

## Original Research Article

# A study of mortality and morbidity profile of electrolyte imbalance in critically ill children with special importance to mechanical ventilation

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**Received:** 22 September 2019

**Accepted:** 08 November 2019

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## ABSTRACT

**Background:** Electrolytes imbalance is not uncommon in critically ill children. The outcome of critically ill child is dependent on various factors like the underlying disease, fluid and nutrition, which are responsible for electrolyte homeostasis in tandem with renal function and many others. In this study authors look into morbidity and mortality associated with dyselecetremia with special importance to children on mechanical ventilation.

**Methods:** This prospective observational study was conducted in the PICU, SVPPGIP (SCB MC and Hospital), Cuttack during the period November 2015 to October 2017. Includes children admitted to PICU (Based on consensus guidelines for PICUs in India, Indian Society of Critical Care Medicine (Pediatric Section) and Indian Academy of Pediatrics (Intensive Care Chapter).

**Results:** Mortality distribution in electrolyte abnormality patients is 27.9% (around 3 times higher than normal electrolyte patients). 25% hyponatremic patients and 31.25% hypernatremia patients expired, 30.76% hypokalemia patients, 32.72% hyperkalemia patients expired. Morbidity distribution in electrolyte imbalance population was 85.27%, with more than 7 days of stay in PICU. Amongst the mechanical ventilated patient, 54.23% patients having potassium disturbances were associated with significant mortality and morbidity. No such significant relation exists between mechanical ventilation and dyselecetremia of sodium and calcium.

**Conclusions:** Early recognition with a thorough understanding of common electrolyte abnormalities and their prompt management definitely pose an implication on the final outcome of the patient. Aggressive and strict adherence to correction of in particular to potassium before weaning is necessary for successful weaning from ventilator.

**Keywords:** Electrolyte imbalance, Mortality, Mechanical ventilation, Pediatric intensive care

## INTRODUCTION

Electrolyte abnormalities are common in children who need intensive care, they occur in variety of condition, may remain unrecognized and result in morbidity and mortality irrespective of primary problem. Early recognition, a high index of suspicion and a thorough understanding of common electrolyte abnormalities is necessary to ensure their correction.<sup>1</sup> The composition of solutes in the ECF and ICF are very different. Sodium and chloride are the dominant cation and anion.

Potassium is the most abundant cation and proteins, organic anions, and phosphate are the most plentiful anions in the ICF.<sup>2</sup>

Osmolality of plasma is normally 285-295 mosm/kg. Sodium is the dominant cation of the ECF and is the principal determinant of extracellular osmolality. Normal serum sodium (Na<sup>+</sup>) concentration is 135-145 mEq/L. Sodium is unique among electrolytes because water balance, not sodium balance, usually determine its concentration. Hyponatremia is less than 135 mEq/L,

classified on overall volume status of the body. Hyponatremia is defined as a serum sodium concentration of more than 145 mEq/L.

Disturbances in plasma sodium concentrations are a common clinical problem in patients admitted to the intensive care unit.<sup>3</sup> Many cases of dysnatremia are acquired after a patient is admitted to ICU and the presence of dysnatremia is associated with poor prognosis.<sup>4</sup>

Major causes of hypokalemia include low dietary potassium intake, shifting of  $K^+$  into the intracellular compartment, extrarenal  $K^+$  loss and renal  $K^+$  loss. Medications like insulin, sympathomimetics, diuretics, dobutamines etc. also causes hypokalemia in ICU. Non-absorbable anions such penicillin and aminoglycosides can cause hypokalemia by increasing  $K^+$  loss in urine (Buckley et al, 2001).<sup>5</sup>

Renal failure, adrenal insufficiency, insulin deficiency and tissue damage from rhabdomyolysis, burns or trauma are predisposing factors for hyperkalemia in critically ill patients. A lot of medications used in ICU can also cause hyperkalemia like  $\beta$ -blockers, Angiotensin Receptor Blockers (ARB),  $K^+$  sparing diuretics, heparin and its derivatives, NSAIDS. Treatment strategies of hyperkalemia depends on the presence of emerging conditions, if ECG changes occurs IV Calcium Gluconates is the 1<sup>st</sup> step of management. Insulin +glucose associated with rapid and biggest drop in plasma potassium. Intravenous albuterol or inhaled albuterol may be used (Blumberg et al, 1988).<sup>6</sup>

Numerous factors contribute to ventilator dependence. However, one should focus on identifying factors that are potentially reversible. Electrolyte imbalances have a direct relationship to weaning from mechanical ventilation.<sup>7</sup>

The importance of fluid resuscitation for patients in shock and with systemic inflammatory response syndrome is indisputable, with an impact that reduces mortality and morbidity. However, new evidence shows that after initial management with intravenous fluids, fluid overload, electrolyte imbalance which frequently occurs in patients admitted to Intensive Care Units (ICU), has deleterious effects and may lead to unfavorable outcomes, such as longer mechanical ventilation, prolonged hospitalization, the need for renal replacement therapy and higher mortality risk.

The development of many electrolyte disturbances in PICU can be prevented by attention to use of intravenous fluids and nutrition.

Serum sodium, serum potassium and serum calcium levels were estimated for children admitted to PICU, two venous sample 3-5 ml each collected were collected in a yellow top vacutainer and 10 ml of urine sample

spontaneous void or catheter specimen were collected in clean sterile bottles. Routine blood and urine investigations, imaging studies as appropriate the diagnosis done.

## METHODS

The study was carried out in the Pediatric Intensive Care Unit at a tertiary care hospital after obtaining approval and waiver of consent from the Institutional Ethics Committee. Authors enrolled all the patients admitted in PICU of age 29 days to 14 years during November 2015 to October 2017.

### Diagnosis

- Normal sodium value 135 - 145 mEq/l (reference nelson textbook of pediatrics).<sup>8</sup>  
Hyponatremia >145 mEq/l  
Hypernatremia < 135mEq/l
- Normal potassium value 3.5 - 5.5 mEq/l  
Hypokalemia < 3.5 mEq/l  
Hyperkalemia >5.5 mEq/l
- Normal ionized calcium 1.12 millimole/l -1.23 mmol/l  
Hypocalcemia < 1.12 millimole/l  
Hypercalcemia >1.23 millimole /l
- Blood urea=5 to 18 mg/dl, serum creatinine=0.17 to 0.71 mg/dl.

### Inclusion criteria

- Based on consensus guidelines for PICUs in India, Indian Society of Critical Care Medicine (pediatric section) and Indian Academy of pediatrics (Intensive Care Chapter).<sup>9</sup>

### Exclusion criteria

- Children admitted to PICU with major congenital anomaly.

### Statistical analysis

The collected data were analyzed with SPSS 16.0 version. To describe about the data, descriptive statistics, frequency analysis, percentage analysis were used for categorical variables and for continuous variables the mean and S.D were used. To find the significant difference between the bivariate samples in independent groups, the independent t test was used. To find the significance in categorical data, Chi-square test was used. In all the above statistical tools, the probability value of <0.05 was considered as significant level.

The sample size for my study was 340 patients after substituting the data in Fischer formula.

Z= The value representing 95% Confidence interval.

d= precision of the study or absolute error fixed at 5%.

P= Prevalence (based on a study done in developing country like India previously).

## RESULTS

This study consists of 340 patients, mortality distribution in patients with electrolyte abnormality is 27.9% and mortality in patients without electrolyte imbalance is 9.47%. the mortality was three times higher in the study population with electrolyte imbalance. This study is significant, p value 0.0000211 (Table 1).

Out of 36 hyponatremic patients 25% expired, out of 16 hypernatremic patients 31.25% expired. Out of 13 hypokalemia patients 30.76% expired and out of 55 patients of hyperkalemia 32.72% expired (Table 2).

Morbidity was considered as prolonged stay i.e. of 7 days of PICU stay. Morbidity distribution in electrolyte imbalance population is 85.27%, which is around 4 times higher than

study population having normal electrolyte that is 21.8%. The chi-square statistic is 129.8825, p value <0.0001. The result is significant at p<0.05 (Table 3).

**Table 1: Distribution of mortality in study population.**

Electrolyte	Number	Mortality number	Percentage
Normal	211	20	9.47%
Abnormal	129	36	27.9%

**Table 2: Distribution of mortality among electrolyte abnormalities in PICU.**

Abnormal electrolyte	No.	Mortality in number (expired)	%
Hyponatremia	36	9	25%
Hypernatremia	16	5	31.25%
Hypokalemia	13	4	30.76%
Hyperkalemia	55	18	32.72%

**Table 3: Distribution of morbidity in study population.**

Study population	Number of study population	ICU stay >7 days (morbidity)	ICU stay <7 days (no morbidity)	Morbidity percentage (%)
Electrolyte imbalance population	129	110	19	85.27%
Normal electrolyte population	211	46	165	21.8%

The prevalence of electrolyte imbalance amongst the patients who were mechanically ventilated in our study has been described in (Table 4). Out of total n=142 mechanical ventilated patient, 54.23% patients were having electrolyte imbalance and 45.77% were not having electrolyte abnormality that authors have considered for the study. The association of mechanical ventilation and electrolyte imbalance was significant with the chi-square of 27.4612, the p value is <0.001 (Table 4).

When the duration of stay is analyzed in PICU (>7 days being considered as morbidity) vis-à-vis mechanical ventilation, out of these 142 mechanically ventilated patients, morbidity was present in 70.4% patients, 29.6% had improved within 7 days of duration. Out of 198 patients who were not on mechanical ventilation 28.3% had stayed for more than 7 days of duration, whereas 71.7% had a shorter duration of stay. The chi-square statistic is 59.1389. The p-value is <0.00001 (Table 5).

Analyzing the relationship between potassium disturbances, mortality and morbidity: Out of 156(100%) patients with PICU stay >7 days (morbid patients), hypokalemia contributes 6.41%, hyperkalemia 30.77%, 62.82% patients having normal potassium. Out of 184 patients with shorter duration of stay (no morbidity <7

days), 1.63% hypokalemic, 3.80% hyperkalemia, 94.57% patients having normal serum potassium.

The chi square statistic is 53.626.the p-value <0.00001. The association was statistically significant. So, potassium disturbances are associated with increased morbidity (Table 6).

**Table 4: Distribution of electrolyte abnormality in ventilated and nonventilated patient.**

Mechanical ventilation	Abnormal electrolyte		Total
	Yes	No	
Yes	77(54.23%)	65(45.77%)	142(100%)
No	52(26.26%)	146(73.74%)	198(100%)

**Table 5: Duration of ICU stay in mechanical ventilated versus non-mechanical ventilated.**

Duration of stay in ICU	Mechanical ventilation		No mechanical ventilation	
	No	%	No	%
Morbidity(>7days)	100	70.4%	56	28.3%
No morbidity (<7 days)	42	29.6%	142	71.7%
Total	142	100%	198	100%

When analysing the mortality, out of 284(100%) improved patients, 3.2% hypokalemic, 13.0% hyperkalemic, 83.3% are with normal potassium level and out of 56 expired patient 7.16 % are hypokalaemia,

32.14% hyperaemic, 60.70% with normal potassium level. The chi-square statistic for mortality is 15.6141. The p-value is 0.000407. The result is statistically significant (Table 6).

**Table 6: Relationship between potassium disturbance morbidity and mortality.**

Potassium abnormalities	ICU stay >7 days (morbidity)		ICU stay <7 days (no morbidity)		Improved		Expired	
	No.	%	No.	%	No.	%	No.	%
Hypokalemia	10	6.41%	3	1.63%	9	3.2%	4	7.16%
Hyperkalemia	48	30.77%	7	3.80%	37	13.0%	18	32.14%
Normal Potassium	98	62.82%	174	94.57%	238	83.8%	34	60.70%
Total	156	100%	184	100%	284	100%	56	100%

Among 142 of mechanically ventilated patients, 3.52% are hypokalemic, 32.29% hyperkalemic, 66.19% are with normal potassium. Out of 198 without mechanical ventilated patients, 4.04% are hypokalemic, 6.06% hyperkalemic, 89.9% are with normal potassium. The chi square statistic is 35.8554. The p-value is <0.00001. The result is statistically significant (Table 7).

**Table 7: Relationship between potassium and mechanical ventilation.**

Potassium abnormalities	Mechanical ventilation			
	Yes		No	
	n	%	n	%
Hypokalemia	5	3.52%	8	4.04%
Hyperkalemia	43	30.29%	12	6.06%
Normal	94	66.19%	178	89.9%
Total	142	100%	198	100%

## DISCUSSION

Table 1 describes the mortality associated with electrolyte abnormality vs patients having no electrolyte abnormality, 27.9% of patient with electrolyte abnormality expired (mortal) whereas only 9.47% expired from patient without having electrolyte abnormality.

This study is significant, p-value 0.0000211. Similar study done by S.D. Subba rao et al, study showed the risk of increased mortality by 3 to 3.5 times with electrolyte imbalance.<sup>10</sup>

Table 2 showed distribution of mortality among electrolyte abnormalities, out of 36 hyponatremic patients 25% expired, out of 16 hypernatremic patients 31.25% expired. out of 13 hypokalemia patients 30.76% expired and out of 55 patients of hyperkalemia 32.72% expired. Hyperkalemia associated with highest no of mortality. Out of death from hyponatremia 3 had hypocalcemia also.

Similar study done by S.D. Subba rao et al, of the 99 patients with electrolyte imbalance, 24(24.2%) expired.<sup>10</sup> In these 24 patients 10(41.6%) had hyperkalemia, 6(25%) had hyponatremia, 5(20.8%) had hypernatremia, 3(12.5%) had hypokalemia. Similar study done by Dr. C. Rukesh highest mortality was associated hyperkalemia 30.76%. Mayank et al, found increased mortality in hypokalemia.<sup>11,12</sup>

In contrast S.V.S.S Prasad, the overall mortality rate showed an increase in hyponatremia.<sup>13</sup> Present study and previous studies all found all found electrolyte abnormalities increase mortality in critically ill children, whether it is sodium or potassium abnormalities.

Table 3 shows Morbidity distribution in electrolyte imbalance population is 85.27%, which is around 4 times higher than study population having normal electrolyte that is 21.8%. this study is significant with p value less than 0.0001. So, electrolyte abnormality associated with increased morbidity.

Table 4 describes, out of total mechanically ventilated patient, 54.23% patients having electrolyte imbalance and 45.77% without electrolyte abnormality. The chi-square is 27.4612, the p value is <0.001. This result is significant. So, electrolyte abnormality associated with increase in number of mechanically ventilated patients.

Table 5 showed duration of ICU stays in mechanically ventilated versus non mechanically ventilated. Out of 142 mechanically ventilated patient morbidity present in 70.4% patients, 29.6% having no morbidity. Out of 198 patients with no mechanical ventilation 28.3% are morbid, 71.7% are non-morbid.

Table 6 shows relationship between potassium disturbance and morbidity, out of 156 (100%) morbid patients (ICU stay > 7 days), hypokalemia contributes 6.41%, hyperkalemia 30.77%, 62.82% patients having normal potassium. so, potassium disturbances associated



with increase in number of morbidities. Out of 184 no morbidity patients, 1.63% hypokalemic, 3.80% hyperkalemia, 94.57% patients having normal serum potassium. The result is significant.  $p$ -value  $<0.05$ . so, potassium abnormalities associated with increased duration of ICU stay.

Table 6 also shows relationship between potassium disturbance and mortality. Out of 284 improved patients, 3.2% hypokalemic, 13.0% hyperkalemic, 83.3% are with normal potassium level and out of 56 expired patient 7.16% are hypokalemic, 32.14% hyperkalemic, 60.70% with normal potassium level. This result is significant. so, potassium disturbance is associated with mortality. Similar study done by Singhi S, Gulati S, Prasad SVSS14 described increase mortality due to hypokalemia. SD Subba rao et al, described highest mortality associated with hyperkalemia.<sup>10</sup> Hessels L et al, showed significant association between mortality and sodium disturbances.<sup>15</sup>

Both hypo and hyperkalemia are known to induce potentially lethal arrhythmias and cardiac dysfunction, as well as other complications.<sup>16</sup> Derangements in serum potassium levels in ICU patients should therefore be avoided, and monitoring of potassium is mandatory. There are surprisingly few data on the relationship between serum potassium and mortality in ICU patients. A recent study showed a strong, independent association between hyperkalemia at the onset of ICU treatment and in-hospital mortality, even at moderate increases above the normal range. A causal relation could not be demonstrated.<sup>17</sup>

Table 7 relationship between potassium and mechanical ventilation. Among 142 of mechanically ventilated patients, 3.52% are hypokalemic, 32.29% hyperkalemic, 66.19% are with normal potassium. Out of 198 without mechanical ventilated patients, 4.04% are hypokalemic, 6.06% hyperkalemic, 89.9% are with normal potassium. This result is significant  $p$ -value  $<0.05$ .

## CONCLUSION

The present study showed high incidence of electrolyte abnormalities in patients admitted to pediatric intensive care unit. PICU staying was prolonged in patients with electrolyte disorder. Mortality in PICU is multifactorial, but abnormalities of electrolytes remain significant predictors of mortality. Patients often with electrolyte imbalance who are on mechanical ventilation had significantly higher morbidity and mortality. As also correcting potassium imbalance is an important successive strategy to successful weaning from ventilation as well significantly reducing morbidity and mortality.

## ACKNOWLEDGEMENTS

Authors would like to thank head of the department Dr Saroj Kumar Satpathy in this endeavor for research and staff in the supervision and treatment of all admitted patients.

*Funding: No funding sources*

*Conflict of interest: None declared*

*Ethical approval: The study was approved by the Institutional Ethics Committee*

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**Cite this article as:** Kishore SV, Routray M, Champatiray J, Satpathy SK. A study of mortality and morbidity profile of electrolyte imbalance in critically ill children with special importance to mechanical ventilation. *Int J Contemp Pediatr* 2020;7:72-7.