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Electrolytic Status in Meningitis of Children in Chittagong Region: A Clinical Survey

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Authors' contributions

This work was carried out in collaboration between all authors. Author CMMH designed and planning, investigations and modify the manuscript. Authors SDG and MMI performed data analysis, interpretation, and wrote the first draft of the manuscript. Authors MRH and FN have provided assistance in data collections and managed the literature search. Authors AAK and AKA edited and modify the manuscript also support in statistical analysis. Author TBE has revised the first draft of manuscript and also assist in the grammatical corrections. All authors read and approved the final manuscript.

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ABSTRACT

Aims: Electrolyte of different body fluid is one kind of important parameter to determine the severity of meningitis. Therefore we aimed to investigate electrolytic status in different types of meningitis together with detailed medical history in children. We wanted to make a comparison of CSF electrolytes between pyogenic and tubercular meningitis in male and female patients.
Place and Duration of the Study: The study was conducted in the Biochemistry, Microbiology laboratory of ChattagramMaa-O-Shishu General Hospital, Chittagong, Bangladesh.
Methodology: A total of 100 subjects were investigated in this study. CSF obtained from the selected patient by the process of lumbar puncture done in the hospital ward by the doctor by maintaining sterility and aseptic condition from the pathology laboratory for electrolytes estimation.
Results: We observed that the Na^+ level was increased (>145 mmol/L), Cl^- level was increased (>107 mmol/L), K^+ level was increased (>5.1 mmol/L) and HCO_3^- level was increased up to (>28 mmol/L) in 16%, 21%, 26% and 7% patients respectively. Furthermore, lymphocytes and neutrophils were also detected in the CSF and blood of the patients. Interestingly, in pyogenic meningitis, the neutrophil count was very high compared to that in viral meningitis. In both cases the correlation of Na^+, Cl^-, K^+ and HCO_3^- were tested among patients.
Conclusion: Our survey and experimental observations reveals that the abnormality is not due to a combined deficiency of sodium, chloride, and potassium. Biochemical parameter such as electrolytes level in CSF might be a potential tool for determining pH, acid-base balance, and hormone secretion.

Keywords: Meningitis; cerebrospinal fluid; electrolytes.

1. INTRODUCTION

The brain may be infected by bacteria, fungus or virus which will cause the inflammation of the meninges. Patients need to receive the treatment within a very short time because it can be lethal. Meningitis can be classified into three main groups based on the causative agents, bacterial meningitis, nonbacterial meningitis, and viral meningitis. Bacterial meningitis is usually caused by *Pneumococcal* species, *Haemophilus influenzae*, *Staphylococcal* species, and *Meningococcal* species. For nonbacterial meningitis, it is related to fungal and parasites that are frequently linked to etiologic agents like *Cryptococcal* species and *Histoplasma* species. In the aspect of viral meningitis, it can be *Enterovirus meningitis* or *Herpes simplex virus* meningitis [1].

The bacteria causing meningitis is transmitted by means of water droplets from person to individual. These will also be promoted by way of intimate and extended contact, for illustration, kissing, sneezing or coughing on yet another person and staying very close to the infected character [2]. The incidence rate of meningitis in developing countries as in Africa and India is larger than that within the developed countries by ten times considering the fact that the entry to preventive measures of the ailment remains to be no longer good developed. Black men have appreciably higher rates than Hispanic and Native American/Alaskan Native men, except in the oldest age group [3]. In the United States in 1996, case rates were low in infancy and decreased somewhat during early childhood. After the age of puberty, they showed a steady increase with age [4]. Children aged 5-14 years often have been referred to as the privileged age because they have lower rates of tubercular meningitis than any other age group. Childhood TB has a limited influence on the immediate epidemiology of the disease because children rarely are a source of infection to others. Younger children are more likely to develop meningeal, disseminated, or lymphatic TB, whereas adolescents more commonly present with pleural, genitourinary, or peritoneal disease [5]. For the adults, the incidences of bacterial meningitis are 1.7 to 7. 2 cases per 100,000 every year and that implies annual incidence is 3.8 cases per 100,000. There is an acclaimed meningitis beginning which is accompanying to the meningococcal meningitis at the meningitis belt. The meningitis belt is a breadth of sub- Saharan Africa characterized by the dust winds and cold nights. Since meningococcal meningitis has melancholia variation, the dry division holds responsibility for ample epidemics that action in the meningitis belt [2]. There are a few common symptoms of meningitis, for instance, neck stiffness, altered mental status, fever and headache [5]. However, the basic triad of fever,

neck stiffness and an altered mental status remains low among adults with community-acquired bacterial meningitis [6].

Chittagong is the biggest port city of Bangladesh getting a lot of meningitis patient among children of rural and slum area. Significant numbers of children are suffering from acute and chronic meningitis, for instance of neck stiffness, altered mental status, fever and headache every year but no study has been conducted to explore the nature and cause of such situation. This study has been designed to investigate the exact physical and biochemical parameters, as much as possible, to differentiate the different types of meningitis in children admitted at Chattagram Maa-O-Shishu General Hospital. More specifically, the main research was focused on categorization of different types of meningitis, investigation of electrolytic status in the CSF of meningitis patients and conduction of detailed cytological, biochemical and microbiological examination to the children of Chittagong region. Also we wanted to make a comparison of CSF electrolytes between pyogenic and tubercular meningitis in male and female patients.

2. MATERIALS AND METHODS

This study was carried out during the period starting on December 2010 in Pathology & microbiology lab, Chattagram MaaShishu-O-General Hospital, Agrabad, Chittagong and completed on October 2015, over one hundred children (age limit; 32 days-78 months) were selected with the complaints of fever. Total 100 subjects were included in this study. There were no specific preferences for race, religion and socioeconomic status. This is a prospective study where children were divided into two groups, Pyogenic (37%) and Tubercular (63%) of total subject. They were matched according to age, sex, weight and mid-upper arm circumference (MUAC) of the children. Each group was again divided into two subgroups according to sex (male and female). This prospective study involved children admitted to CMOSGH. The mother or guardians were informed of the purpose of the study. For each patient a detailed history was taken from mother or the attendant and recorded in a data collection sheet and through clinical examination at admission and daily follow up was recorded during the hospital stay. Children's fulfilled the inclusion criteria were included for this study.

2.1 Exclusion Criteria

- An immuno-competent child.
- Known history of recent head trauma.
- Abnormal level of consciousness.
- Very high CSF pressure evidenced by papilledema.
- Evidence of focal neurological deficits.
- Suspected intracranial space occupying lesions e.g. tumor, abscess, haematoma.
- Local infection at the puncture site.
- Child having Meningomyelocele.

2.2 Developed Questionnaires

A set of questionnaires was developed to obtain relevant information on demographic and socio-economic data. The questionnaire was also included on Anthropometric data, Birth history, Immunization history, Past medical history and Clinical information. The questionnaire were recorded & pre-tested before finalization. The questionnaire was both closed and open ended.

2.3 CSF Sample Analysis

CSF obtained from the selected patient by the process of lumbar puncture done in the hospital ward by the doctor by maintaining sterility and aseptic conditions from the pathology laboratory for electrolytes estimation. Total CSF electrolytes (Na^+, Cl^-, K^+, and HCO_3^-) were estimated in the Biochemistry laboratory of CMOSGH. On the basis of clinical suspicion as causal factors of hypernatremia, hyponatremia, hyperchloremia, hypochloremia, hyperkalemia, hypokalemia, the CSF was investigated in the clinical pathology of CMOSGH for complete count and differential count as well. Electrolytes status was measured in the department of Biochemistry, CMOSGH. Electrolyte status was measured by using auto-analyzer (Konelab 30) is a random access clinical chemistry system for routine and special chemistries, including specific proteins, electrolytes, therapeutic drugs, and drugs of abuse tests. The broad range of characterized marked applications can be complemented with user definable tests. Prepared questionnaire and history sheet was filled up for each subject. A structured questionnaire was developed and revised after pre testing for the survey. Data presentation, statistical analysis and results were presented in the form of figures and tables. Collected data was checked for its completeness, correctness. Editing was done and then data were entered into computer. Analysis was done

by using Statistical Package for Social Science (SPSS version 15.0) software package [7]. Data were expressed as mean ± SD, number of patients and percentage of patients. P<0.05 was considered as minimum level of significance.

3. RESULTS

3.1 Characteristics of the Pyogenic and Tubercular Meningitis

In the observation, we found that 71 female and 29 male patients were infected to pyogenic and tubercular meningitis. It is may be due to our lack of awareness about female children. In male patients, 5.26% and 30% hypernatramic patients were found in PG and TB meningitis respectively. 10.526% PG and 30% TB meningitis hyponatramia. In case of female, the hypernatramic patients were found in 55.55% PG and 0% TB meningitis. The hyponatramic patients were in 30.20% PG and 0% TB meningitis. The hyponatramic were found 31.57% and 30% in TB meningitis. In female there were no hypochloremic patients in both cases. But hyperchloremic patients were 61.11% PG and 13.20% TB meningitis. 20% TB meningitis in male patients was hyperchloremic. But the hypochloremic were 31.58% PG and 30% in TB meningitis. There is no hyperkalemia in PG meningitis in case of male. But TB meningitis would 24.52% hyperkalemic in females. In HCO_3^- there was no increase or decrease of its level I TB and PG meningitis in male. But 21.05% male PG meningitis patients were showed elevated HCO_3^- level. In female patients 16.60% PG and 5.66% TB meningitis were increased and decreased HCO_3^- level respectively. The characteristics of Pyogenic and Tubercular meningitis are summarized in Table 1.

Table 1. Characteristics of the Pyogenic and Tubercular Meningitis

	Pyogenic	Tubercular
Age (Month)	32days - 78months	32days - 78months
Fever (%)	0	90
Vomiting (%)	56.756	84.126
Convulsion (%)	97.29	90.476
Neutrophil % (blood)	53.05 ± 18.65	61.83 ± 19.12
Lymphocyte % (blood)	42.35 ± 18.73	34.29 ± 19.0
Neutrophil (C.S.F.)	>70%	0
Lymphocyte (C.S.F)	0	>70%
ESR	65.08 ± 33.42	61.03 ± 42.88
Hb	9.93 ± 0.92	8.99 ± 2.75
Na+ mmol/l	141.24 ± 5.82	139.35 ± 5.54
Cl- mmol/l	102.80 ± 6.08	101.95 ± 8.24
K+ mmol/l	4.72 ± 0.67	4.78 ± 0.61
HCO_3- mmol/l	24.08 ± 5.48	25.09 ± 2.00

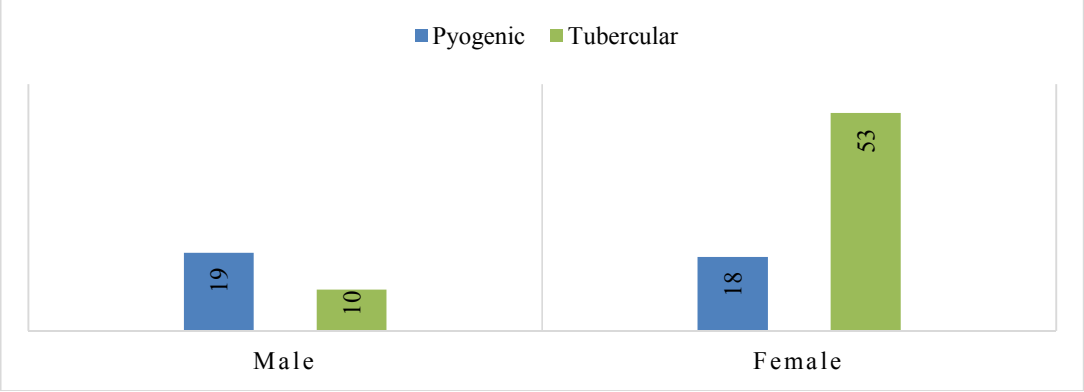

Fig. 1. Comparison between tubercular and pyogenic meningitis in male and female

3.2 Comparison of Meningitis in Male and Female Patients

There are two types of meningitis found in the study, Pyogenic and Tubercular. Total sample of this observation were 100. Among them 29 were male patients and 71 were female. In case of classification, among the 29 male patients 19 of them were Pyogenic and 10 of them were Tubercular. But in case of female patients 53 were Pyogenic and 18 of Tubercular among 71 patients. The graphical representation is given in Fig. 1.

3.3 Comparison of Na^+Change in Case of Meningitis between Male and Female

In case of children meningitis Na^+ was changed. Sometimes it was elevated and sometimes it was decreased. But in maximum cases it was in normal level. In male patients, the percentage of Na ion increase in Pyogenic and Tubercular meningitis were 5.26% and 30% respectively. The percentage of Na^+ ion decrease in Pyogenic and Tubercular meningitis were 10.536% and 30% respectively. In case of female patients, the percentage of Na ion increase in Pyogenic and Tubercular meningitis were 55.55% and 0% respectively. The percentage of Na ion decrease in Pyogenic and Tubercular meningitis were 13.20% and 0% respectively. The graphical representation is shown in Fig. 2.

3.4 Comparison of Cl^- Change in Case of Meningitis between Male and Female

Cl^- ion is an important ion for meningitis treatment. In case of children meningitis Cl^- ion was changed. Sometimes it was elevated and sometimes it was decreased. But maximum cases it was in normal level. In male patients, the percentage of Cl^- ion increase in Pyogenic and Tubercular meningitis were 0% and 20% respectively. The percentage of Na^+ ion decrease in Pyogenic and Tubercular meningitis were 31.57% and 30% respectively. In female patients, the Cl^- ion increases in Pyogenic and Tubercular meningitis were 61.11% and 13.20% respectively. No decreased value had been observed. The graphical representation is shown in Fig. 3.

3.5 Comparison of K^+ ion Change in Case of Meningitis between Male and Female

In children meningitis K^+ ion changed observed is presented in Fig. 4. It shows variable result throughout the study. But in maximum cases it was in normal level. In male patients, the percentage of K^+ ion increase in Pyogenic and Tubercular meningitis were 0% and 20% respectively. The percentage of Na^+ ion decrease in Pyogenic and Tubercular meningitis were 31.58% and 30% respectively. In female patients, the K^+ ion increases in Pyogenic and Tubercular meningitis were 0% and 24.52% respectively. No decreased value had been observed in the graphical demonstrations.

3.6 Comparison of HCO_3^- Change in Case of Meningitis between Male and Female

In children meningitis HCO_3^- ion changed observed. It shows variable result throughout the study. But in maximum cases it was in normal level. In male patients HCO_3^- level was elevated in pyogenic meningitis. There is no change of others values. In female patients, the percentage of HCO_3^- ion increase in Pyogenic and Tubercular meningitis were 0% and 5.66% respectively. The percentage of HCO_3^- ion decrease in Pyogenic and Tubercular meningitis were 16.66% and 0% respectively. The graphical representation is given in Fig. 5.

Table 2. Male pyogenic correlations

		Na^+	Cl^-	K^+	HCO_3^-
Na^+	Pearson Correlation	1	0.729 (**)	0.779 (**)	-0.499 (*)
	Sig. (2-tailed)	.	0.000	0.000	0.030
Cl^-	Pearson Correlation	0.729 (**)	1	0.829 (**)	-0.475 (*)
	Sig. (2-tailed)	0.000	.	0.000	0.040
K^+	Pearson Correlation	0.779 (**)	0.829 (**)	1	-0.616 (**)
	Sig. (2-tailed)	0.000	0.000	.	0.005
HCO_3^-	Pearson Correlation	-0.499 (*)	-0.475 (*)	-0.616 (**)	1
	Sig. (2-tailed)	0.030	0.040	0.005	.

*** Correlation is significant at the 0.01 level (2-tailed), * Correlation is significant at the 0.05 level (2-tailed). Na^+, Cl^-, K^+ each and every one was positively correlated. But HCO_3^- was negatively correlated of those electrolytes in PG meningitis in male patients.*

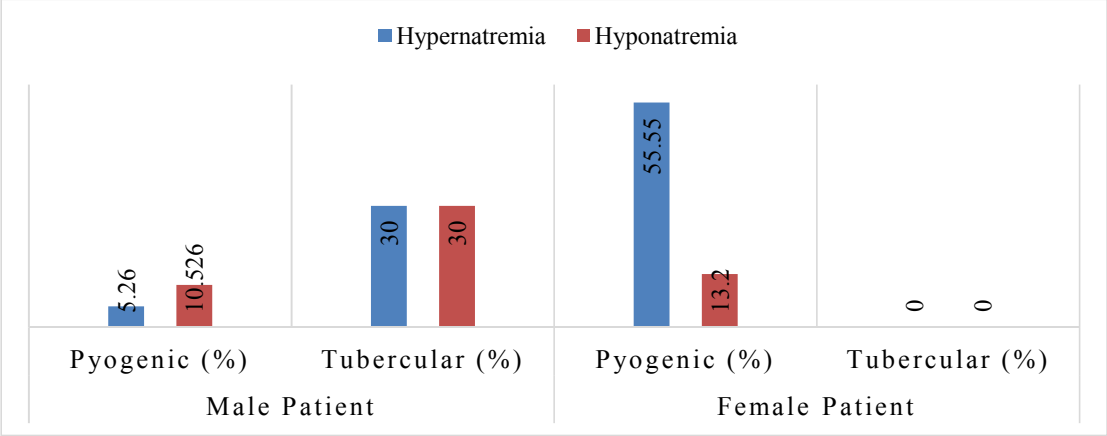

Fig. 2. Comparison between tubercular and pyogenic meningitis in male and female

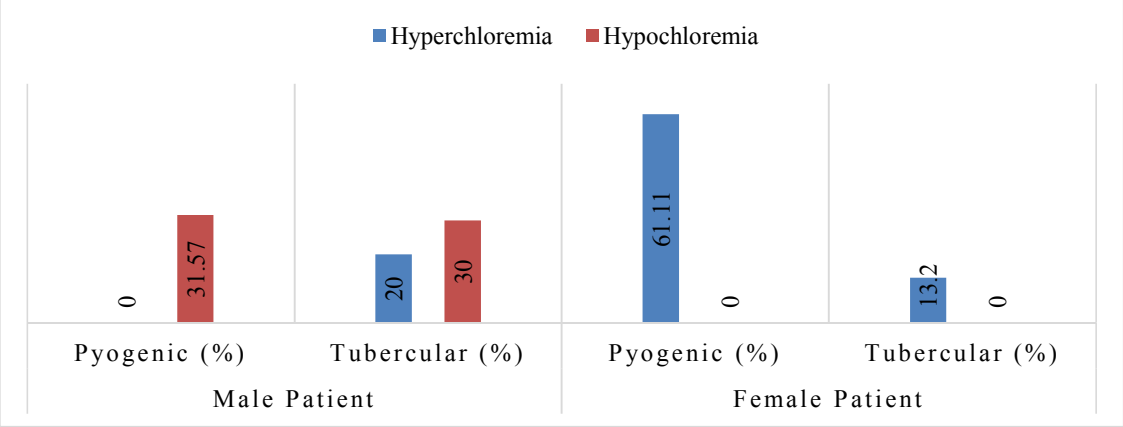

Fig. 3. Cl^- ion change in case of meningitis in male and female patient

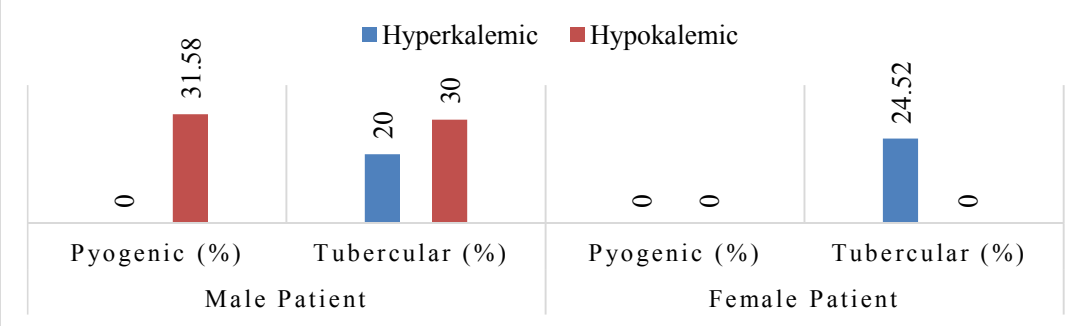

Fig. 4. K^+ ion change in case of meningitis in male and female patients

3.7 Correlation of Different Electrolytes in Meningitis Patients

A correlation is existed among the electrolytes in patients of PG and TB patient in male and female respectively. This correlation table shows the relationship of the electrolytes in Tables 2 and 3 of PG meningitis in male and female respectively and in Tables 4 and 5 showed the correlation among the electrolytes in TB meningitis patient in male and female.

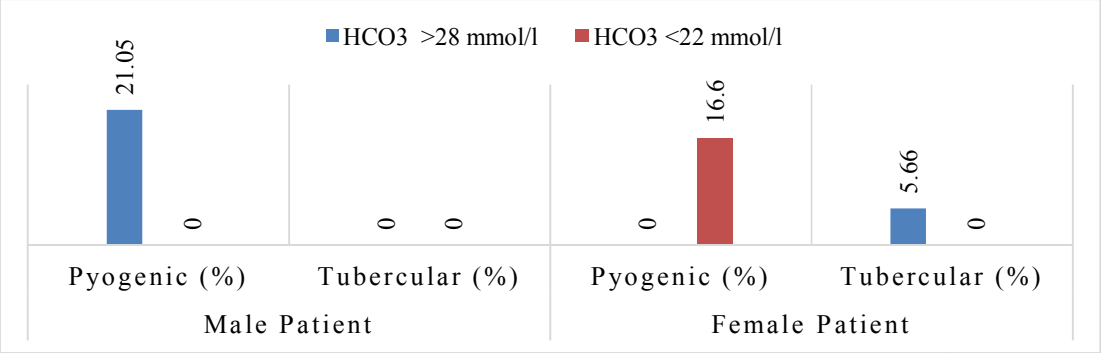

Fig. 5. HCO_3^- change in case of meningitis in male and female

Table 3. Female pyogenic correlations

		Na^+	Cl^-	K^+	HCO_3^-
Na^+	Pearson Correlation	1	0.166	-0.739 (**)	-0.221
	Sig. (2-tailed)	.	0.510	0.000	0.378
Cl^-	Pearson Correlation	0.166	1	0.227	0.722 (**)
	Sig. (2-tailed)	0.510	.	0.364	0.001
K^+	Pearson Correlation	-0.739 (**)	0.227	1	0.419
	Sig. (2-tailed)	0.000	0.364	.	0.084
HCO_3^-	Pearson Correlation	-0.221	0.722 (**)	0.419	1
	Sig. (2-tailed)	0.378	0.001	0.084	.

*** Correlation is significant at the 0.01 level (2-tailed), Here Cl^- and HCO_3^- had positive correlation in case of female pyogenic meningitis. But there were no correlation of other electrolytes in case of female pyogenic meningitis.*

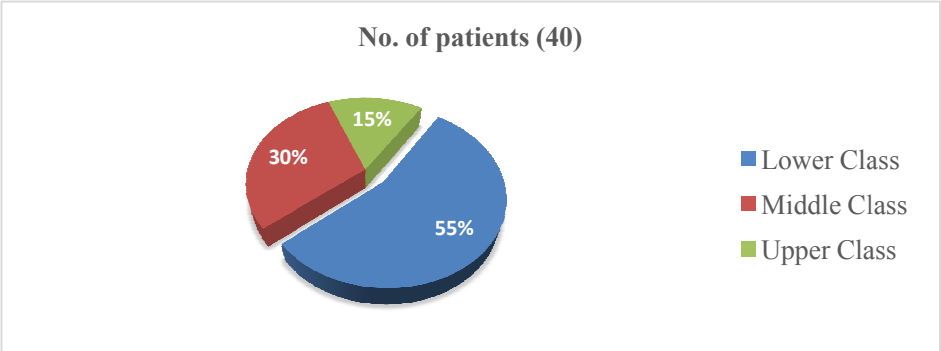

Fig. 6. Pie chart of patients according to socioeconomic status.

Table 4. Male tubercular correlations

		Na^+	Cl^-	K^+	HCO_3^-
Na^+	Pearson Correlation	1	0.989 (**)	-0.234	-0.647 (*)
	Sig. (2-tailed)	.	0.000	0.515	0.043
Cl^-	Pearson Correlation	0.989 (**)	1	-0.103	-.0659 (*)
	Sig. (2-tailed)	0.000	.	0.776	0.038
K^+	Pearson Correlation	-0.234	-0.103	1	-0.259
	Sig. (2-tailed)	0.515	0.776	.	0.470
HCO_3^-	Pearson Correlation	-0.647 (*)	-0.659 (*)	-0.259	1
	Sig. (2-tailed)	0.043	0.038	0.470	.

*** Correlation is significant at the 0.01 level (2-tailed), * Correlation is significant at the 0.05 level (2-tailed). In case of tubercular meningitis in male patients there were positive correlation between Na^+ and Cl^- level. But there were no correlation between Na^+ and K^+ level. Na^+ and HCO_3^- were negatively correlated.*

Table 5. Female tubercular correlations

		Na^+	Cl^-	K^+	HCO_3^-
Na^+	Pearson Correlation	1	-0.204	-0.099	0.354 (**)
	Sig. (2-tailed)	.	0.142	0.479	0.009
Cl^-	Pearson Correlation	-0.204	1	0.572 (**)	-0.627 (**)
	Sig. (2-tailed)	0.142	.	0.000	0.000
K^+	Pearson Correlation	-0.099	0.572 (**)	1	-0.849 (**)
	Sig. (2-tailed)	0.479	0.000	.	0.000
HCO_3^-	Pearson Correlation	0.354 (**)	-0.627 (**)	-0.849 (**)	1
	Sig. (2-tailed)	0.009	0.000	0.000	.

*** Correlation is significant at the 0.01 level (2-tailed).*

Na^+ were positively correlated with HCO_3^-, but HCO_3^- was negatively correlated with Cl^-. K^+ was positively correlated with Cl^- but negatively correlated with HCO_3^- in tubercular meningitis in female patients.

Table 6. Distribution of patients according to socioeconomic status

Socioeconomic status	No. of patients (100)	% of patients
Lower class	55	55%
Middle class	30	30%
Upper class	15	15%

3.8 Patients According to Socioeconomic Status

By the close observation and analyzing the statistical data it is said that the lower class family is at high risk in attack of meningitis shown in Table 6 and Fig. 6.

4. DISCUSSION

In human body, there is a correlation between Na^+ and K^+ level. It could not be altered in meningitis. In extracellular fluid the concentration of Na^+ and K^+ level were decreased. In case of hyponatramia syndrome of inappropriate anti diuretic hormone secretion were observed. In case of pyogenic meningitis in male patients the Na^+, Cl^-, K^+ each and every one were positively correlated. But HCO_3^- was negatively correlated. Here Cl^- and HCO_3^- are positively correlated in case of female pyogenic meningitis patients. But there were no relation of other electrolytes in case of female pyogenic meningitis. In case of tubercular meningitis in male patients there were positive correlation between Na^+ and Cl^- level. But there is no relation between Na^+ and K^+ level. Na^+ and HCO_3^- were negatively correlated. In case of female tubercular meningitis patients Na^+ was positively correlated with HCO_3^-, but HCO_3^- were negatively correlated with Cl^-. K^+ was positively correlated with Cl^- but negatively correlated with HCO_3^-. According to the chart it is perceived that the lower class families are in high risk in attack of meningitis. The fundamental problem in syndrome of inappropriate antidiuretic hormone (ADH) secretion is a failure to maximally suppress vasopressin secretion [8]. Excess ADH secretion results in water retention and volume expansion, leading to weight gain and natriuresis. Serum osmolality falls below the reference range [9]. Hyponatremia does not develop unless the patient is ingesting or receiving some source of free water [10]. The natriuresis, which occurs in syndrome of inappropriate antidiuretic hormone secretion despite hyponatremia and further contributes to hyponatremia, is produced by a decrease in proximal tubular sodium reabsorption, secondary to the expansion of the extracellular fluid volume [11]. Hypervolemia suppresses the renin-angiotensin-aldosterone system during the water retention phase, but later, circulating levels of renin and aldosterone rise again, perhaps in response to hyponatremia [12]. Careful management of fluid and electrolyte balance is important in the treatment of meningitis. Over or under hydration are associated with adverse outcomes. Many children have increased antidiuretic hormone secretion, and some will have dehydration due to vomiting, poor fluid intake or septic shock [13,14]. Hyponatramia occurs in about one third of children with meningitis, and may be due to increased ADH secretion, increased urine sodium losses, and excessive electrolyte-free water intake or administration [15-17]. Children with meningitis require careful and regular monitoring of: clinical signs of hydration state, including signs of over hydration, serum sodium and laboratory markers of hypovolaemia. Under most circumstances any intravenous fluids given to a child with meningitis should be isonatraemic e.g. Plasma-Lyte 148 or 0.9% sodium chloride (normal saline) with additional glucose [18,19]. Hyponatramic solutions (e.g. 4% dextrose and one-fifth normal saline), which deliver excess free-water, may

worsen hyponatraemia and increase the risk of cerebral oedema, and have no place in the management of meningitis [20,21]. In our analysis Na^+ and Cl^- level were elevated in some cases may be due to the different samples. In previous analysis the samples were serum. But in this study it was CSF. In meningitis the K^+ level were normal. We found that, age between 32 days to 12 months baby, are at high risk to get infection of meningitis.

5. CONCLUSION

It is suggested that the serious vomiting and prolonged low food intake can explain the electrolyte disturbances in meningitis in the early stages of the disease. Electrolytes are important because they are what cells (especially nerve, heart, muscle) use to maintain voltages across their cell membranes and to carry electrical impulses (nerve impulses, muscle contractions) across themselves and to other cells. Kidneys work to keep the electrolyte concentrations in blood constant despite changes in body. There is no chance to ignore this parameter for treatment of meningitis. The abnormality is not due to a deficiency of any one electrolyte, but is probably due to a combined deficit of sodium, chloride, and potassium. Insurance of an adequate electrolyte intake may be an important contributory factor to the recovery of patients with meningitis. There were several limitations of the present study. The major limitation of our study was the number of children in terms of gender is not paired, which causes a great bias in order to interpret the results.

CONSENT

As per international standard or university standard, patient's written consent has been collected and preserved by the authors.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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