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Original Article

Pattern of Electrolyte Imbalance among the Convulsive Patients Admitted in the Pediatric Critical Care Medicine Unit of a Tertiary care Hospital in Bangladesh

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Abstract

Background: *Convulsion is one of the most common neurological conditions that occur in children. Electrolyte imbalance is one underlying cause that, if managed appropriately, can prevent further recurrences of seizures. Hence, this study aims to assess the electrolyte imbalances that may be found in convulsive patients at a Pediatric Intensive Care (PICU) setting of a tertiary care hospital.*

Materials and methods: *It was a cross-sectional observational study carried out in the Department of Pediatrics of Chattagram Maa - Shishu O General Hospital. The study period was six months from January 2019 to July 2019. 100 study subjects aged one month to fifteen years admitted to the Pediatric ICU with convulsions were enrolled as study subjects. After stabilization of convulsions, detailed history and clinical examination were recorded. Along with other routine investigations, S. Electrolytes, S. Calcium and S. Magnesium were investigated and analyzed.*

Results: *The age range was 2 months to 8 years. Male participants were more than female, 73(73%) vs. 27(27%). Electrolyte imbalance was found in more than half 56(56%) of the children admitted. Among them hypocalcaemia was the most common finding 33(33%), followed by hypomagnesaemia 17(17%), hypokalemia 9(9%) and finally hyponatremia 7(7%). A significant number of patients with hyponatremia (p <0.001) and hypocalcemia (p<0.049) showed poor GCS score when it was compared with electrolyte imbalance. Encephalitis and complex febrile seizure were the common causes of convulsion in this study, 36(36%) and 32(32%) respectively. Meningitis, status epilepticus, cerebral palsy with seizure disorder and other causes were found in 13(13%) 10(10%), 3(3%) and 6(6%) cases, respectively. Electrolyte imbalances were mostly observed in cases with encephalitis 36(36%) complex febrile seizure 32(32%) and meningitis 13(13%). There are significant differences in calcium levels in cases with complex febrile seizure (p=0.02) and status epilepticus (p=0.006).*

Conclusion: *Electrolyte imbalances are common in children with convulsions. It occurs either as a consequence of an underlying cause of convulsion (eg, Febrile seizure) or can itself be the cause for convulsion in some cases. If these imbalances are corrected recurrence of convulsion as well as use of antiepileptic drugs can be limited.*

Key words: Convulsion; Electrolyte imbalance; Seizure.

INTRODUCTION

There are multiple causes for which children are admitted to the Pediatric Intensive Care Unit (PICU). Among those, neurologic causes are one of the most common, and convulsion is a frequent reason for admission, with etiology varying from a serious underlying neurological illness to electrolyte disturbances. Electrolyte abnormalities often develop or are frequently exacerbated during hospitalization and are associated with increased length of stay and mortality.[1]

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A convulsion is a type of seizure. Seizures involve bursts of electrical activity in the brain. Seizure is the most common pediatric neurological disease that occurs in 10% of children worldwide.[2]

In Bangladesh, there have been epidemiological surveys confirming that seizure disorders are common, with one study showing that 68 out of every 1000 children had a history of any seizure.[3]

When approaching a convulsive patient, finding the cause is necessary to prevent further deterioration of brain function. Some authors recommend the use of serum electrolytes in the evaluation of seizure etiology, others believe that these tests do not contribute much to seizure therapy and are costly and time-consuming.[2]

Acute and severe electrolyte imbalances can manifest as convulsive seizures. Seizures are more frequently observed in sodium disorders (Especially hyponatremia) hypocalcemia, and hypomagnesemia. Although these do not entail a diagnosis of seizure, they are classified as acute symptomatic seizure and are considered to have a different prognosis than unprovoked seizures.[4,5] Some researchers found that serum sodium levels were lower in children with febrile convulsions. A study conducted by Zifman et al. evaluated the impact of fever on sodium levels in children who presented with an episode of gastroenteritis.[6] While the presence or absence of fever did not affect the characteristics or duration of a seizure, mild hyponatremia with sodium levels between 126-134 mEq/L was observed to have increased the duration of seizures, in particular, along with an increased risk of status epilepticus.

Acute hypocalcemia can cause convulsive seizures or akinetic seizures without muscle tetany.[7] Infants with rickets may also be prone to seizures due to hypocalcemia.[8] Severe hypomagnesemia can cause convulsions in children (Especially infants) and adults. In a study conducted in the West Indies, hypomagnesemia was found in 3% of children between 6 months and 8 years who presented to the emergency department with fever and seizures.[9]

Hawas et al. had reported significantly lower mean serum sodium and potassium levels in children with febrile convulsion when compared to febrile children without convulsion and healthy children as well, however insignificant difference was observed for mean serum calcium levels.[10] Another study by Khalaf et al. reported a significant decrease in serum Na^+ and serum Ca^{2+} and a significant increase in serum K^+ in febrile children with convulsions.[11]

There is one more study in Iran, conducted by Salehiomran et al. which compared the electrolytes of normal children, children with simple febrile seizures and children with complex febrile seizures.[12] Children with simple and complex febrile seizures were significantly hyponatremic, but there was no significant difference observed in the potassium and calcium levels.

From the above literature, it is evident that a lot of work has been done regarding electrolyte imbalance and convulsive disorders in children. However, these study results are contradictory to one another. One common finding they can agree on is hyponatremia in febrile convulsions. Thus, this study was conducted to see the pattern of electrolytes abnormalities in convulsive children in a PICU and to find out the association of dyselectrolytemia with the underlying causes of convulsion.

MATERIALS AND METHODS

It was a cross-sectional observational study, conducted at Chattagram Maa Shishu-O-General Hospital. The study duration was six months from January 2019 to July 2019. Aged one month to fifteen years, were enrolled as study subjects. The children who were found to have low CBG (Capillary blood glucose) at the time of admission and the children with congenital malformation, syndromic children, or known cases of chromosomal or genetic disorders were excluded from the study. The type of sampling was purposive. A total of 100 cases were included in this study. Initially, convulsions were managed according to standard protocol as per Ciccone et al.[13] After stabilization and taking written informed consent from the caregivers, blood was sent for investigations. A details history was taken and a thorough clinical examination was done. All details were recorded in the case record form. Once the etiology was confirmed, treatment was given accordingly. All routine investigations like CBC, CRP, RBS, serum electrolytes, serum calcium, serum magnesium, serum creatinine, ALT/AST, urine R/E, X-ray Chest (CXR) were sent as soon as the patient was stabilized. CSF study, blood culture, and urine culture were done in patients suspected of systemic or CNS infection. EEG was performed within 24 hours after a seizure. CT and MRI were done when a severe structural brain lesion was suspected. In case of serum electrolytes, serum calcium, and serum magnesium, an auto analyzer was used to measure the concentration of different electrolytes in the sample. These investigations were done in the Biochemistry Department of Chattagram Maa- Shishu-O-General Hospital. The ethical clearance has been obtained from the ethical review committee. The collected data were analyzed using Statistical Package for the Social Sciences (SPSS) version 22.0. The Chi-square test was used to compare qualitative variables, and the Student t-test was used to determine quantitative variables. p-value <0.05 was considered significant. p-value <0.01 was considered highly significant. And p-value < 0.001 was considered very highly significant.

RESULTS

During this study period, a total of 100 children admitted to the Pediatric ICU with convulsions were included. The age range was 2 months to 8 years. Male participants were more than female, 73(73%) vs. 27 (27%). Among the study population, 77(77%) were belonging to less than 3 years of age.

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Table I Age and gender distribution of study subjects

Age group	Gender		Total
	Male	Female	
Infants (Less than 1 year)	24	6	30
Toddlers (1 to less than 3 years old)	31	16	47
Preschool (3 to less than 5 years old)	10	4	14
School (5 years and more)	8	1	9
Total	73	27	100

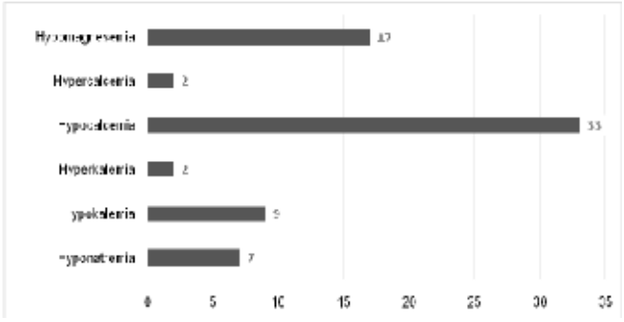

Figure 1 Pattern of electrolyte imbalances observed in study subjects (n=56)

Electrolyte imbalance was found in more than half 56(56%) of the children admitted. Among them hypocalcaemia was the most common finding 33(33%) followed by hypomagnesaemia 17(17%), hypokalemia 9(9%) and finally hyponatremia 7(7%).

7% of the study population was found to have a poor GCS Score (3-7). Moderate (8-13) and good (14-15) GCS scores were found in 51% and 40% of cases, respectively. A significant number of patients with hyponatremia ($p < 0.001$) and hypocalcemia ($p=0.049$) showed poor GCS score when it was compared with electrolyte imbalance.

Table II Diagnosis of cases based on different age groups

Diagnosis	Age group				Total
	Infants (< 1 yr)	Toddlers (1 - < 3 yrs)	Preschool (3 - < 5 yrs)	School (≥5 yrs)	
Complex Febrile Convulsion	10	18	4	0	32
Meningitis	4	7	2	0	13
Encephalitis	10	18	6	2	36
Cerebral Palsy with Seizure Disorder	0	0	0	3	3
Status Epilepticus	0	4	2	4	10
Others	6	0	0	0	6

Encephalitis and complex febrile seizure were the common causes of convulsion in this study, 36(36%) and 32(32%) respectively. Meningitis, status epilepticus, cerebral palsy with seizure disorder and other causes were found in 13(13%) 10(10%), 3(3%) and 6(6%) cases, respectively. Meningitis, encephalitis and complex febrile seizures were very frequent in the toddler age group and below one year of age. Cerebral palsy with seizure disorder and status epilepticus were mostly diagnosed in children 5 years of age and above.

Table III Electrolyte imbalance with the etiology of convulsion

Etiology	Electrolyte imbalance	Frequency
Complex Febrile Convulsion	Hyponatremia	2
	Hypokalemia	4
	Hypocalcemia	2
	Hypomagnesemia	6
Meningitis	Hyponatremia	2
	Hypokalemia	2
	Hypocalcemia	7
	Hypomagnesemia	0
Encephalitis	Hyponatremia	3
	Hypokalemia	3
	Hypocalcemia	14
	Hypomagnesemia	11
Cerebral Palsy with Seizure Disorder	Hyponatremia	0
	Hypokalemia	0
	Hypocalcemia	2
	Hypomagnesemia	0
Status Epilepticus	Hyponatremia	0
	Hypokalemia	0
	Hypocalcemia	6
	Hypomagnesemia	0
Others	Hyponatremia	0
	Hypokalemia	0
	Hypocalcemia	2
	Hypomagnesemia	0

Electrolyte imbalances were mostly observed in cases with encephalitis, meningitis and complex febrile seizures. Hypocalcaemia was the only abnormality observed in patients with status epilepticus and cerebral palsy with seizure disorder.

Table IV Serum calcium levels among study subjects based on diagnosis

Diagnosis	Number of cases	Mean	Std. Deviation	Minimum	Maximum	p- value
Complex Febrile Convulsion	32	9.4063	0.33787	8.80	10.00	0.020
Meningitis	13	8.7308	0.45531	7.80	9.10	0.297
Encephalitis	36	9.2306	0.91957	5.10	10.40	0.304
Cerebral Palsy with Seizure Disorder	3	8.8667	0.11547	8.80	9.00	0.229
Status Epilepticus	10	8.28	1.34891	5.80	9.60	0.006
Others	6	9.6333	1.06708	8.80	11.00	0.152

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Table V Serum magnesium levels among study subjects based on diagnosis

Diagnosis	Number of cases	Mean	Std. Deviation	Minimum	Maximum	p- value
Complex Febrile Convulsion	32	1.9384	0.11939	1.7	2.12	0.740
Meningitis	13	1.9531	0.14121	1.8	2.22	0.590
Encephalitis	36	1.9214	0.12829	1.7	2.14	0.349
Cerebral Palsy with Seizure Disorder	3	2.2533	0.26558	2.1	2.56	0.570
Status Epilepticus	10	2.066	0.1847	1.8	2.32	0.181
Others	6	2.0167	0.14376	1.9	2.2	0.960

There are significant differences in calcium levels were found in cases with complex febrile seizure (p=0.02) and status epilepticus (p=0.006). No significant difference was found in magnesium level in study subject with different causes of convulsion.

DISCUSSION

Seizures are the most common neurological disorder in pediatric patients, affecting about 10% of children. Most of these seizures are provoked and have an underlying cause that originates outside the brain, such as high fever, infection, head trauma, electrolyte imbalance etc. Less than one-third of convulsive seizures are caused by epilepsy. [14]

A total of 100 children who were admitted to the PICU with a convulsion were selected for this study. Apart from their presenting complaints and physical examination, serum electrolytes were investigated and variations in sodium, potassium, magnesium and calcium were observed.

The ages of respondents were between 2 months to 8 years, with a mean of 1.9 years. 91% of the study population was below 5 years of age. A study by Muley et al. showed occurrences of seizures to be greatest in the 1-month to less than 5-year-old age group.[15] There were more male patients than female ones, a finding that was similar to the study by Muley et al.[15] However, neither of the studies could show a significant difference in gender variation. Recurrences of convulsions were more common when the first seizure occurred early in life, as stated by Arzimanoglou et al.[16] Furthermore; it was found that the risk was highest for infants in the 1st year of life and lowest for those above 4 years of age. This might explain why more than two-thirds of our patients were below 3 years of age.

Fever was the most common symptom among the study population. This finding was observed in multiple other studies.[15,17,18,19] Other symptoms were drowsiness, respiratory distress and loss of consciousness.

In this study, a significant association was found between poor GCS score and hyponatremia as well as hypocalcemia. Association between hyponatremia and low GCS was mentioned in a study by Pillai et al. regarding hypocalcaemia, no study could be found showing such an association.[20]

Studies have found febrile seizures to be more common in the age group 0-2 years and more in male children.[21] In our study, the infants and toddlers age group were mostly diagnosed with complex febrile seizures and hence supports this statement to some extent.

The most common electrolyte imbalance was hypocalcemia, affecting 33% of the total study subjects. The other electrolyte imbalances in decreasing order of frequency were hypomagnesemia, hypokalemia and hyponatremia. Several studies found calcium levels to be decreased in children with convulsions irrespective of etiology.[11,22,23] The same is the case for magnesium levels.[24,25] This is because both hypocalcaemia and hypomagnesaemia can irritate the central nervous system, resulting in seizures.[7] In this study, when an ANOVA test was conducted, a significant difference was found in the levels of calcium and magnesium between the different diagnoses, hence making the study more plausible.

Hyponatremia was a common finding in children diagnosed with febrile seizures.[26] In our study, cases with hyponatremia were almost evenly distributed between complex febrile convulsions, meningitis, and encephalitis. One explanation could be that meningitis and encephalitis patients also present with fever. Nevertheless, it is not possible to assign an absolute value for hyponatremia or hypernatremia in case of seizures, since rapid changes in sodium levels can also trigger a convulsion.[27] In other words, even if a child has sodium levels within the normal range, he/ she could have a convulsion if there has been a sudden change in their serum levels.

Variations in potassium levels are a rare cause of convulsions.[4] Nevertheless, this study found nine patients with hypokalemia and two with hyperkalemia. Some study reports hypokalemia as a frequent finding and hyperkalemia as an occasional finding in patients presenting with seizures.[2] However, changes in potassium levels were not associated with the frequency of seizures, suggesting that the finding may be due to other causes.

LIMITATIONS

This study was not without limitations. The limitations of the study were as follows:

- Small sample size of the study population
- The study was a single-center study
- Since the sampling method was purposive, convenient sampling, there is a chance of observer bias that could have occurred.
- Due to budget and resource limitations, long-term follow-up of the patients was not possible.
- Levels of trace elements like zinc were not evaluated.

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CONCLUSION

The prevalence of convulsions was more common in children below 3 years of age and males. The most common etiology was encephalitis, followed by complex febrile seizures. The most common electrolyte imbalance observed was hypocalcemia. Imbalances in electrolytes, such as hyponatremia and hypocalcemia, were found more commonly in children who presented with poor GCS score.

RECOMMENDATIONS

A diagnosis should be made promptly and precisely in order to establish a successful management of a convulsive seizure. Suspicion, rapid identification, and correction of an underlying electrolyte imbalance (Rather than an antiepileptic treatment) are of crucial importance in controlling convulsions and preventing permanent brain damage.

DISCLOSURE

All the authors declared no competing interest.

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