland in the brain. It is the prime regulator of body water and acts on the kidneys to increase total body water. Ordinarily, it is a physiological response to a drop in plasma volume or an increase in serum osmolality that causes the release of ADH. In SIADH, there is a persistent production of ADH despite body fluid hypotonicity and an expanded effective circulatory volume so that the negative feedback mechanism that normally controls ADH fails and ADH continues to be released.

CSWS first described by Peter et al. in 1950 is defined by the development of excessive natriuresis and subsequent hyponatremia, dehydration in patients with intracranial disease. Though many hypotheses have been given, but the exact mechanism of CSWS is not known.

We conducted this study in a tertiary care hospital to determine the incidence and etiology of hyponatremia in patients of stroke admitted in the hospital.

**Materials and Methods**

It was a prospective study performed over a period of 2 years that included established cases of stroke diagnosed on the basis of clinical history, examination, and neuroimaging. A total of 1,000 stroke patients were evaluated for hyponatremia (serum sodium <130 meq/l). All the patients were assessed for volume status. Serum sodium, serum osmolality, urinary sodium, and urine osmolality was also measured. All those patients who had a history of gastroenteritis, head trauma, brain tumor, pulmonary kochs, bacterial pneumonia, bronchogenic CA, leukemia, lymphoma, recent surgery and intake of drugs that can cause hyponatremia were excluded from this study. SIADH
was differentiated from CSWS as per Table 1. The data were analyzed using the Chi-square test using the SPSS (Statistical Package for Social Science) Software.

**Results**

Out of 1,000 patients, 353 patients had hyponatremia. Out of this 353 patients, 238 (67%) had SIADH and 115 (33%) had CSWS. SIADH was seen in 83 patients who had an ischemic stroke and 155 patients of hemorrhagic stroke. CSWS was found in 38 patients with ischemic stroke and 77 patients with hemorrhagic stroke [Table 2].

Table 3 shows distribution of Hyponatremia in hemorrhagic stroke as per site of hemorrhage.

The distribution of Hyponatremia in Ischemic stroke as per vascular territory involved is shown in Table 4.

Out of 353 patients with hyponatremia with stroke, 197 survived and 156 died. Out of 647 patients without hyponatremia, 553 survived and 94 died. The P value for this was 0.00 which is statistically significant.

In the SIADH group of patients (n=238), 129 survived while 109 died, whereas in the CSWS group of patients (n=115), 68 survived and 47 died. On statistical analysis, it was found that CSWS significantly affected the outcome of stroke.

**Discussion**

Hyponatremia in patients with an acute central nervous system disease is the most common electrolyte disturbance encountered in neurological intensive care units. It can present with signs and symptoms mimicking a neurological disease and can worsen the existing neurological deficits.[9]

The symptoms directly attributable to hyponatremia primarily occur with acute and marked reductions in the plasma sodium concentration and reflect neurologic dysfunction induced by cerebral edema and possibly adaptive responses of brain cells to osmotic swelling. Hyponatremia induced cerebral edema occurs primarily with rapid (over 1 to 3 days) reductions in the plasma sodium concentration. The severity of symptoms generally reflects the severity of cerebral over-hydration. Nausea and malaise are the earliest findings, and may be seen when the plasma sodium concentration falls below 125-130 meq/L. This may be followed by headache, lethargy, and obtundation and eventually seizures, coma, and respiratory arrest if the plasma sodium concentration falls below 115-120 meq/L. Non-cardiogenic pulmonary edema has also been described.

Hyponatremia is one of the important causes of persistent altered sensorium in stroke patients. It can also give various other neurological signs and symptoms like seizures, which can further deteriorate level of consciousness and outcome. There are many precipitating factors for hyponatremia in stroke like dietary restriction of sodium for control of hypertension, use of diuretics and infections like aspiration pneumonia. Except in life-threatening disturbances of sodium homeostasis, the initial finding of an abnormal sodium level should always prompt specific investigation into the underlying cause before management is initiated. Hyponatremia in stroke is usually of the hyposmolal type caused either due to SIADH or CSWS.[1]

**Table 3: Hyponatremia in hemorrhagic stroke (number and cause as per site of stroke)**

| Site of hemorrhagic stroke | No. of patients with hyponatremia due to SIADH (n=155) (%) | No. of patients with hyponatremia due to CSWS (n=77) (%) |
|---------------------------|----------------------------------------------------------|--------------------------------------------------------|
| Right putamen hemorrhage  | 32 (21)                                                  | 18 (23)                                                |
| Left putamen hemorrhage   | 34 (22)                                                  | 16 (21)                                                |
| Right thalamic hemorrhage | 26 (17)                                                  | 18 (23)                                                |
| Left thalamic hemorrhage  | 24 (15)                                                  | 17 (22)                                                |
| Right cerebellar hemorrhage | 11 (7)                                                  | 0 (0)                                                  |
| Left cerebellar hemorrhage | 13 (8)                                                  | 0 (0)                                                  |
| Pontine hemorrhage         | 15 (10)                                                  | 8 (11)                                                 |

SIADH=Syndrome of inappropriate secretion of antidiuretic hormone, CSWS=Cerebral salt wasting syndrome

**Table 4: Hyponatremia in ischemic stroke (number and cause as per vascular territory)**

| Vascular territory involved in ischemic stroke | No. of patients with hyponatremia due to SIADH (n=83) (%) | No. of patients with hyponatremia due to CSWS (n=38) (%) |
|-----------------------------------------------|----------------------------------------------------------|--------------------------------------------------------|
| Right MCA                                     | 34 (41)                                                  | 20 (53)                                                |
| Left MCA                                      | 38 (46)                                                  | 12 (32)                                                |
| Posterior circulation                         | 11 (13)                                                  | 6 (15)                                                 |

SIADH=Syndrome of inappropriate secretion of antidiuretic hormone, CSWS=Cerebral salt wasting syndrome, MCA= Middle cerebral artery
SIADH tends to occur in three disease groups: Central nervous system (CNS) disorders, carcinomas, and pulmonary disorders. It can also occur due to many drugs such as analgesics, antidepressants, barbiturates, carbamazepine, and oral hypoglycemic. Patients with SIADH are usually euvolemic and hypertensive. Neurologic signs to look for in patients with SIADH include drowsiness, seizures, and coma. CSWS is defined as “true hyponatremia,” which occurs when there is a primary loss of sodium into the urine without an increase in total systemic volume. The exact mechanism that causes CSWS is unclear, but one hypothesis states that it is due to an exaggerated renal pressure natriuresis that occurs from increased sympathetic nervous system activity.

The following Table 1 shows the features that help in differentiating SIADH from CSWS.

Making the distinction between SIADH and CSWS is important as the treatment is different in the two conditions. SIADH is treated by restricting fluids and drugs such as furosemide, demeclocycline or lithium. CSWS is managed by treating the underlying cause, volume replacement with normal or hypertonic saline and drugs like fludrocortisones.

One study performed previously in critically ill adult neurological patients found hyponatremia in 1-15% of the patients, which was associated with a mortality increase of 7-60%.[10] In another study, hyponatremia in the acute stroke stage was seen in 11.6% of cases and has been found to be a predictor of 3-year mortality in patients with acute first-ever ischemic stroke.[31] We studied 1,000 patients of stroke out of which 353 patients were having hyponatremia giving incidence of 35% approximately, which is more than what was found in a previously done study.[30] Out of 353 patients with hyponatremia with stroke 197 survived and 156 died. Out of 647 patients without hyponatremia, 553 patients survived and 94 died. Statistical analysis revealed that hyponatremia significantly affects the outcome of stroke especially when it is due to CSWS rather than SIADH.

Conclusion

Incidence of hyponatremia in our study population was 35%. In patients of hyponatremia, 67% were having SIADH and 33% were having CSWS. Overall hyponatremia affected the outcome of stroke especially when caused by CSWS. Therefore, close monitoring of serum sodium must be carried out in all patients who are admitted with stroke and efforts must be made to determine the cause of hyponatremia, in order to properly manage such patients thereby decreasing the mortality rate.

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