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A STUDY OF ELECTROLYTES IMBALANCE IN MECHANICALLY VENTILATED PATIENTS

General Medicine

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ABSTRACT

Introduction: Mechanical ventilation is used to assist or replace spontaneous breathing. It is implemented with special devices that can support ventilator function and improve oxygenation through the application of high-oxygen-content gas and positive pressure. Electrolytes and fluid disorders are ubiquitous in critically ill patients especially who are mechanically ventilated. Electrolytes disturbance have great impact on outcome during course and weaning from mechanical ventilation. This study is undertaken to evaluate the association between serum electrolytes changes and mechanical ventilation and their possible impact on prognosis and outcome.

Aims & Objectives: To study the level of serum electrolytes in mechanically ventilated patients, To identify commonest electrolyte abnormality in mechanically ventilated patients, To correlate its effects with patient outcome in terms of mortality

Materials and Methods: During the course of June 2018 to June 2019, total 100 subject requiring mechanical ventilation were undertaken examined into this prospective study. Estimation of serum electrolytes including Na^+, K^+, Ca^{++} and Cl^- were done before ventilation and after the 24 hour interval of ventilation. Obtained data were plotted in excel sheet. APACHE II score was counted at the interval of 24 hours.

Result: Out of 100 subjects, 55 were males with mean age of 46 ± 19 years and 45 were females with mean age of 42 ± 19 years. On comparison of data of serum electrolytes collected before ventilation and at 24 hours of mechanical ventilation with paired T test, it is noticed that there is statistically significant decrement in mean serum sodium, potassium and ionized calcium level at 24 hour interval of mechanical ventilation with difference of 3.15, 0.484 and 0.0485 respectively and P value of <0.0001, <0.0001 and 0.0075 respectively. we observed an incidence of electrolyte imbalance at the interval of 24 hours of mechanical ventilation in the form of Hypocalcemia (75%), Hyponatremia (45%), Hypokalemia (41%), and Hypochloremia (41%).

Conclusion: Patients requiring on mechanical ventilation are at a higher risk of decrease in plasma Sodium, Potassium and Calcium(ionized) level. Intensive treatment during the period of stay on mechanical ventilation added to the disease process itself can cause further deterioration in the level of serum electrolytes. Imbalance of serum electrolytes and delay in time for its correction increase the period of mechanical ventilation, prolongs the stay in critical setup and associated with increment of co-morbidity and mortality.

KEYWORDS

Mechanical ventilation, electrolytes imbalance, hypocalcemia, hypokalemia, Hyponatremia.

SUMMARY:

The present study was conducted for a period of 12 months from June 2018 to June 2019 in the Department of General Medicine, Government Medical College and Sir Takhtasihji General Hospital, Bhavnagar, Gujarat.

Serum electrolytes sample were collected from patients those requiring mechanical ventilation on two occasions (before ventilation and 24 hours of ventilations). APACHE II score was calculated for each subjects at 24 hour of ventilator support. Comparison and statistical analysis were done.

Out of 100 subjects, 55 were males with mean age 46±19 years and 45 were females with mean age of 42±19 years. The distribution was calculated with chi-square test and we found that both sex are comparable with respect to each other and with their age group and was equally distributed.

On distributing primary diagnosis wise, we found that, out of 100 subjects, 18 were of CVA; 17 were of live failure; 14 were of IHD;11 were of epilepsy; 10 were of meningitis; 8 were of poison; 7 were of DKA; and 2 subjects were of tetanus. On statistical analysis with chi-square test, there is unequal distribution of disease in male and female groups. Commonest primary diagnosis in this study was CVA.

On comparison of data of serum electrolytes collected before ventilation and at 24 hours of mechanical ventilation with paired T test, it is noticed that there is statistically significant decrement in mean serum sodium, potassium and ionized calcium level at 24 hour interval of mechanical ventilation with difference of 3.15, 0.484 and 0.0485 respectively and P value of <0.0001, <0.0001 and 0.0075 respectively. The difference in serum chloride level was not significant.

At the interval of 24 hours of mechanical ventilation, serum sodium was normal in 45; Hyponatremia was in 45 and hypernatremia was in 10 subjects. Serum potassium was normal in 52; hypokalemia was in 41 and hyperkalemia in 7 subjects. Serum calcium(ionized) was normal in 25; hypocalcemia was in 75 subjects whereas hypercalcemia was not detected. Serum chloride was normal in 28; Hypochloremia was in 41 and hyperchloremia seen in 31 subjects. Statistically, the change in serum sodium, potassium and ionized calcium was significant

Statistical data counted at the 24 hours of mechanical ventilation suggests that Hyponatremia is more common than hypernatremia; Hypokalemia is more common than hypernatremia; hypocalcemia is seen in 75 and no subjects were found having hypercalcemia and on comparing with ANOVA test, we found that there was no significant difference of APACHE II score and mortality prediction in either group.

Observation of serum electrolytes level carried out on the basis of underlying condition. We tested association between underlying disease and distribution of electrolyte status by chi-square test but it was found not significant statistically.

Out of 100 subjects, maximum fall into APACHE II score category 20-24 that is 35 and most common electrolyte abnormality in this category is hypocalcemia(69%). Another 27 subjects fall into APACHE II score category 15-19 having commonest electrolyte abnormality is hypocalcemia(78%). Only 1 subject falls into category >34 having all serum electrolytes levels below normal limit.

In this study, out of 100 subjects who required ventilator management, we observed an incidence of electrolyte imbalance at the interval of 24 hours of mechanical ventilation in the form of Hypocalcemia (75%), Hyponatremia (45%), Hypokalemia (41%), and Hypochloremia (41%).

Out of 100 subjects, 17 were survived and 83 were expired. The electrolytes abnormality found was in similar fashion as described above.

INTRODUCTION

Mechanical ventilation is used to assist or replace spontaneous breathing. It is implemented with special devices that can support

ventilator function and improve oxygenation through the application of high-oxygen-content gas and positive pressure. The primary indication for initiation of MV is respiratory failure, of which there are two basic types: (1) hypoxemic, which is present when arterial O2 saturation (Sao2) <90% occurs despite an inspired O2 fraction and usually results from ventilation-perfusion mismatch or shunt and (2) hypercarbic, which is characterized by elevated arterial carbon dioxide partial pressure (PCO2) value (usually>50 mmHg) resulting from conditions that decrease minute ventilation or increase physiologic dead space such that alveolar ventilation is inadequate to meet metabolic demands.[1]

Electrolytes and fluid disorders are ubiquitous in critically ill patients especially who are mechanically ventilated. Electrolytes disturbance have great impact on outcome during course and weaning from mechanical ventilation.[19]

The problems found in mechanically ventilated patients will affect either the capacity of or the demand on the respiratory system that include: electrolyte disturbance, acid-base disorder, hemodynamic instability, volume overload, decreased respiratory muscle function.[19]

Electrolytes disturbance during mechanical ventilation and weaning have been studied. It has shown that hypophosphatemia, hypokalemia, hypocalcemia, and hypomagnesemia, reduce muscle contractility and affects the clinical course during mechanical ventilation and have great impact on weaning attempts.[20] So serial monitoring and correction of plasma electrolyte is crucial.

This study is undertaken to evaluate the association between serum electrolytes changes and mechanical ventilation and their possible impact on prognosis and outcome

AIM AND OBJECTIVES

To study the level of serum electrolytes in mechanically ventilated patients To identify commonest electrolyte abnormality in mechanically ventilated patients To correlate its effects with patient outcome in terms of mortality

MATERIAL & METHOD

Source of Data

During the course of June 2018 to June 2019, total 100 subject admitted to Sir T general hospital Bhavnagar and requiring mechanical ventilation were undertaken into this prospective study.

Sample Size: 100 cases
Sample procedure: a prospective study.
Duration: 2018-2019

Inclusion criteria:

All patients admitted to Sir t General hospital Bhavnagar put on mechanical ventilatory support and having electrolytes imbalance.

Exclusion criteria:

- Patient not giving consent
- Age < 12 years

METHOD:

During the course of June 2018 to June 2019, total 100 subject requiring mechanical ventilation were undertaken and examined into this prospective study. Estimation of serum electrolytes including Na^+, K^+, Ca^{++} and Cl^- were done before ventilation and after the 24 hour interval of ventilation. Obtained data were plotted in excel sheet. APACHE II score was counted at the interval of 24 hours.

The following parameters were collected: age, gender, religion, blood pressure and clinical chemistry parameters. Blood samples (2ml) were collected in clot activator Vaccute from each participant while employing standard infection prevention procedures. The serum was obtained after centrifuging the blood for 5 min at 2500 rpm. The serum samples were then used to determine the concentrations of Sodium, Potassium, ionized Calcium and Chloride. Data collected were entered in excel. Percentage, Mean and Standard deviation were calculated. Appropriate test of significance like paired t test, unpaired t test, chi-square test, ANOVA(one way analysis of variance) were done. Values were considered statistically significant if $p < 0.05$.

OBSERVATION AND RESULT

The present study was undertaken to evaluate the significance possible electrolytes abnormality in mechanically ventilated patients. 100 subjects with various electrolytes abnormality put on ventilator machine due to various underlying condition had been taken into consideration. The result of study is as follow.

Table 1 Age and sex distribution of study subjects

1. Age in years	MALE(N=55)	FEMALE(N=45)	TOTAL(N=100)	P value**
12y-25y	11	15	26	0.25 (Not-significant)
26y-50y	23	12	35	
51y-75y	18	17	35	
>75y	03	01	04	

**chi-square test

Out of 100 subjects, 55 were males with mean age of 46 ± 19 years and 45 were females with mean age of 42 ± 19 years. Out of 55 males, 11 fall into 12-25 years ; 23 fall into 26-50 years; 18 fall into 51-75 years and 3 fall into >75 years of age group. Out of 45 female, 15 fall into 12-25 years; 12 fall into 26-50 years ; 17 fall into 51-75 years and 1 falls into >75 years of age group. Male and female are comparable with respect to each other and with their age groups.

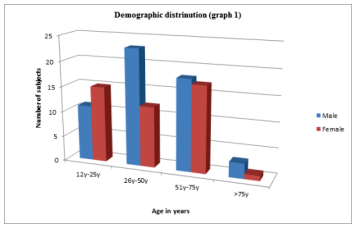


Table 2 Primary diagnosis in study subject:

2. Disease associated	Male(n=55)	Female(n=45)	Total(n=100)	P value**
CVA	9	9	18	***0.0085**** (Significant)
Liver failure	14	3	17	
Renal failure	3	11	14	
IHD	10	3	13	
Epilepsy	4	7	11	
Meningitis	4	6	10	
Poison	7	1	8	
DKA	3	4	7	
Tetanus	1	1	2	

**chi-square test

Out of 100 subjects, 18 were of CVA (9 male, 9 female); 17 were of liver failure (14 male,3 female); 14 were of renal failure (3 male; 11 female); 13 were of IHD (10 male, 3 female); 11 were of epilepsy (4 male , 7 female); 10 were of meningitis (4 male, 6 female); 8 were of poison (7 male, 1 female); 7 were of DKA (3 male, 4 female) and 2 were of tetanus (1 male, 1 female). On testing with chi-square test, there is unequal distribution of disease in male and female groups.

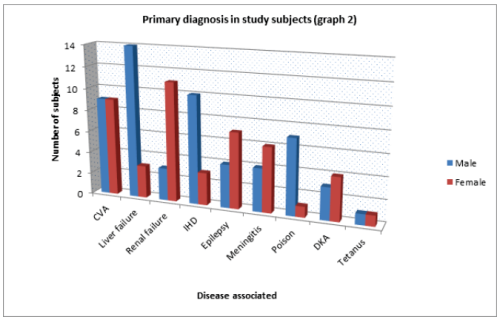


Table 3 Statistical Comparison of electrolyte abnormality before and after 24 hours of mechanical ventilation

On comparison of data of serum electrolytes collected before ventilation and at 24 hours of mechanical ventilation with paired T test, it is noticed that there is statistically significant decrement in mean serum sodium, potassium and ionized calcium level at 24 hour interval of mechanical ventilation with difference of 3.15, 0.484 and 0.0485 respectively and P value of <0.0001, <0.0001 and 0.0075 respectively. The difference in serum chloride level was not significant.

3. Electrolytes	Before venti	24 hours	difference	P value**	Significant or not
Sodium Mean ±SD(range)	138.42±8.87 (118-160)	135.27±8.28 (117-156)	3.15	***<0.0001****	Extremely Significant
Potassium Mean ±SD(range)	4.183±1.005 (2.4-6.6)	3.699±0.798 (2.4-5.8)	0.484	***< 0.0001****	Extremely Significant
Calcium (ionized) Mean ±SD(range)	1.103±0.172 (0.67-2.0)	1.054± 0.097 (0.82-1.28)	0.0485	***0.0075****	Very Significant
Chloride Mean ±SD(range)	107.14± 11.25 (77-139)	105.53±11.64 (78-137)	1.61	0.3244	Not significant

**paired t test

Table 4 Electrolyte abnormality in study subject

At the interval of 24 hours of mechanical ventilation, serum sodium was normal in 45; Hyponatremia was in 45 and hypernatremia was in 10 subjects. Serum potassium was normal in 52; hypokalemia was in 41 and hyperkalemia in 7 subjects. Serum calcium(ionized) was normal in 25; hypocalcemia was in 75 subjects whereas hypercalcemia was not detected. Serum chloride was normal in 28; Hypochloremia was in 41 and hyperchloremia seen in 31 subjects. Statistically, the change in serum sodium, potassium and ionized calcium was significant.

4. Electrolyte abnormality in study subject		Before venti(n=100)	24 hours after(n=100)	P value**
SODIUM (meq/L)	Hyponatremia	32	45	***0.0186****
	Normal Na+	44	45	
	Hypernatremia	24	10	
POTTASIUM (meq/L)	Hypokalemia	28	41	***0.0088****
	Normal K+	51	52	
	Hyperkalemia	21	07	
CALCIUM(ionized) (mmol/L)	Hypocalcemia	54	75	***0.0037****
	Normal Ca++	43	25	
	Hypercalcemia	03	0	
CHLORIDE (meq/L)	Hypochloremia	33	41	***0.16***
	Normal Cl-	23	28	
	Hyperchloremia	44	31	

**chi-square test

Table 5 Sodium disturbance regarding APACHE II score (counted at 24 hours of mechanical ventilation) and mortality prediction:

Statistical data counted at the 24 hours of mechanical ventilation suggests that Hyponatremia is more common than hypernatremia but on comparing with ANOVA test, we found that there was no significant difference of APACHE II score and mortality prediction in either group.

5. Sodium	Hyponatremia(n=45)	Normal Na+(n=45)	Hypernatremia (n=10)	P value**
APACHE II score Mean ±SD(range)	21.96±5.46 (11-35)	21.16±4.82 (10-32)	20.3±4.8(14-30)	0.58
Mortality prediction% Mean ±SD(range)	41.24±16.38(15-85)	38.2±15.2 (15-73)	40.8±17(15-73)	0.65

**One-way Analysis of Variance (ANOVA) test

Table 6 Potassium disturbance regarding APACHE II score (counted at 24 hours of mechanical ventilation) and mortality prediction:

Statistical data counted at the 24 hours of mechanical ventilation suggests that Hypokalemia is more common than hyperkalemia but on comparing with ANOVA test, we found that there was no significant difference of APACHE II score and mortality prediction in either group.

6. Potassium	Hypokalemia(n=41)	Normal K+(n=52)	Hyperkalemia(n=7)	P value**
APACHE II score Mean ±SD(range)	21.61±5.38 (10-35)	21.67±4.87 (13-32)	21.43±5.82 (15-30)	0.99
Mortality prediction% Mean ±SD(range)	40.22±17.07(15-85)	39.44±14.77(15-73)	39.43±18.2 (25-73)	0.97

**One-way Analysis of Variance (ANOVA) test

Table 7 Calcium (ionized) disturbance regarding APACHE II score (counted at 24 hours of mechanical ventilation) and mortality prediction:

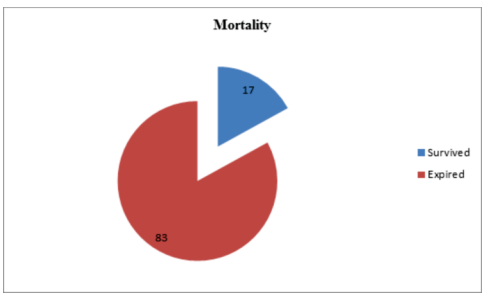
Out of 100 subjects, hypocalcemia is seen in 75 and no subjects were found having hypercalcemia. So on comparing with unpaired t test, we found that there was no significant difference of APACHE II score and mortality prediction in either group.

7. Calcium (ionized)	Hypocalcemia (n=75)	Normal Ca++(n=25)	Hypercalcemia (n=0)	P value**
APACHE II score Mean ±SD(range)	21.73±5.19 (10-35)	21.32±4.88 (11-32)	---	0.73
Mortality prediction% Mean ±SD(range)	40.2±16.44 (15-85)	38.72±14.10 (15-73)	---	0.69

**Unpaired t tes

Table 8 Comparison of electrolytes distribution on the basis of mortality

9. Electrolytes distribution on the basis of mortality		Survived (n=17)		Expired(n=83)	
		Before venti	24 hours	Before venti	24 hours
Serum Sodium	Hyponatremia	5 (29%)	**7 (41%)**	27 (33%)	**38 (46%)**
	Normal Na+	8 (47%)	9 (53%)	36 (43%)	36 (43%)
	Hypernatremia	4 (24%)	1 (6%)	20 (24%)	9 (11%)
Serum potassium	Hypokalemia	6 (35%)	**7 (41%)**	22 (27%)	**34 (41%)**
	Normal K+	8 (47%)	7 (41%)	43 (52%)	45 (54%)
	Hyperkalemia	3 (18%)	3 (18%)	18 (21%)	4 (5%)
Serum ionized calcium	Hypocalcemia	6 (35%)	**13 (76%)**	48 (57%)	**62 (75%)**
	Normal Ca++	10 (59%)	4 (24%)	32 (39%)	21 (25%)
	Hypercalcemia	1 (6%)	0 (0%)	03 (4%)	0 (%)
Serum chloride	Hypochloremia	4 (24%)	6 (35%)	29 (35%)	35 (42%)
	Normal Cl-	6 (35%)	6 (35%)	17 (20%)	22 (27%)
	Hyperchloremia	7 (41%)	5 (30%)	37 (45%)	26 (31%)



Out of 100 subjects, 17 were survived and 83 were expired. Commonest electrolytes abnormality found in survived and expired was hypocalcemia, hypokalemia and Hyponatremia.

DISCUSSION

The advent of mechanical ventilation played an important role in improving outcome in critically ill patients. The mechanical ventilation and its course are associated with many complications including serum electrolyte imbalance, acute lung injury, hypoxic ischemic encephalopathy, ventilation associated pneumonia, etc.

Unfortunately, limited data and studies are available regarding serum electrolytes imbalance in association with mechanical ventilation. So this study was undertaken to evaluate electrolyte changes after implication of mechanical ventilation.

In this study, out of 100 subjects who required ventilator management, we observed an incidence of electrolyte imbalance at the interval of 24 hours of mechanical ventilation in the form of Hypocalcemia (75%), Hyponatremia (45%), Hypokalemia (41%), and Hypochloremia (41%), that is described in table 3. On comparison with **"A study of clinical profile of patients requiring prolonged mechanical ventilation and their outcome in a tertiary care medical ICU;JAPI Vol 63; Oct 2015"**,[4] it also shows high incidence of electrolyte imbalances in prolonged mechanical ventilation needing patients viz. hypocalcemia (84.44%), hypokalemia (31.11%) and hypomagnesemia (40.9%).

On comparison with another study of electrolytes imbalance in association with mechanical ventilation **"Serum electrolytes levels and outcomes in patients hospitalized with hepatic encephalopathy"; Ali A. Alsaad et al 2018**,[7] that study observed the change of electrolytes in association with mechanical ventilation are 10 unit increase in sodium, 1 unit increase in potassium, 1 unit increase in ionized calcium and 10 unit increase in chloride level. This difference may be due to different underlying etiology.

In another study of "**Electrolytes disturbances and their impact on mechanically ventilated patients with acute exacerbation of COPD", Faris M. ouf et al 2015**,[6] there was a significant decrease in serum sodium, potassium, calcium and magnesium on third and fifth day of mechanical ventilation.

In another study of **"Electrolyte studies in the respiratory paralysis of poliomyelitis" by A. E. Thomas, M.D., university of Manitoba, Winnipeg, Canada: April, 1957**,[24] it was observed that during acute mechanical respiration induced alkalosis and acidosis, plasma potassium level could be directly related to coexisting level of pCO_2 and in each instance the increase in ventilation was accompanied by slight change in plasma concentration of sodium, potassium and chloride in the form of a fall in sodium and potassium together with a rise in chloride.

In another study of **"Respiratory alkalosis and associated electrolytes in long term ventilator dependent person with tetraplegia" by JWH Watt and P Silva, Southport hospital UK,**[5] it was observed that there was no evidence of biochemical jeopardy from long term mechanical hyperventilation although acutely administered hyperventilation has the potential to cause fall in serum potassium, magnesium and phosphate so caution should be exercised in part time ventilated patients.

On comparison of data of serum electrolytes collected before ventilation and at 24 hours of mechanical ventilation with paired T test, it is noticed that there is statistically significant decrement in mean serum sodium, potassium and ionized calcium level at 24 hour interval of mechanical ventilation with difference of 3.15, 0.484 and 0.0485 respectively and P value of <0.0001, <0.0001 and 0.0075 respectively. The difference in serum chloride level was not significant.

In this study, on comparison between electrolytes abnormality and death prediction by APACHE II score (table 5-7) , we found that there was no significant effect on mortality due to acute change in serum electrolytes status. The higher mortality may be due to mechanical ventilator support itself and other ventilator associated complications rather than electrolytes abnormality.

The limitation is that, in this study, changing trend of electrolytes is observed only during 24 hours of mechanical ventilation. More studies are in need comparing impact, of long term mechanical ventilation support, on serum electrolytes level.

CONCLUSION

Patients requiring on mechanical ventilation are at a higher risk of decrease in plasma Sodium, Potassium and Calcium(ionized) level. Intensive treatment during the period of stay on mechanical ventilation added to the disease process itself can cause further deterioration in the level of serum electrolytes.

Imbalance of serum electrolytes and delay in time for its correction increase the period of mechanical ventilation, prolongs the stay in critical setup and associated with increment of co-morbidity and mortality.

So, plasma electrolyte levels should be monitored routinely and regularly in those patients and attempt should be made to correct them as early as possible to avoid poor outcomes.

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