ELECTROLYTE DISTURBANCES IN CRITICALLY ILL CHILDREN ADMITTED TO PAEDIATRIC TERTIARY CARE CENTRE

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ABSTRACT

BACKGROUND
To study the incidence, aetiology and length of ICU stay in children admitted to Paediatric Intensive Care Unit with electrolyte disturbances.

MATERIALS AND METHODS
Descriptive prospective study in children aged 1 month to 12 years.

RESULTS
Incidence of hyponatraemia (< 135 mEq/L) was 16.8%, hypernatraemia (> 145 mEq/L) 4%, hypokalaemia (< 3.5 mEq/L) 11.9% and hyperkalaemia (> 5.5 mEq/L) 2% respectively; 01 month - 4 years age (41.2%) group of our study population emerged as a susceptible age group to electrolyte disturbances with mean age of 4.36 ± 4.10 yrs. Hyponatraemia occurred in 64.7% of boys, hypernatraemia occurred in 75% boys, hypokalaemia and hyperkalaemia in 50% boys. Spectrum of illness in hyponatraemia includes CNS disorders (52.9%), GI disorders (17.6%) and sepsis (11.8%). In hypernatraemia all four children were diagnosed to have CNS disorders. In hypokalaemia group CNS disorders, GI disorders, sepsis and renal disorders were responsible for 58.3%, 16.7%, 8.3% and 8.3% respectively. In hyperkalaemia group, CNS and GI disorders were responsible for 50% each. Mean Length of Stay (LOS) in hyponatraemia was 8.18 ± 7.65 days, hypernatraemia 10.50 ± 4.65 days, hypokalaemia 9.0 ± 8.56 days and hyperkalaemia 9.50 ± 7.78 days. Mortality was 1.9 times higher in children with hyponatraemia and 1.2 times higher in children with hypokalaemia compared to normal serum levels.

CONCLUSION
Disturbances in the serum sodium and potassium levels during the ICU stay predicted an increased length of hospital stay. Early detection through regular monitoring and early correction may help in improving the outcome.

KEYWORDS
Sodium, Potassium, ICU Stay, Mortality.


BACKGROUND
Fluid and electrolyte abnormalities are common in critically ill children and often represent complications from underlying disease states or medications. Critical disorders such as pneumonia, seizures, meningocencephalitis, severe burns, trauma, sepsis, traumatic brain injury, heart failure, respiratory infections, acute gastroenteritis, postoperative state and congenital disorders lead to disturbances in fluid and electrolyte homeostasis. Intravenous Fluid (IVF) and volume management play a crucial role in achieving and maintaining this balance. Despite that, Intensive Care Unit (ICU) physicians do face daily difficulty in management of fluid status.[1,2] Electrolyte abnormalities can adversely affect the outcome; the serum levels of electrolytes should be closely monitored with serial measurements and treated properly.[3]

Dysnatraemias, especially hyponatraemia is one of the most common electrolyte disorders encountered in hospitals, occurring in approximately 11% - 30% of hospitalised children.[4-7] Plasma sodium plays a significant role in plasma osmolality and tonicity.[8] Hyponatraemia results from deficit of sodium or surplus of water. Impaired water excretion, inappropriate release of vasopressin, use of hypotonic fluids, redistribution of sodium and water, several drugs and primary illness all contribute to hyponatraemia. ICU-acquired hyponatraemia and hypernatraemia are common in critically ill patients and are associated with increased risk of hospital mortality.[9-16] Incidence of hypernatraemia in children admitted to PICU varies from 4% - 7%.[7,17-19] Predisposing factors include the administration of sodium bicarbonate solutions to correct metabolic acidosis, renal water loss through a concentrating defect from renal disease, gastrointestinal fluid losses through nasogastric suction, lactulose administration and water losses through fever.[18]

Potassium plays a key role in maintaining the resting membrane potential of the cell through the activity of Na+/K+-ATPase. Hypokalaemia and hyperkalaemia in ICU has been observed at an incidence of 12% - 15%.[7,20-24] and 2% - 6%.[7,25,26] respectively. Potassium is necessary for the electrical responsiveness of nerve and muscle cells and for the contractility of cardiac, skeletal and smooth muscle.
Drugs such as K+-losing diuretics are a frequent cause of mild hypokalaemia. Generally, patients are asymptomatic, although complaints of muscle spasms or cramps are common. Other drugs responsible for hypokalaemia, especially in the intensive care setting include Asthelia nebulisations, glucocorticoids, chemotherapeutic agents and laxatives. Renal failure, adrenal insufficiency, insulin deficiency and tissue damage from rhabdomyolysis, burns or trauma are predisposing factors for hyperkalaemia in critically ill patients.

MATERIALS AND METHODS
This prospective study was conducted over a period of one year and included critically ill children aged 1 month to 12 years admitted to a paediatric tertiary care hospital. Ethical clearance was obtained from Institutional Ethical Committee. Informed consent was obtained from the parents of all the children enrolled in the study.

Inclusion Criteria
Children of age group 1 month to 12 years, admitted in the PICU with severe clinical condition requiring intensive care, satisfying the criteria based on the Consensus Guidelines for PICUs in India, Indian Society of Critical Care Medicine (Paediatric Section) and Indian Academy of Paediatrics (Intensive Care Chapter).[27]

Exclusion Criteria
Include
1. PICU stay of less than 24 hours.
2. Infants < 1 month old.
3. Children transferred in from other service/civil hospital.
4. Children with already diagnosed electrolyte disturbances, e.g. Bartter syndrome.

At admission, detailed history was taken and systemic examination was recorded. Venous blood samples were obtained and serum electrolytes were estimated by using Combi line Ion-Selective Electrode (ISE). An Ion-Selective Electrode (ISE), also known as a specific ion electrode (SIE), is a transducer (or sensor) that converts the activity of a specific ion dissolved in a solution into an electrical potential, which can be measured by a voltmeter or pH meter.

If an electrolyte abnormality was diagnosed during ICU stay, complete blood count, random blood sugar, urea, creatinine, urine electrolytes, Arterial Blood Gas analysis (ABG), plasma osmolality and fractional excretion of sodium (PENa) were done. If required special investigations such as USG, x-ray, CT, MRI and other relevant investigations as required for diagnosis and treatment of patient were done.

In case of multiple electrolytes abnormalities, child was evaluated for abnormalities simultaneously. In case same electrolyte abnormality was noted multiple times during ICU stay, numbers of episodes of electrolyte disturbances were documented. For analysis outcome and other statistical calculations, electrolyte abnormality at an extreme range (e.g. lowest recording during ICU stay) was taken into consideration. During the ICU stay use of Intravenous Fluids (IVF), antibiotics, mannitol, diuretics and blood transfusion (PRBC, FFP, RDP) which would influence the electrolyte levels were noted.

Hyponatraemia in our study was defined as serum sodium < 135 mEq/L, hypernatraemia as > 155 mEq/L, hypokalaemia as < 3.5 mEq/L and hyperkalaemia as > 5.5 mEq/L.

Data was analysed using Statistical Package for Social Sciences version 19.0. The values were represented in Number (n) and Mean +/- SD. The following statistical values were employed: Mean, Standard deviation, Chi-square tests (x2) and level of significance (p).

RESULTS
A total of 160 cases were admitted during the study period, out of which 59 cases did not meet the inclusion criteria, thereby leaving 101 cases for the study.

Consort Flow Chart showing the Establishment of Electrolyte Disturbances

<table>
<thead>
<tr>
<th>Sodium disturbances</th>
<th>Potassium disturbances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hyponatraemia Incidence</td>
<td>Hypernatraemia Incidence</td>
</tr>
<tr>
<td>(n=17)</td>
<td>(n=4)</td>
</tr>
<tr>
<td>Hypokalaemia Incidence</td>
<td>Hyperkalaemia Incidence</td>
</tr>
<tr>
<td>(n=12)</td>
<td>(n=2)</td>
</tr>
</tbody>
</table>

Sex and Age Distribution
Of the 101 children studied, 61 (60.4%) were boys and 40 (39.6%) girls. Majority (56.4%) was in the age group of 1 month - 4 years, 23.8% of the children were between 5 - 8 years of age and the remaining 19.8% were between 9 - 12 years of age. Mean age of the study population was 4.36 ± 4.10 years. Distribution of age and sex were represented in Table 1.

Episodes of electrolyte disturbances include hyponatraemia 19, hypernatraemia 8, hypokalaemia 15 and hyperkalaemia 2. Combined hyponatraemia and hypokalaemia was noted in 2, hypernatraemia and hypokalaemia in 4.

Incidence
The overall incidence of hyponatraemia in our study was observed as 16.80% (n = 17), hypernatraemia was 4% (n = 4), hypokalaemia was 11.9% (n = 12) and hyperkalaemia was 2% (n = 2) respectively. Incidence of electrolyte disturbances was represented in Table 1.

Spectrum of Illness
Hyponatraemia occurred with higher frequency in disorders of the Central Nervous System and GI disorders followed by patients with sepsis admitted to our hospital. Similarly, hypernatraemia was noted in CNS disorders (100%). Hypokalaemia occurred with higher frequency in CNS and GI
disorders, while hyperkalaemia occurred in equal proportion in CNS disorders and GI disorders. Causes for different electrolyte disturbances were outlined in Table 2.

Length of the Hospital Stay
Majority of children with electrolyte disturbances had ICU stay of < 5 days. Mean Length of Stay (LOS) in hyponatraemia (8.18 ± 7.65 days), hypernatraemia (10.50 ± 4.65 days), hypokalaemia (9.0 ± 8.56 days) and hyperkalaemia (9.50 ± 7.78 days) was more compared to children requiring ICU stay with normal serum electrolyte levels, Table 3.

Inotrope and Ventilation
Of the 11 children who required inotropic support during the course of their ICU stay, 45.4% (n = 5) were hyponatraemic, 18.8% (n = 2) were hypokalaemic and 18.8% (n = 2) had combined electrolyte disturbances; 9.9% (n = 9) of children in our study population required to be mechanically ventilated, of which 44.4% (n = 4) were hyponatraemic and 22.2% (n = 2) were hypokalaemic during the course of the study as detailed in Table 4.

Mortality
Mortality was 1.9 times higher in children with hyponatraemia and 1.2 times higher in children with hypokalaemia compared to normal serum levels. Mortality was significantly higher among the ventilated group (77.7%) as compared to the non-ventilated study population (0%).

<table>
<thead>
<tr>
<th>Electrolyte Abnormality</th>
<th>Incidence No. (%)</th>
<th>Age Distribution No. (%)</th>
<th>Sex Distribution No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 m – 4 y</td>
<td>5 – 8 y</td>
<td>9 – 12 y</td>
</tr>
<tr>
<td>Hyponatraemia</td>
<td>17 (16.8)</td>
<td>7 (41.2)</td>
<td>3 (17.6)</td>
</tr>
<tr>
<td>Hypernatraemia</td>
<td>4 (4)</td>
<td>3 (75)</td>
<td>1 (25)</td>
</tr>
<tr>
<td>Hypokalaemia</td>
<td>12 (11.9)</td>
<td>5 (41.7)</td>
<td>3 (25)</td>
</tr>
<tr>
<td>Hyperkalaemia</td>
<td>2 (2)</td>
<td>1 (50)</td>
<td>0</td>
</tr>
<tr>
<td>P</td>
<td>0.16</td>
<td>0.5</td>
<td>0.23</td>
</tr>
</tbody>
</table>

Table 1. Demographic Characteristics and Incidence of Electrolyte Disturbances

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Hyponatraemia (n = 17)</th>
<th>Hypernatraemia (n = 4)</th>
<th>Hypokalaemia (n = 12)</th>
<th>Hyperkalaemia (n = 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. (%)</td>
<td>No. (%)</td>
<td>No. (%)</td>
<td>No. (%)</td>
<td>No. (%)</td>
</tr>
<tr>
<td>Respiratory disorders</td>
<td>1 (5.9)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sepsis</td>
<td>2 (11.8)</td>
<td>0</td>
<td>1 (8.3)</td>
<td>0</td>
</tr>
<tr>
<td>GI disorders</td>
<td>3 (17.6)</td>
<td>0</td>
<td>2 (16.7)</td>
<td>1 (50)</td>
</tr>
<tr>
<td>Renal disease</td>
<td>0</td>
<td>0</td>
<td>1 (8.3)</td>
<td>0</td>
</tr>
<tr>
<td>CVS</td>
<td>1 (5.9)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>CNS</td>
<td>9 (52.9)</td>
<td>4 (100)</td>
<td>7 (58.3)</td>
<td>1 (50)</td>
</tr>
<tr>
<td>Haematology</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>1 (5.9)</td>
<td>0</td>
<td>1 (8.3)</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>17 (100)</td>
<td>4 (100)</td>
<td>12 (100)</td>
<td>2 (100)</td>
</tr>
<tr>
<td>P</td>
<td>0.230</td>
<td>0.70</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Spectrum of Illness in Electrolyte Disturbances

<table>
<thead>
<tr>
<th>Electrolyte Abnormality</th>
<th>1 - 5 Days</th>
<th>6 - 10 Days</th>
<th>&gt; 10 Days</th>
<th>Statistical Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td>%</td>
<td>No.</td>
<td>%</td>
<td>No.</td>
</tr>
<tr>
<td>Hyponatraemia (n = 17)</td>
<td>9</td>
<td>52.9</td>
<td>5</td>
<td>29.4</td>
</tr>
<tr>
<td>Hypernatraemia (n = 4)</td>
<td>1</td>
<td>25</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Hypokalaemia (n = 12)</td>
<td>7</td>
<td>56.3</td>
<td>2</td>
<td>16.7</td>
</tr>
<tr>
<td>Hyperkalaemia (n = 2)</td>
<td>1</td>
<td>50</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 3. Length of Stay in Electrolyte Disturbances

<table>
<thead>
<tr>
<th>Electrolyte Abnormality</th>
<th>Inotrope Usage (n = 11)</th>
<th>Mechanical Ventilation (n = 9)</th>
<th>Mortality (n = 7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td>%</td>
<td>No.</td>
<td>%</td>
</tr>
<tr>
<td>Hyponatraemia (n = 17)</td>
<td>5</td>
<td>29.4</td>
<td>4</td>
</tr>
<tr>
<td>Hypernatraemia (n = 4)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Hypokalaemia (n = 12)</td>
<td>2</td>
<td>16.7</td>
<td>2</td>
</tr>
<tr>
<td>Hyperkalaemia (n = 2)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 4. Inotrope, Mechanical Ventilation and Mortality in Electrolyte Disturbances
DISCUSSION

The outcome of patient in a paediatric intensive care unit is dependent on multiple factors. The pre-ICU factors like severity of illness, treatment received before seeking intensive care, time and mode of transport required to reach the intensive care facility, etc. have a direct impact on the therapy and the outcome of the patient.

Electrolyte abnormalities were observed in 34.6% of the children getting admitted to PICU. Hyponatraemia was the commonest accounting for 16.8%. This is in contrast to incidence observed by Singh et al at 29.8% and Subba Rao et al 9.5%,[5,7] variation could be due to varied disease characteristics. Hypernatraemia in present study was noted in 4% of the critically ill children. This finding is in consistent with the studies by Michael D. Waite et al,[14] Richard Conway et al[21] and Singh et al[24] who observed hypokalaemia in 4.9% and 5.4% respectively, which were nearly comparable with our results.

Age and Sex Distribution

There was no statistical significance between sex predilection of the study population and the incidence of hypo and hypernatraemia. Stelfox et al[4] and O’Donoghue et al[13] reported hypernatraemia in 40% females and 60% males consistent with our results. The higher male preponderance in our study can be attributed to the higher male study population and Biju Thomas with mean age being 49.1 years and 25.5% were above 5 years of age.

Mean age of hyponatraemic children in our study was 6.15 ± 4.81 years. Similar age group comprised the study population in the prospective study conducted by Subba Rao and Biju Thomas with mean age being 49.1 ± 48.01 months. In hypernatraemia, the mean age of the study population was 1.58 ± 2.28 years in consistent with study by Subba Rao et al with mean age of 22.54 ± 32.4 months. Comparable with our studies, the mean age of hypokalaemic children in study by Subba Rao et al[7] was 48.45 ± 45.00 months. Singh et al[23] observed 41.8% children were under 1 year of age, 32.5% between 1 - 5 years and 25.5% were above 5 years of age. Sunil G et al[22] reported highest incidence of hypokalaemia (82%) in children between 1 - 5 years.

Spectrum of Illnesses

The observations in present study were consistent with the prospective study by Subba Rao et al,[7] wherein CNS cause accounted for 41.6% of the hyponatraemic admissions. Sitaraman S et al[28] found meningitis/encephalitis as single most important cause of hyponatraemia accounting for 20.5% of cases. Different causes reported by Singh et al[5] in their study were pneumonia (20%), acute gastroenteritis (20%), meningoencephalitis (12%), sepsis (8%), renal, CVS and liver causes (6.7%).

All the 4 cases of hypernatraemia in our study were due to CNS disorders. Consistent with our results Subba Rao et al[7] noted the causes for hypernatraemia as CNS (26.75), infections (26.7%) and GIT (18.8%).

Subba Rao et al[7] reported the most common causes of hypokalaemia were CNS (26.7%), infection (9.1%), CVS (9.1%), GIT (18.8%), respiratory (9.1%), renal (9.1%), haematology (9.1%) and others (18.8%), which were consistent with our studies. Sunil G et al[22] and Singh et al[23] reported renal disorders and diarrhoeal dehydration as most common causes of hypokalaemia.

Singhi et al[24] and Subba Rao et al[7] found the most causes of hyperkalaemia were CNS and infections.

Length of Stay

Mean length of stay in hyponatraemic (8.81 ± 7.65 days) and hypernatraemic children (10.50 ± 4.65 days) were more than normonatraemic children (4.63 ± 2.97 days). Presence of hyponatraemia has been associated with a significantly prolonged hospital stay. In the prospective study by Subba Rao et al[7] reported a significant increase in the length of stay among hypernatraemic children.

In another prospective study by Singhi et al,[5] reported that with increasing severity of hyponatraemia, the length of hospital stay in creased.


The length of hospital stay was increased with dyskalaemia. However, a statistical significant association was not noted. In consonant with present study, Singhi et al[23] and Eylem Eliacik et al[29] noted significant increased length of hospital stay with dyskalaemia.

Mortality

The overall mortality rate in our study population was 7%. Subba Rao et al[7] in their study observed that the risk of mortality is increased by 3 - 3.5 times in patients with hyponatraemia, when compared to those with normal sodium levels. Hyponatraemia has been associated with poor prognosis regardless of the clinical cause in the present study. This emphasises the need for early detection and institution of rational therapy for hyponatraemia.

In hypokalaemic group, mortality was estimated to be 1.2 times higher than normokalaemia consistent with results by Richard Conway et al,[21] Singh et al[23] and Subba Rao et al[7] noted 27.7% mortality in hypokalaemic children.

CONCLUSION

Disturbances in the serum sodium and potassium levels during the ICU stay predicted an increased length of hospital stay. Early detection through regular monitoring and early correction may help in improving the outcome.

REFERENCES


