

# A Clinical Profile of Serum Sodium Status in Children with Cardio-Respiratory Instability Admitted To Picu and Its Effect in Predicting the Clinical Outcome: A Prospective Cohort Study

Dr.ATHULYA.V.J.<sup>1</sup>M.D.,Dr.V.UMAMAHESWARI<sup>2</sup>M.D.,  
Dr.AZARUDEEN.K.<sup>3</sup>

<sup>1</sup> (Senior resident of Pediatrics, Chengalpattu medical college, Chengalpattu, India)

<sup>2</sup> (Assistant professor of Pediatrics, Coimbatore medical college, Coimbatore, India)

<sup>3</sup> (Assistant professor of Pediatrics, Chengalpattu medical college, Chengalpattu, India)

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## Abstract:

**Objective:** To find out the clinical profile of serum sodium status in children with cardiorespiratory instability admitted to PICU and its effect in predicting the clinical outcome.

**Background:** Maintenance of fluid and electrolyte balance is one of the focal points of critical care. Critically ill children admitted to the PICU usually have associated electrolyte imbalance. Our interventions, particularly in the form of sodium containing fluids may add to the dyselectrolytemia. Hence, this study aims to describe the clinical profile and document the clinical outcome in children with serum sodium abnormalities in PICU setting.

**Materials and Methods:** The study was done in 168 children aged from 2 months to 12 years who were admitted to the PICU of a tertiary care hospital during the period of 10 months from February 2019 to November 2019. Biographic details, clinical symptoms and signs as well as treatment measures were recorded in a proforma. The admitted children were subjected to serum sodium testing as per primary clinician's perspective within 2-4 hours of admission or as per departmental protocol during the course of admission. Those who were found to have abnormalities in the serum sodium values were followed up. Data was compared and tests of significance were run.

**Results:** The incidences of hyponatremia was 25.6% and that of hypernatremia was 26.8%. The incidence of Hypernatremia was slightly higher than hyponatremia. Length of PICU stay was more in hypernatremic children with a median of 4 days, as compared to 2 days in hyponatremia cases. 58% of children with hypernatremia had residual neurological deficits. 67% of children with hypernatremia succumbed to death which was more than due to hyponatremia.

**Conclusion:** The results of this study were comparable to previous studies. Dysnatremias are very common in the PICU setting and is found to influence the physiological status at presentation as well as the emergency treatment required to establish hemodynamic stability. They also influence the morbidity in terms of length of stay in the PICU as well as residual neurological abnormalities. So it is important to closely monitor and take appropriate measures to correct the serum sodium abnormalities associated with the primary disease process.

**Keywords:** serum sodium abnormalities, PICU stay, fluid and electrolytes.

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## I. Introduction

Electrolyte abnormalities are very common in hospitalised patients. Children in the PICU are at a higher risk of having electrolyte disturbances, either at admission or in the course of stay in PICU. Acute, severe hyponatremia can cause brainstem herniation and apnea, whereas chronic hyponatremia may have only subtle neurological abnormalities. Moderate or severe hypernatremia has significant morbidity, including its effect on the brain, result of underlying disease and risk of overly rapid correction. However children in PICU are assessed routinely for electrolyte abnormalities as maintenance of fluid and electrolyte balance is one of the focal points of critical care. Therefore swift adaptations would be expected to be implemented if an electrolyte disturbance is detected.

## **II. Aim Of The Study:**

This study aims to evaluate children admitted to the PICU with cardiorespiratory instability and found to have abnormalities in serum sodium levels, assess their clinical profile, outcome after initiation of treatment and its predictive value with regard to outcome.

## **III. Objectives:**

### **Primary:**

- To evaluate the incidence of serum sodium abnormalities in the PICU of our urban referral hospital.
- To find the effect of dysnatremias on morbidity and mortality.

### **Secondary:**

- To find the etiological profile of serum sodium abnormalities.

## **IV. Materials And Methods**

### **Study design:**

- Prospective cohort study

### **Location:**

- Paediatric intensive care unit at Coimbatore medical college and hospital. Institutional Ethical committee approval was obtained.

### **Time:**

- 10 months.

### **Study population:**

- **Inclusion criteria:** age-2 months to 12 years.
- A child in PICU with Shock requiring fluid boluses or/and inotropes, as per established diagnostic criteria.
- Child requiring any form of ventilation including CPAP.

### **Sample size:**

- Sample size was calculated using the formula

#### **Formula**

$$n = \frac{Z_{1-\alpha/2}^2 p(1-p)}{d^2}$$

Where,

p : Expected proportion

d : Absolute precision

1-  $\alpha/2$  : Desired Confidence level

- Single Proportion - Absolute Precision

Expected Proportion = 0.53

Precision (%) = 5

Desired confidence level (%) = 80

Required sample size = 163

- Clinical data about age, sex, suggestive history, clinical manifestations, complications and outcome were analyzed.

**Methodology:**

- All children aged 2 months to 12 years in the PICU meeting the inclusion criteria during the period of study were enrolled and their history and clinical findings and treatment provided during unstable clinical condition were recorded in the preformed proforma.
- They were then screened for serum sodium as per primary clinician’s perspective within 2-4 hours of admission or as per departmental protocol throughout the course of admission.
- Those who were found to have abnormalities in the electrolyte values were followed up until clinical recovery/discharge/death.
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**Table no 1** The normal range of values for each electrolyte was taken as:

Electrolyte	Hyponatremia	normal	Hypernatremia
Sodium(mmol/L)	<135	135-145	>145

- The most abnormal values that correlated with the clinical condition were recorded in the master chart along with details recorded in the proforma in a categorical manner.

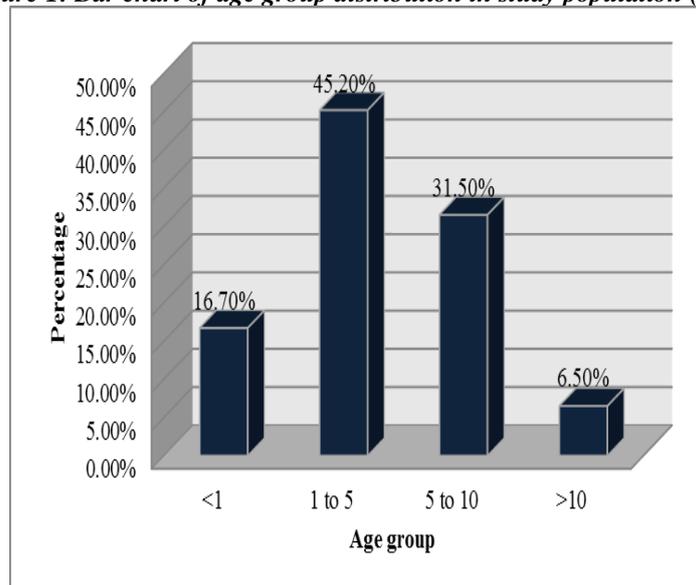
**Statistical analysis:**

- Data collected were organised and analysed statistically.
- A total 168 children were included in the final analysis.
- Chi-square test was used as the test of significance.
- A p-value less than 0.05 was taken as significant.

**V. Results:**

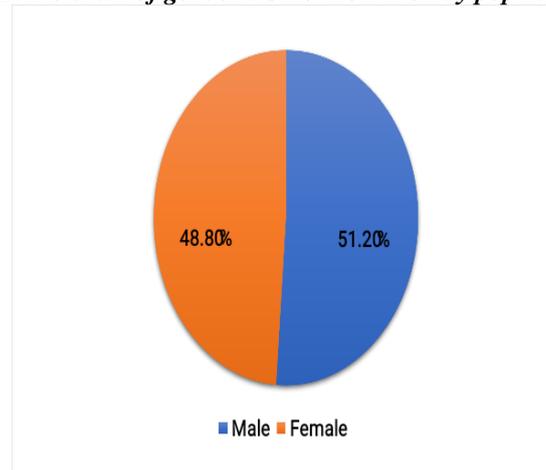
**Statistical analysis of clinical data of children enrolled in the study:**

**Figure 1: Bar chart of age group distribution in study population (N=168)**



- Most (45.2%) of the children in the study belonged to the age group of 1 year to 5 years, whereas the age group least (6.5%) represented was above 10 year olds.

Figure 2: Pie chart of gender distribution in study population(N=168)



➤ The study population were almost equally distributed among male and female genders.

Table no 2.Descriptive analysis of the common diagnoses in study population:

Diagnosis	Frequency	Percentage
Pneumonia	25	23.8%
ADD + AGE	14	13.3%
Encephalitis/meningitis/ME	12	11.4%
Snake bite	12	11.4%
AGN/ Glomerulonephritis / PIGN	9	8.6%
Asthma	8	7.6%
Nephrotic syndrome	8	7.6%
Seizure	7	6.7%
DKA / diabetic ketoacidosis	6	5.7%
Acute leukemia	4	3.8%

➤ Regarding the diagnosis of cases admitted to the PICU, it was found that the most common diseases were pneumonia (23.8%) and acute gastroenteritis (13.3%) and the least common were diabetic ketoacidosis (5.7%) and leukaemia (3.8%).

➤ The most and least common parameters of physiological status during presentation in each category were as follows:

○ **Airway-**

- 81% had stable airway;
- 1.25% had unstable airway requiring endotracheal intubation and ventilation at presentation.

○ **Breathing:**

- 48.8% had respiratory distress in the form of tachypnea with increased use of accessory muscles of respiration.
- 0.6% were apneic during presentation.

○ **Circulation:**

- 71.4% did not have cardiovascular instability but 8.9% were in warm septic shock.

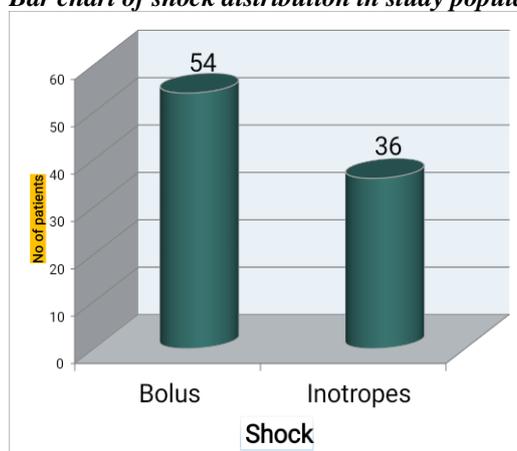
○ **Disability:**

- 63.1% were in altered sensorium and responsive to voice stimulus whereas 0.6% were unresponsive.
- 0.6% had features of raised intracranial hypertension.

**Table no 3:**

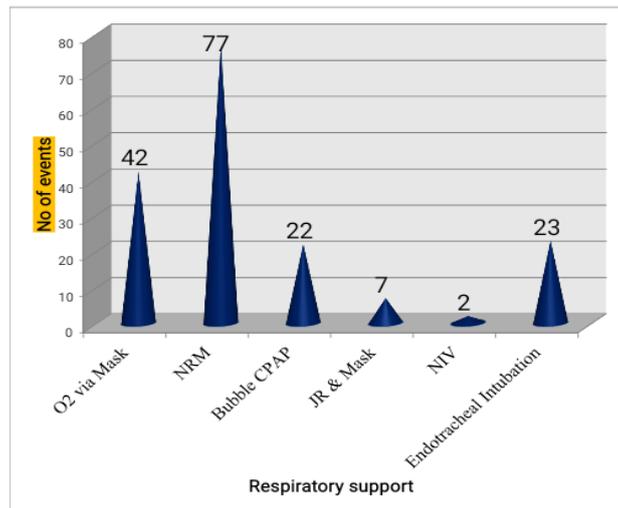
Physiological Status	No of cases	Percentage
<b>Airway</b>		
Stable	136	81%
Not Stable	27	16.1%
Obstructed	3	1.8%
Endotracheal intubation	2	1.25%
<b>Modified Breathing</b>		
Effortless Tachypnea	68	40.5%
Respiratory Distress	82	48.8%
Respiratory Failure	15	8.9%
Relative bradypnea	3	1.8%
Apnea	1	0.6%
<b>Circulation</b>		
No shock	120	71.4%
Warm shock	15	8.9%
Cold shock	33	19.6%
Total	168	100%
<b>Disability</b>		
Alert	15	8.9%
Voice responsive	106	63.1%
Pain responsive	33	19.6%
Unresponsive	1	0.6%
Convulsive status epilepticus	9	5.4%
Non convulsive status epilepticus	4	2.4%
Raised intracranial pressure	1	0.6%

**Figure 3: Bar chart of shock distribution in study population (N=168)**



➤ 54 children out of 168 were found to have shock at presentation which required treatment with bolus with or without inotropes. Inotropes were required in more than half of the shock patients along with initial treatment with i.v. fluid boluses.

Figure 4: Respiratory support distribution in the study population



- A total of 173 events of respiratory interventions were required with some patients requiring more than 1 type of respiratory support.
- Among these, the most commonly used was oxygen via non- rebreathable mask (44.5%).

Table no.4: Descriptive analysis of serum sodium in study population (N=168)

Serum electrolytes	Mean ± SD	Min	Max	95% C.I	
				Lower	Upper
Na(sodium)	141.19 ± 9.44	107.00	180.00	139.75	142.63

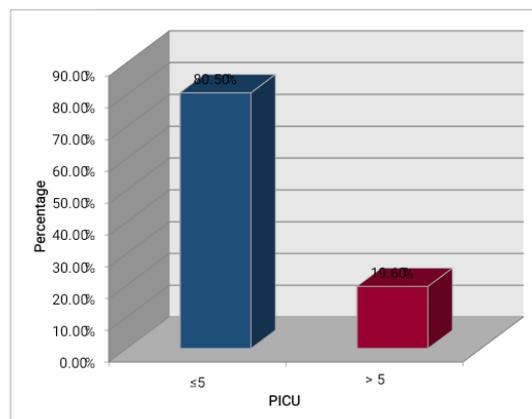
- The mean values and range of serum sodium measured in the study population were 141.19 ± 9.44.

Table no.5: Descriptive analysis of no. Of days of stay in study population

No. of days of stay	Mean ± SD	Median	Min	Max	95% C.I	
					Lower	Upper
PICU	4.1 ± 3.63	3.00	1.00	25.00	3.55	4.65
HOSPITAL	7.01 ± 5.17	5.00	1.00	30.00	6.17	7.84

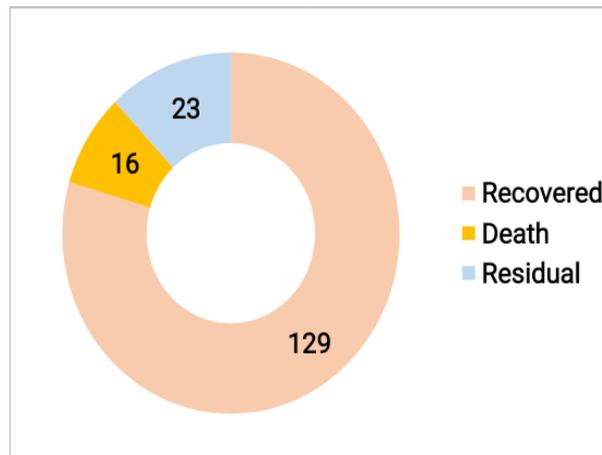
- The length of stay in the PICU was a mean of 4.1 days +/- 3.63 days.
- The mean duration of stay in the hospital, out of PICU was 7.01+/-5.17 days.

Figure 8: Bar chart of PICU stay distribution in study population



➤ Only 19.6% of the study population required PICU stay more than 5 days (prolonged).

✚ Figure 2: Pie chart of outcome distribution in study population



➤ The outcomes of the study populations were as follows:

- 16(9.5%) of the study population succumbed to illness among which more-43.8% belonged to age group 5-10 years whereas less-0% were among >10 years age. Death was more among female children(10) as compared to 6 among males.
- 152(90.5%) survived, among which 23(13.7%) had residual neurological abnormalities.
- Residual neurological deficits were more among (16) males than females(7)

**Table no.6: Comparison of age group between outcome (N=168)**

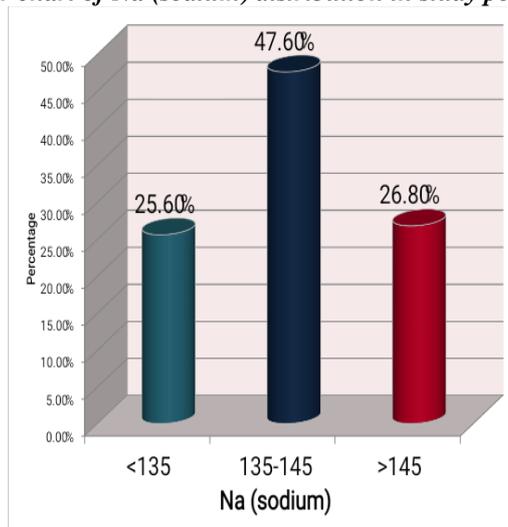
Age group	Outcome			Total	Chi square	P value
	Recovered	Residual	Death			
<1	21 (16.3%)	3 (13%)	4 (25%)	28 (16.7%)	4.141	0.658
1 - 5	59 (45.7%)	12 (52.2%)	5 (31.3%)	76 (45.2%)		
5 - 10	39 (30.2%)	7 (30.4%)	7 (43.8%)	53 (31.5%)		
>10	10 (7.8%)	1 (4.3%)	0 (0%)	11 (6.5%)		
Total	129 (100%)	23(100%)	16 (100%)	168 (100%)		

**Table no.7: Comparison of gender between outcome (N=168)**

Gender	Outcome			Total	Chi square	P value
	Recovered	Residual	Death			
Male	64 (49.4%)	16 (69.6%)	6 (37.5%)	86 (51.2%)	4.437	0.109
Female	65 (50.4%)	7 (30.4%)	10 (62.5%)	82 (48.8%)		
Total	129 (100%)	23 (100%)	16 (100%)	168 (100%)		

Statistical analysis of sodium abnormalities:

Figure 5: Bar chart of Na (sodium) distribution in study population (N=168)



- Around 50% of them had normonatremia.
- Among the abnormal sodium values slightly higher (about 1%) incidence of hypernatremia (26.8%) was noted.
- There was no significance noted in the age-wise distribution of sodium abnormalities.
  - Among <1 yr old children-hypernatremia (12) (42.8% among <1yr. old patients) was found to be higher than hyponatremia (3).
  - Among children >1 yr incidence of hyponatremia was higher than hypernatremia.

Table no.8:

AGE	Na<135	Na>145
1 – 5	22 (51.2%)	19 (42.2%)
5 – 10	15 (34.9%)	12 (26.7%)
>10	3 (7%)	2 (4.4%)

- However gender distribution of sodium abnormalities showed significance as both hypo- and hypernatremia were noted more among (around 65%) males whereas 63.8% of females had normonatremia.

Table no.9: Comparison of gender across Na (sodium) (N=168)

Gender	Na (sodium)			P value
	<135	135-145	>145	
Male	28 (65.1%)	29 (36.3%)	29 (64.4%)	0.001
Female	15 (34.9%)	51 (63.8%)	16 (35.6%)	

- There was no significance in the distribution of sodium abnormalities among various diagnosis of the study population.

**Table no.10:**

Diagnosis	Na (sodium)		P value
	<135	>145	
Acute leukemia	0 (0.0%)	2 (50.0%)	-
ADD+AGE	3 (21.4%)	5 (35.7%)	0.623
AGN/ glomerulonephritis/ pign	3 (33.3%)	2 (22.2%)	0.938
Asthma	1 (12.5%)	1 (12.5%)	0.211
DKA/ diabetic ketoacidosis	1 (16.7%)	4 (66.7%)	0.059
ENCEPHALITIS/meningitis/ME	4 (33.3%)	3 (25.0%)	0.981
Nephrotic syndrome	2 (25.0%)	2 (25.0%)	0.963
Pneumonia	11 (44.0%)	4 (16.0%)	0.124
Seizure	1 (14.3%)	2 (28.6%)	0.679
Snake bite	4 (33.3%)	2 (16.7%)	0.743

- Hyponatremia was found to be more in acute gastroenteritis/acute diarrheal disease group/diabetic ketoacidosis/seizures.
- Hyponatremia occurred more with renal causes/meningo-encephalitis/pneumonia and snake bite cases.
- There was also no significance in the clinical presentations of the children and cardio-respiratory treatment required in relation to sodium abnormalities.
- There was a significant relationship between number of days of stay in PICU and sodium abnormality, which was higher with hypernatremia-median 4 days as compared to median of 2 days in hyponatremic and normonatremic patients. Also more no. of cases of hypernatremia (12) required PICU stay more than 5 days than cases of hyponatremia (8). There was no significance of the abnormal sodium values causing prolongation in the length of hospital stay out of PICU.

**Table no.11:Comparison of median No. Of days of stay across Na (sodium)**

No. of days of stay	Na (sodium)			P value
	<135	135-145	>145	
PICU	2 (2, 5)	2 (2, 4)	4 (3, 6)	0.006
HOSP	7 (4, 11)	5 (3.25, 8)	5 (3,10)	0.505

**Table no.12:Comparison of PICU stay across Na (sodium) (N=168)**

PICU	Na (sodium)		P value
	<135	>145	
≤5	35 (81.4%)	33 (73.3%)	0.364
>5	8 (18.6%)	12 (26.7%)	
Total	43 (100%)	45 (100%)	

- No statistically significant relationship was observed between the sodium abnormalities and their effect on the outcomes. More cases of hypernatremia (8) as compared to hyponatremia (4) succumbed to death whereas residual neurological deficits were also high among hypernatremic patients (7) than hyponatremics(5).

**Table no.13:Comparison of outcome across Na (sodium) (N=168)**

Outcome	Na (sodium)		P value
	<135	>145	
Recovered	34 (79.1%)	30 (66.6%)	0.065
Death	4 (9.3%)	8 (17.8%)	0.065
Residual	5 (11.6%)	7 (15.6%)	0.866

## VI. Discussion

Our study was intended to find the association of the serum sodium abnormalities observed in critically ill children and their outcome. The overall incidences of hyponatremia (25.6%) and hypernatremia(26.8%), were similar in the study population,with hypernatremia being slightly more frequent. On analysis of the clinical characteristics of the children enrolled in the study, it was observed that there was no significant difference in the age-wise incidence of the dysnatremias studied.

Hypernatremia was more common among children <1 year old whereas hyponatremia was more common in the other age groups.

However sodium abnormalities were notably more in the male gender, and it was statistically significant.

### Outcome predictors:

- Length of PICU stay was more in hypernatremic children.
- Residual neurological abnormalities and death were more in children with hypernatremia.

A study by Sadeghi-Bojd S et.al done in 189 subjects at the Zahedan university of medical sciences, Iran ,unlike the findings in our study found the incidence of hyponatremia to be 20.1%, hypernatremia–16.9%. This could be due to the differences in the demographic profile of the patients. They also found a significant association between the hypernatremia and mortality, which was not the case in our study.<sup>18</sup>

A study published in Indian Pediatrics in December, 2000 by S.D.Subba Rao et.al in 305 patients at St. John’s medical college and hospital had hyperkalemia (14.4%) as the most common electrolyte abnormality in the PICU. The second most common abnormality was hyponatremia (9.5%). The comparatively lower percentage of the incidences of electrolyte abnormalities could be due to exclusion of acute gastroenteritis cases and wide range of normal electrolyte values used in the study.<sup>24</sup>

Babaliche, Prakash et al. found a male preponderance in their study of 100 patients with hyponatremia which is also the case in our study.

The study by Waite, Michael D et al. demonstrated 28% increase in ICU length of stay associated with hypernatremia which is consistent with the findings in our study.

A summary of Hypernatremic disorders in the Intensive Care Unit by Surender Kumar Arora concluded that hypernatremia is associated with increased length of stay and mortality.

## VII. Conclusion

Dysnatremias are very common in the PICU setting and is found to influence the physiological status at presentation as well as the emergency treatment required to establish hemodynamic stability. They also influence the morbidity in terms of length of stay in the PICU as well as residual neurological abnormalities. Therefore close monitoring and appropriate measures to correct the serum sodium abnormalities associated with the primary disease process should be done meticulously.

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