

# Assessment of Serum Phosphorus Levels as a Factor in Weaning Off ICU Patients from Mechanical Ventilation - A Cross Sectional Observational Study in a Tertiary Care Hospital

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## ABSTRACT

### BACKGROUND

Serum electrolyte levels are a very important factor in the management and prognosis of patients admitted in critical care, as serum electrolytes are involved in many of normal physiological processes. This study intends to assess the serum phosphorus levels in critically ill patients and its significance in weaning off patients from mechanical ventilation.

### METHODS

The study was conducted among 110 patients admitted in the medical intensive care unit (ICU) who required mechanical ventilator support, after applying inclusion and exclusion criteria. A proper history was taken, and examination was done. Laboratory values of serum phosphorus were checked during admission and during initiation of mechanical ventilation and the number of days of requirement of mechanical ventilation was noted. Patients were divided into two groups, group A and group B with < / = 6 days of mechanical ventilation and more than 6 days respectively.

### RESULTS

We found that, there was a significant difference between serum pH levels at the time of admission (group A:  $3.40 \pm 0.40$  mg / dl, group B:  $2.14 \pm 0.38$ , P value < 0.001) and at the time of initiation of mechanical ventilation (group A:  $3.34 \pm 0.34$ , group B:  $2.10 \pm 0.35$ , P value < 0.001).

### CONCLUSIONS

According to the study, hypophosphatemia is associated with prolonged duration of mechanical ventilation, assessment and monitoring of the same is very important.

### KEYWORDS

Serum Phosphorus Levels, Mechanical Ventilation, Critically Ill Patients

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## BACKGROUND

Mechanical ventilation (MV) is an important supportive therapy for maintaining oxygenation in patients with acute respiratory failure.<sup>1,2</sup> Very often we see that critically ill patients with multiple organ failures need mechanical ventilation to support their respiratory failure.<sup>3</sup> However, prolonged mechanical ventilation is not always advocated and is associated with severe life threatening complications like tracheal stenosis, barotraumas, pneumothorax, and sepsis including Ventilator Associated Pneumonia (VAP).<sup>4</sup> Therefore, in critically ill patients, elimination of predisposing illness, successful management and weaning from ventilator are key survival factors.<sup>5</sup>

Patients who have been receiving prolonged time mechanical ventilation may have many problems in one or more areas, which should be corrected; out of which electrolyte abnormalities such as hypokalaemia, hypophosphatemia, hypomagnesemia, hyponatremia, and hypocalcaemia are of concern.<sup>6</sup>

Phosphorus (P) is one of the most important intracellular and extracellular ions. The normal range of Phosphorus is between 2.5 – 4 mg / dl and a large portion of it is intracellular.<sup>1</sup>

The most common clinical manifestation of phosphorus deficiency is weakness of skeletal or smooth muscle; however, rhabdomyolysis, impaired cardiac contractility, and haemolytic anaemia are also manifestations of hypophosphatemia.

Hypophosphatemia can cause acute respiratory failure and it impairs diaphragmatic contractility.<sup>7</sup> Although hypophosphatemia has been studied as a cause of respiratory failure, to our knowledge, the effect of serum phosphorus level on weaning from mechanical ventilation has only been suggested by relatively infrequent case reports.

Significant hypophosphatemia may have occurred without low serum phosphorus levels. Thus, severe and life-threatening hypophosphatemia may not be diagnosed, because it has nonspecific manifestations such as loss of consciousness, hypotension, muscular weakness, ventilator dependence and acute respiratory failure.

## METHODS

The study was a single centre prospective observational study conducted in a tertiary care hospital, Hubballi, Karnataka. The sample size was calculated using appropriate formulas and 110 samples were taken into the study. The study was done over a period of 1 year from July 2018 to July 2019, on 110 patients admitted to KIMS hospital, Hubli in the medical ICU, who were on mechanical ventilator support.

Around 450 cases were admitted to medical ICU in last 1 year and out of whom 75 cases were on mechanical ventilator.

Sample size was calculated using the formula

$$N = Z^2 pq / d^2$$

Where Z, considering 95 % confidence interval is 1.96<sup>8</sup>

P is 450

1-p is q

D is allowable error of 5 %.

Using this above formula, sample size comes to around 115 and fkr. For calculation purpose it is approximated to 110.

Patients' history was taken, and clinical examination was done. All the patients' serum phosphorus levels at the time of admission and the time of initiation of mechanical ventilation were recorded.

The patients were observed and tried to be weaned off from mechanical ventilation based on the improvements shown. The patients were divided into two groups depending on the number of days required for mechanical ventilation: group A with less than or equal to 6 days of mechanical ventilation support and group B with more than 6 days of mechanical ventilation support. Statistical analysis was carried out and results were drawn.

### Statistical Analysis

Data was entered into Microsoft Excel data sheet and was analysed using SPSS 22 version software. Categorical data was represented in the form of frequencies and proportions. Continuous data was represented as mean and standard deviation. Independent t test was used as test of significance to identify the mean difference between two quantitative variables.<sup>9</sup>

MS Excel and MS Word was used to obtain various types of graphs such as bar diagram and receiver operating characteristics (ROC) curve. P value (Probability that the result is true) of < 0.05 was considered as statistically significant after assuming all the rules of statistical tests.

### Weaning Criteria<sup>1</sup>

- Respiratory condition is stable / resolving
- Low fraction of inspired oxygen-FiO<sub>2</sub> (< 0.5), positive end-expiratory pressure-PEEP (< 5 – 8 cm H<sub>2</sub>O) requirement and pH ≥ 7.25
- Hemodynamic stability: No active myocardial ischemia, no clinically important hypotension (vasopressors, low dose < 5 g / Kg / min dopamine or dobutamine are not accepted)
- Able to initiate spontaneous breaths (good neuromuscular function).

### Guidelines for Indicating the Feasibility of Discontinuing Mechanical Ventilation Included

- Vital capacity of more than 15 mL / Kg
- Alveolar arterial oxygen difference of < 350 cm of H<sub>2</sub>O while breathing 100 % oxygen
- PaO<sub>2</sub> of more than 60 mm Hg with FiO<sub>2</sub> of < 0.5
- Negative inspiratory pressure of more than – 20 cm of H<sub>2</sub>O.
- Normal pH.
- Respiratory rate of < 20 breaths / min and

- Dead space ventilation / tidal volume ratio of < 0.6.

Breathing at rapid rates and with low tidal volumes usually signified an inability to tolerate extubation.

**RESULTS**

	Duration of Mechanical Ventilation				P Value
	≤ 6 days (N = 42)		> 6 days (68)		
	Mean	SD	Mean	SD	
Age	53.69	12.07	56.38	9.72	0.201
Serum phosphorus at the time of admission	3.40	0.40	2.14	0.38	< 0.001*
Serum phosphorus at the time of intubation	3.34	0.34	2.10	0.35	< 0.001*

**Table 1. Profile of Subject's Comparison with Respect to Duration of Mechanical Ventilation**

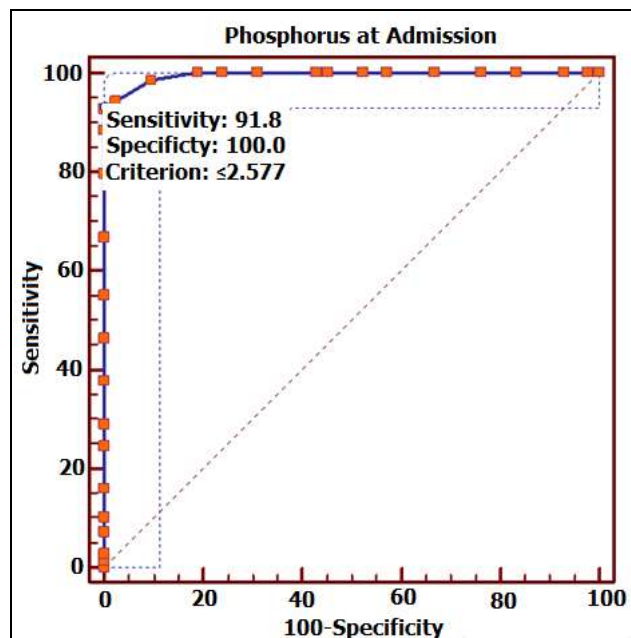
Mean age of subjects requiring ≤6 days of mechanical ventilation was 53.69 ± 12.07 and among subjects with > 6 days of mechanical ventilation was 56.38 ± 9.72 years. There was no significant difference in mean age between two groups of ventilation.

Mean serum phosphorus at admission among subjects requiring ≤ 6 days of mechanical ventilation was 3.40 ± 0.40 and among subjects with > 6 days of mechanical ventilation was 2.14 0.38. There was a significant difference in the mean serum phosphorus at admission between two groups. Mean serum phosphorus at admission was lower in subjects requiring a duration of mechanical ventilation for > 6 days.

In the study, 42 patients were weaned out successfully from the mechanical ventilation without any problems, however, the following out comes of the patients were not included in the study. Whereas 68 patients in the study took more than 6 days to wean off from ventilation or could not be weaned whose outcome is monitored in the study.

Similarly mean serum phosphorus at the time of intubation among subjects requiring ≤ 6 days of mechanical ventilation was 3.34 ± 0.34 and among subjects with > 6 days of mechanical ventilation was 2.10 ± 0.35. There was a significant difference in mean serum phosphorus at the time of intubation between two groups. Mean serum

phosphorus at the time of intubation was lower in subjects requiring duration of mechanical ventilation for > 6 days.



**Figure 1. Receiver Operating Characteristics Curves for Need of Longer Mechanical Ventilation Drawn of Serum Phosphorus Concentration on Admission**

Area under the ROC curve (AUC)	1.000
Standard error	0.000421
95 % confidence interval	0.967 to 1.000
Z statistic	1187.123
Significance level P (area = 0.5)	< 0.0001

**Table 2a. Validity of Serum Phosphorus at Intubation in Predicting Longer Duration of Ventilation**

Youden index J	0.9855
95 % confidence interval	0.9286 to 1.0000
Associated criterion	≤ 2.7
95 % confidence interval	2.5 to 2.7

**Table 2b. Youden Index**

In the study serum phosphorus level at admission at cut-off ≤ 2.7 had sensitivity of 98.55 %, specificity of 100 %, positive predictive value (+ PV) of 100 % and negative predictive value (- PV) of 97.7 %.

Criterion	Sensitivity	95 % CI	Specificity	95 % CI	+ LR	95 % CI	- LR	95 % CI	+PV	95 % CI	-PV	95 % CI	Cost
≤2.6	92.75	83.9 - 97.6	100.00	91.6 - 100.0			0.072	0.03 - 0.2	100.0	94.4 - 100.0	89.4	76.9 - 96.5	0.0450

**Table 3. Criterion Values and Coordinates of the ROC Curve**

+PV: Positive predictive value, -PV: Negative predictive value, ROC: Receiver operating characteristics

**DISCUSSION**

In our study with a total of 110 patients, 77 cases had primary respiratory pathology, 10 cases had primary cardiovascular pathology, 13 cases were of poisoning with various substances and the rest 10 cases were of miscellaneous causes. Most of the patients' age group was between 40 - 70 years of age, with only 8 cases where age was less than 40 years and 7 cases whose age was more than 70 years.

Out of these 110 patients, 42 patients were successfully weaned from mechanical ventilation applying the fore-

mentioned criteria in less than or equal to 6 days. Out of the remaining 68 patients, 16 patients could not be weaned from ventilation and 52 patients were weaned after 6 days of mechanical ventilator support.

In all those patients, mean age of subjects requiring ≤ 6 days of mechanical ventilation was 53.69 ± 12.07 and among subjects with > 6 days of mechanical ventilation was 56.38 ± 9.72 years. There was no significant difference in mean age between the two groups of ventilation.

Mean serum phosphorus at admission among subjects requiring ≤ 6 days of mechanical ventilation was 3.40 ± 0.40 and among subjects with > 6 days of mechanical ventilation

was 2.14 ± 0.38, with a significant 'P' value of < 0.001. This is a statistically significant observation. There was a significant difference in the mean serum phosphorus at admission between the two groups. Mean serum phosphorus at admission was lower in subjects requiring duration of mechanical ventilation for > 6 days.

Similarly, mean serum phosphorus at the time of intubation among subjects requiring ≤6 days of mechanical ventilation was 3.34 ± 0.34 and among subjects with > 6 days of mechanical ventilation was 2.10 ± 0.35, with 'P' value of less than < 0.001. This is a statistically significant observation. There was a significant difference in the mean serum phosphorus at the time of intubation between two groups. Mean serum phosphorus at the time of intubation was lower in subjects requiring duration of mechanical ventilation for > 6 days.

There are not many studies which show a correlation between serum phosphorus and the duration of mechanical ventilation. One such study by Alsumrain et al. noted that hypophosphatemia occurred in 21.2 % of patients in ICU<sup>10</sup>

Yuliangzhao et al. showed that a significantly higher percentage of failure-to-wean from mechanical ventilation was observed in the hypophosphatemia group vs. the normophosphatemic group (34.21 vs. 10.34 %, P < 0.05).

Reihanak Talakoub et al. showed that lower levels of serum phosphorus during initiation and continuation of mechanical ventilator support lead to a significant prolongation in the duration of requirement of mechanical ventilation.

In one more study, Agusti et al. says that irrespective of cause of mechanical ventilation, serum phosphorus levels should be corrected to achieve successful weaning.

### CONCLUSIONS

It is observed that serum phosphorus levels are very important in weaning off ventilatory support in critically ill patients and its assessment can be used as a predictor of duration of mechanical ventilation.

Data sharing statement provided by the authors is available with the full text of this article at jebmh.com.

Financial or other competing interests: None.

Disclosure forms provided by the authors are available with the full text of this article at jebmh.com.

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