



Changes in Serum Sodium and Potassium Levels in Paediatric Patients with Chest X-Ray Suggestive Severe Pneumonia: A Cross-sectional and Observational Study

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ABSTRACT

Introduction: Electrolyte disturbance commonly coexist with severe pneumonia. So, that the treating doctors must focus in balancing electrolyte status along with initial management of severe pneumonia to prevent complications.

Aims and objectives: To identify the incidence of dyselectrolytemia in children between 2 months to 5 years suffering with severe pneumonia.

Materials and methods: A cross-sectional and observational study conducted on 67 cases of severe pneumonia presenting in 2 months to 5 years of age and both genders. Thorough clinical and radiological screening done. Laboratory investigations CBC (complete blood count), Serum electrolyte (Serum Na and K), Renal function tests (urea, creatinine), urine sodium, serum osmolality and urine osmolality were done on admission day and then daily for next 3 days. Statistical Analysis were performed using Epi Info (TM) 7.2.2.2.

Results: Severe pneumonia was most prevalent in children with age 1- 5 years (67.2%). Out of 67, 44 (65.67%) had dyselectrolytemia, out of which 4 (9.09%) had mixed electrolyte imbalances. Hyponatremia (46.2%, n=31), hypokalemia (10.4%, n=7), hypernatremia (5.9%, n=4) and hyperkalemia (2.9%, n=2) were mostly seen. 86.57% (n=58) had normal but 13.43% (n=9) had abnormal level of potassium in which 77.78% (n=7) and 22.22% (n=2) has hypokalemia and hyperkalemia respectively. About, 57% (4 out of 7) children with hypokalemia also had hyponatremia also.

Conclusions: In view of these facts, regular estimation of serum electrolyte concentration and plasma and urine osmolality is necessary to guide appropriate fluid and electrolyte management of children with severe pneumonia requiring hospitalization.

Keywords: Serum Sodium, Serum Potassium, Severe Pneumonia, Paediatric patients.

INTRODUCTION

The advances made in the medical field with better antibiotics and immunization has reduced the incidence of lower respiratory tract infection in the developed world. However, pneumonia is currently the leading cause of death in children younger than 5 years in developing countries, accounting for approximately 20% of childhood deaths.¹ India is a developing country and pneumonia remains a significant cause of morbidity and mortality.

Electrolyte disturbances especially hyponatraemia have been described in a wide variety of acute infections including pneumonia.² Hypokalemia and hyperkalemia are other infrequent electrolyte disorders seen in pneumonia.³

The proposed explanations for the electrolyte abnormality in pneumonias are

1. Impairment of the intrarenal mechanism of urine dilution due to extra cellular fluid volume depletion.
2. Inappropriate Antidiuretic hormone secretion.^{4,5}

The latter has gained wide acceptance. Most of the studies have shown Syndrome of Inappropriate Antidiuretic Hormone secretion (SIADH) as the most probable mechanism of hyponatremia in respiratory tract infections.^{4,6}

Many a times electrolyte imbalances remain unrecognized for a significant period of time. They have a significant contribution to the morbidity and mortality, irrespective of the primary problem. The consequences may be dire if abnormalities of serum electrolyte concentration remain undetected and untreated. The therapeutic objective in the treatment of fluid and electrolyte imbalances in infants and children is to restore normal physiologic homeostasis.

To achieve this goal, timely recognition, a high index of suspicion and a thorough knowledge of the common electrolyte abnormalities are necessary. So regular monitoring of serum electrolyte concentration and plasma and urine osmolality is necessary to guide appropriate fluid and electrolyte management in children with severe pneumonia. The fluid therapy in children with severe pneumonia should be individualized and those with hypo-osmolality need fluid restriction.



Purpose of the Study

It has been documented that dyselectrolytemia commonly coexist with severe pneumonia. Rural areas of Bihar state have less economic development and people reach hospitalization late. Therefore, there is a need to study electrolyte changes in our hospital cases to see the existence of dyselectrolytemia in pneumonia so that the treating doctors may focus in balancing electrolyte status along with initial management of severe pneumonia to prevent complications.

Aim and Objectives: To identify the incidence of dyselectrolytemia in children between 2 months to 5 years suffering with severe pneumonia.

MATERIALS AND METHODS

Study site: Department of Biochemistry, Paediatrics and Radiodiagnosis of Narayan Medical College & Hospital, Jamuhar, Sasaram, Bihar.

Study design: Cross-sectional and observational study.

Study duration: 6 months (February 2023 to July 2023)

Study population: Children between 2 months to 5 years of age admitted in Ward/ NICU/ PICU of Department of Pediatrics in Narayan Medical College & Hospital, Jamuhar, Sasaram, Bihar and diagnosed with severe pneumonia clinically as per modified WHO / BTS guideline⁷ and radiologically confirmed using chest x-ray.

Sample size: The number of subjects included in this study was 67 with power 80%. (As per the study by Singhi et al the proportion of hyponatremia was associated with 60% longer hospital stay (i.e. $p = 0.60$). The formula used for sample size calculation was as follows

$$n = 4pq / (L^2), \text{ Where}$$

$n =$ Required sample size, $p = 0.6363$ (as per the study by Singhi et al.) $q = 1 - p$, $L =$ Loss % (Loss of information) = 20%, Thus $n = 67$

Inclusion criteria:

1. Infants > 2 months and Children < 5 years of age group of both the gender
2. Diagnosed cases of severe pneumonia clinically as per modified WHO / BTS guideline.⁷
3. Chest X-ray findings suggestive of severe pneumonia

Exclusion criteria:

1. Infants < 2 months of age.
2. Children > 5 years of age.
3. Children with renal disorders.
4. Children with associated CNS infections.
5. Children with gastroenteritis.

6. Children on drugs which can cause electrolyte imbalance such as diuretics, anti- convulsants etc.

Methodology

Severe pneumonia was defined according to modified WHO / British Thoracic Society guidelines⁷ and on confirmed radiological finding (Chest X-ray). Children with tachypnoea (Infants from 2 months to 1 year: Respiratory rate ≥ 50 breaths / min and children 1 to 5 years: Respiratory rate ≥ 40 breaths / min) and any one or more of the following criteria were included in the study.

- 1) Infants of 2 months to 1 year: chest recession, nasal flaring, cyanosis, intermittent apnoea, grunting respiration, not feeding, capillary refill time $>2s$, oxygen saturation $<92\%$.
- 2) Children of 1 to 5 years: chest recession, nasal flaring, cyanosis, grunting respiration, capillary refill time $>2s$, oxygen saturation $<92\%$.

At the time of enrolment an informed written consent was obtained from the parents. Detailed history was elicited from the parents/guardians with relevance to the case. Detailed clinical examination was done. All children were screened clinically and radiologically. Laboratory investigations like CBC (complete blood count), Serum Electrolyte (serum sodium and serum potassium), Renal function tests (urea, creatinine), Urine sodium, Serum osmolality and Urine osmolality were done on admission day and then daily for next 3 days. If dyselectrolytemia was detected, further evaluation was done to determine the cause. Any other investigations were done as and when required.

Definitions:

Hyponatremia: serum sodium concentration < 135 mEq/L,

Hypertatremia: serum sodium concentration >145 mEq/L,

Hypokalemia: serum potassium concentration < 3.5 mEq/L,

Hyperkalemia: serum potassium concentration > 5.5 mEq/L.^{8,9}

Serum electrolytes were estimated using indirect reading ion selective electrodes [ROCHE COBAS 6000 AUTOANALYZER]. Osmolality was estimated using the freezing point depression osmometer [CRYOBASIC-1]. ECG was done in patients with hyperkalemia (serum K^+ value >5.5 mEq/L); and also, in patients with hypokalemia (serum $K^+ < 3.5$ mEq/L). Correction was given as and when indicated.

Statistical Analysis

Statistical Analysis were performed with help of Epi Info (TM) 7.2.2.2 which is a trademark of the Centers for Disease Control and Prevention (CDC). Using this software, basic cross-tabulation and frequency distributions were prepared. Chi-square (χ^2) test was used to test the association between different study variables under study.



Corrected χ^2 test was used in case of any one of cell frequency was found less than 5 in the bivariate frequency distribution. Test of proportion (Z-test) was used to test the significant difference between two proportions. t-test was used to test the significant difference between means. $p < 0.05$ was considered to be statistically significant.

RESULTS

Table 1: Age and Sex distribution of severe pneumonia patients

Age Group (in years)	Gender		Total
	Male (n=33)	Female (n=34)	
2 months to <1 year	9	13	22
Row %	40.9	59.1	100.0
Col %	27.3	38.2	32.8
1 year – 5 years	24	21	45
Row %	53.3	46.7	100.0
Col %	72.7	61.8	67.2
TOTAL	33	34	67
Row %	49.3	50.7	100.0
Col %	100.0	100.0	100.0
Mean ± SD	2.00±1.55	1.72±1.56	
Median	1.50	1.20	
Range	0.20-5.00	0.20-4.6	
Male: Female ratio	1.0: 1.1		

$\chi^2=0.91$; $p=0.33$ NS- Not significant

The mean age (mean ± SD) of the patients was 1.90±1.56 years with range 0.20-5.00 years and the median age was 1.20 years.

Test of proportion showed that the proportion of the patients with age between 1 - 5 years (67.2%) was significantly higher than other age group ($Z=4.86$; $p < 0.001$). Thus, severe pneumonia was most prevalent in children with age 1- 5 years.

The ratio of male and female was 1.0:1.1. There was no significant difference in the proportion of males (49.25%) and females (50.75%) ($Z= 0.24$; $p=0.80$). Thus, severe pneumonia was more or equally prevalent among male and female children.

Chi-square (χ^2) test showed that there was no significant association between age and gender of the patients ($p=0.33$). The mean age (mean± SD) of males was 2.00±1.55 years with range 0.20 - 5.00 years and the median age was 1.50 years. The mean age (mean± SD) of females was 1.72±1.56 years with range 0.20 - 4.6 years and the median age was 1.20 years. Though the mean age of the females was lower than that of males t-test showed that there was no significant difference in mean age of males and females ($t_{65}=0.71$; $p=0.47$). However, females were more prone to be a patient of severe pneumonia at a younger age than males.

Table 2: Distribution of status of electrolytes

Status of Electrolytes	Number	%
Normal Electrolytes	23	34.33
Dyselectrolytemia	44	65.67
Total	67	100.0

Test of proportion shows that percentage of children having electrolyte abnormalities (65.67%) is significantly higher than that of having normal electrolytes (34.33%) ($Z= 3.16$; $p < 0.001$). Thus, the incidence of dyselectrolytemia was 65.67%. Out of 44 patients with dyselectrolytemia, 4 (9.09%) had mixed electrolyte imbalances.

The most frequent electrolyte abnormality was hyponatremia (46.2%) which was followed by hypokalemia (10.4%) ($Z=5.61$; $p < 0.001$). Only 5.9% and 2.9% of the children were suffering from hypernatremia and hyperkalemia respectively.

The mean level of sodium (mean± SD) of the patients was 135.59±6.22 mEq/L with range 121-150 mEq/L and the median was 136 mEq/L. 47.76% and 46.27% of the patients had Eunatremia and Hyponatremia respectively ($Z=0.24$; $p=0.80$). Only 5.97% of them had Hypernatremia. In overall 52.24% of the patients had abnormal level of sodium.

Hyponatremia accounted for 31 (46.2%) out of 67 patients with severe pneumonia.

The mean serum level of Na^+ was 135.59±6.22 mEq/L, with a range of 121-150 mEq/L. Moderate hyponatremia accounted for 51.61% followed by mild hyponatremia which accounted for 41.94% of hyponatremia cases ($Z=5.84$; $p < 0.001$). Severe hyponatremia was present in 6.45% of the cases.

Hypernatremia was detected in 4(5.8%) out of 67 children with severe pneumonia. 2(2.9%) children with age<1 year and another 2(2.9%) children with age 1 -5 year had hypernatremia. The hypernatremia in both cases was mild and there was no mortality due to hypernatremia.

The mean level of potassium (mean± s.d.) of the patients was 4.31±0.62 mEq/L with range 2.9-6 mEq/L and the median was 4.3 mEq/L. Most of the patients had level of potassium within normal limit (86.57%). ($Z=20.36$; $p < 0.0001$). In overall 13.44% of the patients had abnormal level of potassium.

Hypokalemia was detected in 7(11.7%) out of 60 patients with severe pneumonia.

About 57% (4/7) children with hypokalemia also had hyponatremia.

The mean serum K^+ value was 3.09 ± 0.11mEq/L with a range of 2.9-3.2mEq/L.

This table showed that the age wise distribution of children with hypokalemia. In the age group <1 year, 13.6% of children had hypokalemia. But the difference

was statistically not significant (Z=1.05; p>0.05).

The table shows the sex wise distribution of children with hypokalemia. Though the incidence of hypokalemia was slightly more in males (12.12%) than in females (8.82%), this difference was statistically not significant. (p=0.66, χ^2 -test)

Of the 67 patients with severe pneumonia, 2(2.98%)

patients had hyperkalemia. Both the children were from age group 1-5 years had hyperkalemia.

Mixed electrolyte abnormalities: Of the 67 patients with severe pneumonia, 4(5.97%) patients had mixed electrolyte abnormalities. All of them had a combination of hyponatremia and hypokalemia.

Table 3: Distribution of Electrolyte problems (n=44) in severe pneumonia

Number of patients of severe pneumonia with electrolyte problems (n=44)				Total Number of patients (n=67)	%
Serum Sodium					
Hyponatremia (Na⁺< 135mEq/L)	Hyponatremia on the basis of severity (n=31)			31	46.2%
	Mild (131-134) (n=13)	Male	6		
		Female	7		
	Moderate (126-130) (n=16)	Male	8		
		Female	8		
	Severe (\leq 125) (n=2)	Male	1		
		Female	1		
	Hyponatremia on the basis of age (n=31)				
	2 months to <1yr (n=12)	Male	5		
		Female	7		
1 year- 5 years (n=19)	Male	10			
	Female	9			
Eunatremia				32	47.8%
Hypernatremia (Na⁺>145mEq/L)	2 months to <1yr	Male	2	4	5.9%
		Female	-		
	1 year- 5 years	Male	-		
		Female	2		
Mean\pm SD-135.59\pm6.22, Median-136, Range-121-150					
Serum Potassium					
Hypokalemia (K⁺<3.5mEq/L)	2 months to <1yr	Male	2	7	10.4%
		Female	1		
	1 year- 5 years	Male	2		
		Female	2		
	Chi square test p=0.66, NS (Hypokalemia according to Sex)				
Eukalemia				58	86.6%
Hyperkalemia (K⁺>5.5mEq/L)	2 months to <1yr	Male	-	2	2.9%
		Female	-		
	1 year- 5 years	Male	1		
		Female	1		
Mean\pm SD- 4.31\pm0.62, Median- 4.3, Range- 2.9 – 6.0					

DISCUSSION

A total of 67 children between 2 months to 60 months were taken as the study group who met the inclusion and exclusion criteria. Table 1 showed that the children between the age group of 1-5 years were predominating accounting for 67.2% than the other age group. Among the total children enrolled in the study, 49.25% were

males and the rest 50.75% were female children.

Frequency of Electrolyte imbalances: Electrolyte disturbances in children with severe pneumonia were common in our population.⁶ In our study electrolyte abnormalities (of sodium and potassium) were observed in 59.8% of children admitted with severe pneumonia.



Hyponatremia: In various studies hyponatremia was the most frequent electrolyte abnormality in children hospitalized due to pneumonia.^{6,10,11} In our study 31 children had hyponatremia which accounts to 46.3% of the total cases which is similar to the study done by Don et al¹² in which hyponatremia was found in 45.4% of children with community acquired pneumonia. In our study the high incidence of hyponatremia was possibly due to two reasons: 1) Increased incidence of SIADH in severe pneumonia 2) Pneumonia/Severe pneumonia cases were referred from village where quacks gave initial treatment with only dextrose containing fluids for >48 hrs.

The studies which are similar to our study in assessing hyponatremia in pneumonia cases are listed as below.

Table 4: Comparative studies showing Incidence of Hyponatremia in severe pneumonia cases

Studies	Prevalence of hyponatremia
Prasad SVSS, Singhi S, Chugh KS ¹¹	26%
Singhi S, Dhawan A ⁶	27%
Shann F, Germer S ¹⁰	45%
Wrotek A, Jackowska T ¹³	33.3%
Don M, Valerio G, Korppi M ¹²	45.4%
Nair V, Niederman MS, Masani N ¹⁴	27.9%
Duru NS et al ¹⁵	31%
Sitaraman S, Saxena M ¹⁶	46.5%
Sakellaropoulou A et al ²	35.2%
Our study	46.3%

In our study out of 31 children with hyponatremia, 15 (45.4%) children were males and 16 (47.1%) children were females. The incidence of hyponatremia was almost same among two sexes.

The frequency of hyponatremia was more common in children <1 year age group (54.5%) than in 1-5 years age group (42.2%). Test of proportion showed that there was no significant difference in the two proportions (54.5% Vs. 42.2%) (Z=1.74; P > 0.05).

Hypokalemia: Hypokalemia was the second commonest electrolyte abnormality noted in this study (10.4%). The studies which are similar to our study in assessing hypokalemia in pneumonia cases are listed as below.

Table 5: Comparative studies showing Incidence of Hypokalemia in severe pneumonia cases

Studies	Incidence of Hypokalemia
Singhi S, Dhawan A ⁶	12%
Singhi S, Gulati S, Prasad SVSS ³	12.4%
Singhi S, Marudkar A ¹⁷	6.1%

In our study incidence of hypokalemia in <1 year age group was (13.6%) and in 1-5 years age group it was

(8.9%). This difference was statistically not significant. (Z=1.05; p>0.05). Incidence of hypokalemia was slightly more in males (12.12%) than in females (8.82%). This difference was statistically not significant (p=0.66; χ^2 -test). These findings are similar to the study done by Singhi et al⁶ where the occurrence of hypokalemia was not related to child's sex or age.

Hypernatremia: In our study hypernatremia was detected in 4(5.8%) out of 67 children with severe pneumonia. In a study done by Singhi et al⁶ reported similar incidence of 3.7% hypernatremia in children with pneumonia. 2 (2.9%) children with age 2 months to 1 year and another 2 (2.9%) in the age group of 1-5 year had hypernatremia. In our study hypernatremia was mild. And there was no mortality due to hypernatremia.

Hyperkalemia: In our study hyperkalemia was detected in 2(2.98%) children with severe pneumonia. The studies which are similar to our study in assessing hyperkalemia in pneumonia cases are listed as below.

Table 6: Comparative studies showing Incidence of Hyperkalemia in severe pneumonia cases

Studies	Percentage of Hyperkalemia in pneumonia cases
Singhi S, Dhawan A ⁶	2%
Singhi S, Gulati S, Prasad SVSS ³	6.8%
Our study	2.98%

Mixed electrolyte imbalances:

In our study 4(5.97%) had mixed electrolyte imbalances. All of them had a combination of hyponatremia and hypokalemia. In a study done by Singhi and coworkers⁶ from Chandigarh 47% children with hypokalemia also had hyponatremia.

This study was very useful in assessing the electrolyte imbalance in children with severe pneumonia. This is helpful in administering appropriate fluid therapy in these children. A few studies done advice drinking plenty of fluids in children with respiratory infection¹⁸, which may worsen the clinical condition, by increasing total body water and worsening of hyponatremia.

LIMITATIONS OF THE STUDY

- 1) The present study is a single centric study and is thus subjected to regional bias.
- 2) The sample size is small so, definitive recommendations cannot be put forward.



CONCLUSIONS

In view of these facts, regular estimation of serum electrolyte concentration and plasma and urine osmolality is necessary to guide appropriate fluid and electrolyte management of children with severe pneumonia requiring hospitalization. The fluid therapy in children with severe pneumonia should be individualized and those with hypo-osmolality need fluid restriction. There is also a need for further studies to evaluate the significance of hypokalemia and hyperkalemia in children with pneumonia.

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