Serum Sodium level as a Prognostic Indicator of Acute Bacterial Meningitis

By

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Abstract

Background: The most frequent central nervous system illness is acute bacterial meningitis (ABM). It is a fatal condition, especially in newborns and infants (under age of one year).

The aim: of this work was to determine the incidence of hyponatremia in ABM in pediatric patients admitted at Aswan University Hospital and to study different **factors associated with** hyponatremia in bacterial meningitis regarding hospital stay, mortality, and outcomes .

Methods: This is a cross sectional study that was carried out on 65 infants and children aged < 5 years admitted at Aswan University hospital, pediatric department from April 2022 to march 2023, all studied patients were subjected to Full history taking and examination, general. Systemic and neurological followed by laboratory evaluation.

Diagnosis of bacterial meningitis was done by cerebrospinal fluid (CSF) cytology or antigen detection test &CSF culture .

Results: Nearly all the included patients in this study had fever (98%). Convulsions, and status epilepticus were reported in 86.2%, and 20% of the patients respectively, while Headache was found in 3.1% of patients. The most commonly detected neurological complication was hydrocephalous and focal neurological deficit found in 6.2% and 1.5% respectively. As regard the mean serum sodium level at admission it was 132.1 ± 2.6 meq/L with minimum of 127 meq/L. and maximum of 140 meq/L. At first week it was 133.4 ± 3.9 meq/L. with minimum of 126 meq/L. and maximum of 145 eq/L. At second week, it was 132.7 ± 3.8 meq/L. with minimum of 118 meq/L and maximum of 143 meq/L. At third week, it was 131.6 ± 4.5 meq/L. with minimum of 118 meq/L. and maximum of 137 meq/L.

The majority of participants discharged (89.2%), while only (10.8%) died. There was A statistically significant increase in the serum sodium level at first week, second week and third week when compared with serum sodium level at admission. The mean serum sodium level was reduced among died patients contrasted to patients discharged .

Conclusions: Hyponatremia was mild and was associated with worse outcome, a link was shown between serum sodium level at admission, during hospital stay and the incidence of complication in cases of bacterial meningitis, so the serum sodium level is considered as an indicator for outcome of acute bacterial meningitis, the lower the level of serum sodium the worse the outcome (morbidity and mortality).

Keywords: Acute Bacterial Meningitis, Hyponatremia

Introduction :

Acute bacterial meningitis (ABM) is a disease that is characterized by a rapid onset, high rates of mortality and morbidity, and the potential for an outbreak or epidemic **(Sonko MA, Senghore M, et al, 2019)**.

It is a disease that is particularly destructive in newborns (age < one month) and young infants (age < one year). The case-fatality rate of bacterial meningitis is as high as 30% **(Shieh HH, Raggazi SL, Glio AE, 2012)**, and neurological complications may develop in up to 50% of survivors **(Lucas MJ, Brouwer MC, van de Beek D, 2016)**. with severe complications that are dependant upon the patient's age and the organism responsible for the disease.

A diverse array of complications is associated with bacterial meningitis. These include both short-term and long-term effects, including deafness, cognitive impairment, hydrocephalus, learning disability, and convulsions **(Mahmoud S, Zandi H, Pourakbari B, Ashtiani MTH, Mamishi S, 2013)**. Localized neurological impairments, seizures, and subdural effusions comprise short-term complications.

Hyponatremia, which is characterized by a serum sodium concentration of less than 135 meq/L, is a condition that is particularly prevalent in individuals with neurological conditions due to the significant role of the CNS in the regulation of sodium and water homeostasis (**Spasovski G, Vanholder R, Allolio B, Annane D, Ball S, Bichet D, et al, 2014)**.

Studies on the hyponatremia clinical manifestation and prevalence in children with bacterial meningitis are scarce, with order to evaluate the prevalence, clinical presentation, diagnostic value, and hyponatremia influence on prognosis, hospitalization length, outcomes, and death rate among hyponatremia patients with bacterial meningitis, the study's objective was to report on this information.

Aim of this study: to determine the hyponatremia incidence in ABM in pediatric patients admitted at Aswan University Hospital, Pediatric department and to study different factors associated with hyponatremia as a prognostic factor in bacterial meningitis regarding hospital stay, mortality, and outcomes .

Ethical consideration :

1 .An informed oral and written was obtained from all parents of both patients and control groups before getting them involved in the study.

2 .The researcher explained the stages, the aims, the potential benefits and hazards of the study to all parents of the patients and control groups.

3 .The patients had the right to leave the study at any time.

4 .Confidentially and privacy were respected.

5 .Ethical approval was obtained from the ethics committee of the Pediatrics department at the faculty of medicine Aswan University

6 .No conflicts of interest are to be declared, as reported by the authors.

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Sample Size Calculation:

The STATCALC module of Epi-Info statistical package program Version 7.2.5 (CDC 2021, Atlanta, GA, U.S.A) was employed to determine the necessary sample size for this cross-sectional study design. The following assumptions were made: Confidence level = 95%; Design effect = 1; clusters = 1; Prevalence 4 % of children with meningitis in Pediatric department at Aswan university hospital (Lim MJ, Pek JH). Considering 10% possible non-response rate, 65 children were needed

Inclusion criteria

- infants with onset of bacterial meningitis in the first 90 days of life will be included in this study.
- diagnosed bacterial meningitis by CSF cytology or antigen detection test or CSF culture.
- suspected meningitis will be defined as the detection of a bacteria recognized to cause central nervous system infection from blood or another normally sterile site or head imaging consistent with bacterial meningitis.

Exclusion criteria :

- Any infant with one or more of the following:
- fungal isolate or viral encephalitis ,
- primary hepatic, renal, or cardiac failure;
- traumatic brain injury;
- pulmonary disease;
- hypoxic-ischemic encephalopathy,
- or intracranial hemorrhage in the past month and
- patient known epileptic or have inherited cause to have seizures like neurocutaneous syndromes

SYUDY PROCEDURE:

This cross sectional study was conducted on 65 infants and children aged < 5 years of age diagnosed of bacterial meningitis by CSF cytology or antigen detection test, CSF culture .

All studied patients were admitted to pediatric department, were subjected to the following:

1. Full history taking including present illness , past, developmental and family history.
2. Thoroughly clinical Examination: general ,systemic and neurological.

3 – Lab. Evaluation including:

*Complete CBC

* Kidney function test e.g. s.creatinine ,BUN

4-CSF examination :. (cytological, chemical, bacteriological &C/S)

5- serum sodium concentrations was evaluated on admission and then again weekly until discharge of the patient

6-Imaging study if indicated as :

- MRI , CT

-transcranial sonography

Statistical analysis

All data were collected, tabulated and statistically analyzed using SPSS 22.0 for windows (SPSS Inc., Chicago, IL, USA)**.**

Data were tested for normal distribution using the Shapiro Walk test. Qualitative data were represented as frequencies and relative percentages. Chi square test ($\chi 2$) and Fisher exact was used to calculate difference between qualitative variables as indicated. Quantitative data were expressed as mean ± SD (Standard deviation) for parametric and median and range for non-parametric data**.**

One-way ANOVA test was used to compare between more than two dependent groups of normally distributed variables. While Kruskal-Wallis test was used for non-normally distributed variables**.**

Repeated measures ANOVA test was used to compares means across one or more variables that are based on repeated observations of normally distributed variables. While Friedman test was used for non-normally distributed variables**.**

All statistical comparisons were two tailed with significance Level of P-value ≤ 0.05 indicates significant, $p < 0.001$ indicates highly significant difference while, $P > 0.05$ indicates Non-significant difference**.**

Results

Our result will be demonstrated in the following tables:

Table -1 Demographic and clinical data in studied patients

Item N=65		**No.**	**%**
Age (y)	**>1 month**	20	30.8%
	1 month : 1 year	32	49.2%
	1 years : 5 years	13	20%
` Sex	**Male**	44	67.7%
	Female	21	32.3%
Weight (kg)	**Mean ±SD**	6.5 ± 3.9	
Clinical data at admission	**Fever**	63	96.9
	Convulsions	56	86.1
	Anorexia	**38**	**58.5**
	Status epilepticus	**13**	**20**
	Headache	**2**	**3**
(PCPC)scale at admission : **range** **Mean ±SD** **at discharge:** **range** **Mean ±SD**	1-5 **1.61 ± 1.35** **1.6 – 6** **4.41±1.48**		
Duration of symptoms prior to admission (days)	**Mean ±SD**	5.49 ± 1.57	
Duration of symptoms after admission (days)	**Mean ±SD**	2.33 ± 0.5	
Duration of hospital stay (weeks)	**Range**	**2..4**	

(PCPC) : PEDIATRIC CEREBRAL PERFORMANCE CATEGORY

Table -2

Neurological complications in studied patients

Co-morbidity		N = 65 no.	. %
neurological complications	**Hydrocephalous**	4	6.2%
	Subdural empyema	0	0%
	Hemorrhage	0	0%
	Infarction	0	0%
	Focal neurological deficit	1	1.5%
	Brain abscess	0	0%

This table show neurological comorbidities in studied patients during hospital stay

There were 4 patients (6.2%) with hydrocephalous, while there no patients with subdural hematoma, hemorrhage, infarction and brain abscess, and 1 patients with focal neurological deficit 1.5%

Table -3 Routine Laboratory findings in studied patients

Lab. item	**Minimum**	**Maximum**	**Mean**	**±SD**
BL.Urea (mg/dl)	15	78	30.8	9.9
S.Creatinine.(mg/dl)	0.3	0.8	0.53	0.13
Hb (gm/dl)	8.3	15	11.3	1.4
WBCs (10^3)	3.9	23.3	12.7	4.5
PLT (10^3)	122	629	320.4	132.2
K++(meq/L)	3.1	5.9	4.3	0.7

Table-4 C.S.F. Finding in studied cases：

Item		**Studied patients (N = 65)** NO. %		
CSF culture	**No growth**	47	72.3%	
	E. Coli	10	15.3%	
	Strept agalactiae	7	10.7%	
	Strept pneumonia	1	1.5%	
	Minimum	**Maximum**	**Mean**	**±SD**
CSF WBCs/dl	100	17000	563.2	2155.6
CSF Protein(mg/dl)	3	797	94.6	156.4
CSF Glucose(mg/dl)	5	99	44.8	22.7

This table show laboratory data description of studied patients

As regard CSF culture, only 1 patient (1.5%) revealed strept. pneumoniae while E coli positive cultures were found in 10 patients (15.3%), in other 7 patients strept agalactiae positive cultures (10.7%) in remaining 47 patients (72.3%) revealed no growth CSF culture

Table 5 Outcome & comorbidities in the studied cases .

Comorbidities	**Studied patients (No.65)** N	%%
DVT (deep vein thrombosis)	3	30%
HAP (hospital acquired pneumonia)	4 (4 cases died 100%% mortality)	40%
DIC . (disseminated intra vascular coagulation) / HAP	3 (all of them died 100% mortality)	30%
Discharged	58	89.2%
Died	7	10.8%

This table shows that

There were 58 patients (89.2%) discharged, 7 dead patients (10.8%) in the studied patients. There were 10 patients (15.4%) with associated complications; 3 patients (30%) with DVT, 4 patients (40%) with HAP (all of them died with 100% mortality) and 3 patients (30%) with DIC/HAP, (all of them died with 100% mortality)

Table-6 Serum sodium (mmol/L.) follow- up in the studied patients

n = 65	**range**	**Mean±SD**		**Na level Median (IQR)**	**P-value**
Serum Na^{++} (at admission)	127-140	132.1	2.6	131(131 – 133)	**0.036 S**
Serum Na^{++} (1^{st} week)	126-145	133.4	3.9	132(131 – 134)	
Serum Na^{++} (2^{nd} week)	118-143	132.7	3.8	132(131 – 134)	
Serum Na^{++} (3^{rd} week)	118-137	131.6	4.5	132 (132 – 133.75)	

p-value < 0.05 is considered significant

This table shows a statistically significant elevation was observed in serum Na level at 1st week 2nd week and 3rd week when compared with serum Na level at admission (p-value = 0.036).

Table -7 Correlation of serum Na status with duration throughout study

		Follow								**X^2**	**P-value**
		At admission (n = 65)		**1st week (n = 64)**		**2nd week (n = 63)**		**3rd week (n = 59)**			
Na^{++}	**Normal**	8	12.3%	14	21.9%	11	17.5%	38	64.4%	**19.2**	**0.023 S**
	Mild hyponatremia	54	83.1%	44	68.8%	50	79.4%	19	32.2%		
	Mod. hyponatremia	3	4.6%	6	9.4%	0	0%	0	0%		
	Severe hyponatremia	0	0%	0	0%	2	3.2%	2	0.03%		

X2: chi-square test. S: p-value < 0.05 is considered significant.

This table show a statistically significant difference of serum Na throughout the study as at admission (p-value = 0.023), there were 8 patients (12.3%) normal, 54 patients (83.1%) with mild hyponatremia and 3 patients (4.6%) with moderate hyponatremia while there were no cases with severe hyponatremia. At 1st week, there were 14 patients (21.9%) normal, 44 patients (68.8%) with mild hyponatremia and 6 patients (9.4%) with moderate hyponatremia while there were no cases with severe hyponatremia. At 2nd week, there were 11 patients (17.5%) normal, 50 patients (79.4%) with mild hyponatremia and 2 patients (3.2%) with severe hyponatremia while there were no cases with moderate hyponatremia. At 3rd week, there were 38 patients (64.4%) normal, 19 patients (32.2%) with mild hyponatremia and 2 patients (0.03%) with severe hyponatremia while there were no cases with moderate hyponatremia

table 8:Correlation of serum Na level and outcome

		Prognosis		
		Discharged (n = 58)	**Complicated (n =10)**	**Died (=7)**
Na $^{++}$ (admission)	**Mean ±SD**	132.4 ± 2.4	130.4 ± 3.8	131.3 ± 1.5
	Range	130 – 140	127 - 138	130 – 133
Na $^{++}$ (1st week)	**Mean ±SD**	133.8 ± 4.07	132.7 ± 3.2	130.8 ± 2.4
	Range	126 - 145	128 - 139	129 – 134
Na^{++} (2nd week)	**Mean ±SD**	132.8 ± 4.1	132.7 ± 2.2	131.5 ± 0.54
	Range	118 - 143	131 - 137	131 – 132
Na $^{++}$ (3rd week)	**Mean ±SD**	130.9 ± 5.5	133.2 ± 2.5	132.4 ± 0.5
	Range	118 - 137	132 - 137	132 – 133

This table shows that

At admission: the mean Na level was 132.4 ± 2.4 with range of 130 - 140. At 1st week: the mean Na level was 133.8 ± 4.07 with range of 126 - 145. At 2nd week: the mean Na level was 132.8 ± 4.1 with range of 118 - 143. At 3rd week: the mean Na level was 130.9 ± 5.5 with range of 118 – 137. In the complicated patients, At admission: the mean Na level was 130.4 ± 3.8 with range of 127 - 138. At 1st week: the mean Na level was 132.7 ± 3.2 with range of 128 - 139. At 2nd week: the mean Na level was 132.7 ± 2.2 with range of 131 - 137. At 3rd week: the mean Na level was 133.2 ± 2.5 with range of 132 - 137. while In died patients at admission there were : the mean Na level was 131.3 ± 1.5 with range of 130 – 133. At 1st week: the mean Na level was 130.8 ± 2.4 with range of 129 – 134. At 2nd week: the mean Na level was 131.5 ± 0.54 with range of 131 – 132. At 3rd week: the mean Na level was 132.4 ± 0.5 with range of 132 - 133.

Discussion

According to Liamis et al. hyponatremia in the infection context specifically reflects the underlying disease state severity and is linked to a long hospital stay and severe morbidity **(Liamis G, Millions HJ, Elisaf M 2011)**.

In the present study patients 30.8% of them were < 1 month age, 49.2% aged 1month: 1 year and 20% age ranged from 1 year to 5years.

Dunbar and colleagues studied 43 pediatric patients had confirmed bacterial meningitis. It was found that 26% of them were neonates, 40% infants aged one month to one year and 37% children older than one year (37%) **(Dunbar M, Shah H, Shinde S, Vayalumkal J, Vanderkooi OG, Wei X-C, et al, 2018)**.

In the current study, male cases were 44 (67.7%) and females were 21 (32.3%). This agreed with an Egyptian study by Abdelkader et al. among bacterial meningitis pediatric patients; in which 64.7% were males, while 35.3% were females **(Abdelkader MM, Aboshanab KM, El-Ashry MA, Aboulwafa MM, 2017)**.

A study of Tibussek et al. and Dunbar et al. also showing males more prone to have CNS infection than females **(Dunbar M, Shah H, Shinde S, Vayalumkal J, Vanderkooi OG, Wei X-C, et al, 2018), (Tibussek D, Sinclair A, Yau I, Teatro S, Fittipaldi N, Richardson SE, et al, 2015)**.

At admission, 98% of patients had fever, and 86.2% had convulsions, 20% of them progressed to had status epileptic us. That was agreed with Snaebjarnardóttir et al. that showed that among all bacterial meningitis children, the most common symptoms were fever (92%) **(Snaebjarnardóttir K, Erlendsdóttir H, Reynisson IK, Kristinsson K, Halldórsdóttir S, Hardardóttir H, et al, 2013)** Also, according to Vasilopoulou and colleagues the vast majority of cases at initial presentation had fever (93.2%), with an estimated median body temperature of 39.0°C **(Vasilopoulou VA, Karanika M, Theodoridou K, Katsioulis AT, Theodoridou MN, Hadjichristodoulou CS, 2011)**.

Among bacterial meningitis children included in Zheng et al. study symptoms included fever (97.1%), and convulsions (53.1%) **(Zheng F, Ye X, Shi X, Lin Z, Yang Z, Jiang L, 2019)**.

In our study, 61.6 % of cases have needed to be admitted at intensive care unit with range duration of stay 1 - 4 weeks. Al-Mazrou et al. had observed that a quarter of bacterial meningitis children (25.4%) required admission to intensive care units (ICU) with a mean stay of 7 - 8 days **(Al-Mazrou YY, Musa EK, Abdalla MN, Al-Jeffri MH, Al-Hajjar SH, Mohamed OM, 2004)**.

Wee and coworkers study included confirmed bacterial meningitis children, it was found that ICU admission was required in 44% cases **(Wee LYJ, Tanugroho RR, Thoon KC, Chong CY, Choong CT, Krishnamoorthy S, et al, 2016)**.

According to Husain et al. study, 47% of the children with bacterial meningitis required admission to ICU **(Husain E, Chawla R, Dobson S, Davies HD, 2006)**.

The mean CSF WBCs of the current study patients was 563.2 ± 2155.6 WBC/μL. The mean CSF glucose of all studied patients was 44.8 ± 22.7. As regard the mean CSF protein, it was 94.6 ± 156.4 mg/dL with minimum CSF protein of 3. The mean WBCs of the studied patients was 12.7 ± 4.5 × 109/L with minimum WBCs of 3.9 and maximum WBCs of 23.3, which is higher than normal level. These observations are consistent with the findings of Uddin et al., who demonstrated that TLC had significantly increased in pyogenic meningitis **(Uddin MB, Rahman M, Siddique A, 2009)** .

The mean serum K level was 4.3 ± 0.7 109/L with minimum K level of 3.1 and maximum K level of 5.9. Supporting to this study, Nguyen-Huu et al. deteced that the mean potassium levels were 3.8 mmol/L, respectively **(Nguyen-Huu CD, Bui-Binh-Bao S, Tran KH, Mai VT, Nguyen-Thi DC, Tran-Thi HC, et al, 2022)**.

As regard CSF culture, our cases culture were negative in 47 patients (72.3%) while result were positive in only 18 patients (27%) revealing E. coli in 10 patients (15.3), strept agalactiae in7 cases (10.7%) and strept pneumonia in one patient (1.5%). Supporting to the current study Vasilopoulou and colleagues found that 17% of bacterial meningitis children had positive blood culture **(Vasilopoulou VA, Karanika M, Theodoridou K, Katsioulis AT, Theodoridou MN, Hadjichristodoulou CS, 2011)**.

Tan and coworkers studied neonates with bacterial meningitis, it was observed that bacteriological confirmation of meningitis was blood and **CSF** positive cultures of were obtained in (40.9%) cases and (72.8%) cases, respectively (**Tan J, Kan J, Qiu G, Zhao D, Ren F, Luo Z, et al, 2015)**.

Our research indicates that hyponatremia was observed in 87.6% of pediatric bacterial meningitis patients, with the majority of these cases being classified as mild. At admission, 8 patients (12.3%) had normal sodium level and 54 cases (83.1%) had mild hyponatremia and 3 patients (4.6%) with moderate hyponatremia while there were no cases with severe hyponatremia. In other words, there was a statistically-significant reduction in the serum sodium level at end of the 1st week, the 2nd week and 3rd week when compared with serum sodium level at admission, along with concomitant

improvement of the clinical condition of majority of patients.

Zheng et al. study supports our study, they have found that hyponatremia was observed in 66.4% of the meningitis patients measured and was categorized as mild in 44% , moderate in 14 %, and severe in 7.4% **(Zheng F, Ye X, Shi X, Lin Z, Yang Z, Jiang L, 2019)**.

The majority of our study participants; 58 patients (89.2%) were discharged after clinical and laboratory improvement, and 7 cases died (9.2%), and among all admitted patients there were 10 cases (15.4%) had complications and co-morbidities during hospital stay , these complications were as the following: Deep Vein Thrombosis (DVT), 3 cases (4.6% of all admitted cases) they have improved and discharged. Hospital-acquired pneumonia (HAP), 4 cases (6.1% of all admitted patients) three of them died and one case had improved and discharged. HAP/DIC, 4 cases (6.1% of all admitted cases) all of them died .

The serum sodium level in died patients as the following :

Case (1), the serum sodium levels at admission, at the end of third week, at the end of second week and at the end of first week post-admission were 131, 118, 118 and 126 mmol/L respectively. The direct cause of death was respiratory failure due to HAP leading to septic shock and multi-organ dysfunction. The duration of hospital stay was 4 weeks.

Case (2), the serum sodium levels at admission, at the end of third week, at the end of second week and at the end of first week post-admission were 130, 132, 131 and 129 mmol/L respectively. The direct cause of death was respiratory failure. The duration of hospital stay was 4 weeks.

Case (3), the serum sodium levels at admission, at the end of third week, at the end of second week and at the end of first week post-admission were 132, 130, mmol/L respectively and the direct cause of death was respiratory failure. The duration of hospital stay was 10 days

Case (4), the serum sodium levels at admission, at the end of third week, at the end of second week and at the end of first week post-admission were 133, 133, 133 and 134 mmol/L respectively. The direct cause of death was hospital acquired pneumonia complicated by septic shock and DIC. The duration stay was 4weeks.

Case (5), the serum sodium levels at admission, at the end of third week, at the end of second week and at the end of first week post-admission were 129, 131, 132 mmol/L respectively. The direct cause of death was respiratory failure and ventilator-acquired pneumonia and DIC. The duration stay was 3 weeks.

Case (6), the serum sodium levels at admission, at the end of third week, at the

end of second week and at the end of first week post-admission were 132, 129, 131and 130 mmol/L respectively. The direct cause of death was HAP, septic shock and DIC. The hospital stay duration was 4 weeks.

Case (7), the serum sodium levels at admission, at the end of third week, at the end of second week and at the end of first week post-admission were 130, 132, 134 and 131 mmol/L respectively. The direct cause of death was HAP/DIC (Disseminated Intravascular Coagulation). The hospital stay was 3 weeks.

This comes into agreement with Zheng et al. who stated that severe hyponatremia in bacterial meningitis children was associated with a significantly higher frequency of multiple organ dysfunction syndrome (MODS, p value = 0.016), shock (p value = 0.002), and acute respiratory failure requiring invasive mechanical ventilation (p value = 0.013) than normonatremia cases **(Zheng F, Ye X, Shi X, Lin Z, Yang Z, Jiang L, 2019)**.

Ouchenir and coworkers also had reported that among infants with bacterial meningitis, adverse sequelae were documented in 74% of the infants, including 7% deaths **(Ouchenir L, Renaud C, Khan S, Bitnun A, Boisvert A-A, McDonald J, et al, 2017)**.

Regarding neurological complications that occurred in our patients, 4 patients developed hydrocephalus (6.2%), 1 patient developed meningitis with focal neurological deficit (1.5%) (free CT brain), and there were no cases of cerebral hemorrhage, infarction or brain abscess .

Hsu et al. supporting our study, he reported that neurological complications developed through clinical course of young bacterial meningitis infants aged < 90 days in (76.5%) patients. The most common neurological complication was seizure (58.8%), then subdural effusion (47.1%), ventriculomegaly (41.2%), hydrocephalus (18.8%) and subdural empyema (21.2%) **(Hsu M-H, Hsu J-F, Kuo H-C, Lai M-Y, Chiang M-C, Lin Y-J, et al, 2018)** .

As regard GCS at admission, most of the patients had GCS ≥ 8 (93.8%) and only 6.2% with GCS < 8. At discharge, the mean GCS at discharge of all studied patients was 13.4 ± 3.48, ranging from 3 to 15.

At admission, the mean PCPC at admission of all studied patients was 1.69 ± 1.05 with minimum PCPC of 1 and maximum PCPC of 5. As at discharge, the mean PCPC at discharge of all studied patients was 1.61 ± 1.35 with minimum PCPC of 1 and maximum PCPC of 6.

According to Zheng et al. severe and moderate hyponatremia were linked to an elevation in some symptoms (disturbance, consciousness and convulsion), elevated maximum PCPC scores, reduced minimum

GCS scores, and increased CSF proteins levels, which are a pro-inflammation higher degree and clinical indicators of a more serious brain injury **(Zheng F, Ye X, Shi X, Lin Z, Yang Z, Jiang L, 2019)**.

Limitations: Lacking of long-duration follow-up, assessing neurodevelopmental outcomes, such as the intellectual profile and slowly-appearing hydrocephalus and presence of confounding factors, contributing to case –death that share in mortality other than fluctuation in serum electrolytes.

CONCLUSION

Our data suggest that hyponatremia is a common association in children with bacterial meningitis that share in complications of the disease, prolongation in hospital stay and increase the cost of treatment. Hyponatremia was generally mild and was associated with worse outcome, Hence our study show a link between serum sodium level at admission, during stay and the incidence of complication in the cases of bacterial meningitis ,the lower the sodium level, the higher the complication.

RECOMMENDATION

Studies with a larger number of patients may indicate possible sex-related or infecting organism-based differences.

Further studies are needed to evaluate the practice variations and effectiveness of treatment of hyponatremia in patients with pediatric bacterial meningitis, as well as the impact of various treatments on patient outcomes.

long term studies are needed to evaluate further neurodevelopmental outcomes, such as the intellectual profile ,and to eliminate the confounding factors participating in morbidity and mortality other than fluctuation in serum electrolytes.

A larger study is required to confirm our findings. Further work is also required to determine the etiological mechanism.

LIMITATIONS

Our study has some limitations summarized as the following:

Lacking of long-duration follow-up, assessing neurodevelopmental outcomes, such as the intellectual profile and slowly-appearing hydrocephalus.

Presence of confounding factors, contributing to case –death that share in mortality other than fluctuation in serum electrolytes.

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