Journal of Cardiovascular Disease Research

ISSN: 0975-3583, 0976-2833 VOL14, ISSUE 06, 2023

ORIGINAL RESEARCH

Treatment of Electrolyte Disorders in Adult Patients in the Intensive Care Unit (ICU)

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ABSTRACT

Background: Fluid and electrolytes disturbances are among the most common clinical problems encountered in the intensive care unit (ICU). Studies among critically ill patients have shown that fluid and electrolyte imbalances are associated with increased morbidity and mortality. Objective: To study treatment and outcome of electrolyte disorders in adult patients in the intensive care unit (ICU).

Methods: A prospective observational study of Treatment of Electrolyte Abnormalities in patients admitted in Intensive Care Unit at Base Hospital Delhi Cantt. The study was carried out over a period starting 01 Apr 2013 to 31 Sep 2014 at Intensive Care Unit at Base Hospital Delhi Cantt.

Results: Treatment of electrolyte imbalances was with either supplementation or withholding of electrolytes & treatment of associated conditions, and withdrawal offending drugs in drug induced patients. Only 2 patients with hyperkalemia & 1 patient with hypercalcemia required hemodialysis, however these patients had other associated comorbidities.

Conclusion: Our study has been handicapped by its short duration and limited number of patients, multiple comorbidities and mixed electrolyte abnormalities. Thus larger studies are required involving individual electrolytes and specific conditions. Therefore, it is suggested that clinician working in emergency department should have good knowledge of fluid and electrolyte balance dynamics.

Keywords: Treatment, Electrolyte abnormalities, Intensive Care Unit patients, outcome

INTRODUCTION

Health care providers should be familiar with the principles and practice of fluid and electrolyte physiology and pathophysiology for providing optimal care. Fluid resuscitation should be aimed at restoration of normal hemodynamics and tissue perfusion. Early goal directed therapy has been shown to be effective in patients with severe sepsis or septic shock [1].

Normal electrolyte homeostasis encompasses a complex system involving multiple organs, neuro-hormonal pathways; fluid status and acid–base balance[2]. The clinical manifestations, depending upon the specific electrolyte disorder can range from asymptomatic to death, and the magnitude of the abnormality in the patient's serum concentration[3]. Liberal fluid administration on the other hand, is associated with adverse outcomes such as higher cost of care, prolonged stay in the ICU, and increased mortality. Hyponatremia in critically ill patients is associated with either disturbances in the renal mechanism of urinary dilution or removal of nonosmotic stimuli for vasopressin secretion or judicious use of hypertonic saline, and close monitoring of plasma

ISSN: 0975-3583, 0976-2833 VOL14, ISSUE 06, 2023

and urine electrolytes are essential components of therapy. Hypernatremia leads to cellular dehydration and central nervous system damage. Water deficit should be corrected considering the ongoing water loss. Cardiac manifestations should be identified and treated before stepwise diagnostic evaluation of dyskalemias. Divalent ion deficiencies such as hypocalcemia, hypomagnesemia and hypophosphatemia are associated with increased adverse events among critically ill patients[1].

Critical illness causes major stress on all regulatory functions of the body including those responsible for maintaining normal electrolyte balance. Therapies directed at sustaining vital organs functions directly or indirectly affect these regulatory systems[1].

Treatment of electrolyte disorders in the intensive care unit is often empirical, based on published literature, expert opinion and recommendations, and patient's response to the initial treatment. Clinicians should have a good knowledge about all the electrolyte homeostasis and their underlying pathophysiology to provide optimal therapy for patients [1].

In this study we have evaluated the general characteristics of patients admitted to our Intensive care Unit (ICU), and diagnosed as having electrolyte imbalance. The etiology, clinical manifestations and management of specific electrolyte disorders is being studied. Literature data generally focused on imbalances of specific electrolytes, and the majority of the studies recruited patients of a specific disease or risk group. To our knowledge, only three studies focused on electrolyte imbalances in emergency department patients, and two of them conducted with elderly patients[4]. There are not many studies been done on the electrolyte abnormalities in ICU setup. This study is the second study of its kind which investigates the generic electrolyte disturbances in intensive care unit admissions, and it will contribute to the literature data by providing valuable information for the ICU physicians. This study focuses on treatment and outcome of such disorders in adult patients in the Intensive Care Unit (ICU).

MATERIALS AND METHODS

A prospective observational study of treatment of Electrolyte Abnormalities in patients admitted in Intensive Care Unit at Base Hospital Delhi Cantt. The study was carried out over a period starting 01 Apr 2013 to 31 Sep 2014 at Intensive Care Unit at Base Hospital Delhi Cantt.

Study population and sample size: Based on the statistical calculation study population was included a total number of 100 patients admitted in Intensive Care Unit, Base Hospital, Delhi Cant.

Calculation of the sample size as the outcomes is being studied on a dichotomous scale:-

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

Hence based on the statistical calculation a minimum of 100 cases is required in the study groups.

Inclusion Criteria

1. All patients admitted in Intensive Care Unit Base Hospital Delhi Cantt having imbalance in Sodium, Potassium, Calcium, Phosphate and Magnesium levels.

Exclusion Criteria

1. Non availability of consent of individuals/next of kin for participating in study.
2. Patients on electrolyte supplements

Methods of Study

The patients presenting with or developing abnormalities in Sodium, Potassium, Calcium, phosphate and Magnesium levels in Intensive Care Unit were evaluated for clinical profile,

ISSN: 0975-3583, 0976-2833 VOL14, ISSUE 06, 2023

management outcomes. Laboratory evaluation for the cause of electrolyte abnormalities and other relevant work up including Renal/ Neurological/ Endocrinal work up was done.

We have obtained the necessary approval to conduct the study from the institutional ethics committee of Base Hospital, Delhi Cantt. New Delhi. The participants/ next of kin were given a full explanation about the purpose of the study and assurance about the confidentiality of the information and that the participation was optional.

Statistical Analysis

All the statistical analysis was performed using SPSS version 20. The clinical profile of patients was analyzed by chi-square test for qualitative variables. Student t test was performed for comparison of quantitative variables. 5% probability level was considered as statistically significant i.e., $p<0.05$.

RESULT

Of these 64 patients (32%) had single electrolyte imbalance and 36 patients (18%) had more than one electrolyte imbalance.

In the 100 patients with electrolyte imbalance, 66% (n=66) were male and 34% (n=34) were females. The mean age of patients was 64.28 ±1.51 years. Hyperkalemia was more common electrolyte disorder in the ICU followed by Hypokalemia &hyponatremia. Hypermagnesemia and hypernatremia was the least common electrolyte disorder in our study. The likely attributable features include Muscle weakness and peaked T waves for hyperkalemia. Fatigue, muscle weakness, leg cramps and T wave flattening was the most common association with hypokalemia.

Treatment of electrolyte imbalances was with either supplementation or withholding of electrolytes & treatment of associated conditions, and withdrawal offending drugs in drug induced patients. Only 2 patients with hyperkalemia & 1 patient with hypercalcemia required hemodialysis, however these patients had other associated comorbidities.

In my study the maximum number of deaths occurred in patients who had potassium imbalance (Hypokalemia and Hyperkalemia). Their combined mortality was found to be 7%. The total no deaths were 10 in the study population as compared 3 in remaining ICU patients without electrolyte imbalance ($P < 0.05$). There is also a slight increase in deaths in patients with multiple electrolyte imbalances as compared to single electrolyte imbalance. However due to multiple comorbidities and mixed electrolyte imbalances, the dyselectrolytemia could not be considered as the only cause of death.

All the patients in our study had comorbid conditions. The most common co morbidity was hypertension followed by Diabetes and CAD.

Table 1: Treatment of Hypokalemia (n=24)

Treatment	number of patients
Oral KCL	20
IV KCL	10
With-holding of diuretics	8
K sparing diuretics	4

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Table 2: Treatment of Hyperkalemia (n=26)

Treatment	number of patients
Salbutamol nebulisation	24
Withdrawal of drugs	16
Insulin + Dextrose	10
IV Calcium	6
Hemodialysis	2

Table 3: Treatment of Hyponatremia (n=22)

Treatment	number of patients
Oral salt	17
Normal saline	16
3% saline	7

Table 4: Treatment of Hypernatremia (n=5)

Treatment	number of patients
Salt restriction	5
Oral free water	3
Withdrawal IV NS	3
IV dextrose	1

Table 5: Electrolyte abnormalities and outcome in the study group

Dyselectrolytemia	Abnormalities in Number	Outcome		
		Recovered	Death	Percentage died
Hypokalemia	24	20	4	16.66
Hyperkalemia	26	23	3	11.53
Hyponatremia	22	20	2	9.09
Hypernatremia	5	5	0	0
Hypophosphatemia	17	15	2	11.76
Hyperphosphatemia	16	15	1	6.25
Hypocalcemia	14	13	1	7.14
Hypercalcemia	8	8	0	0
Hypomagnesemia	11	10	1	9.09
Hypermagnesemia	6	6	0	0

Table 6: Comparison of outcome with and without electrolyte imbalance

Study subjects	Number of Patients	Number of Deaths	Percentage
With electrolyte imbalance	100	10	10%
Without electrolyte imbalance	98	3	3.06%
Total	198	13	6.56%

P value 0.049

DISCUSSION

Zafar MH et al., in their study conducted in a tertiary care teaching hospital of north India, over a period of 2 years found that out 17 (24.29%) of 70 critically ill patients studied, were

ISSN: 0975-3583, 0976-2833 VOL14, ISSUE 06, 2023

hypomagnesemic, three patients were hypermagnesemic and 50 patients (71.43%) were normomagnesemic[5].

Limaye et al, in their study carried out in the Medical ICU of a tertiary care hospital from April 2004 to May 2005, showed that 52% had hypomagnesemia, 7% had hypermagnesemia and 41% were having normal magnesium levels [6].

Wong ET et al.,[7] studied on the prevalence of hypomagnesemia and hypermagnesemia among hospitalized patients and were determined that magnesium levels in 621 serum samples randomly selected from those submitted to the clinical chemistry laboratory for a biochemical test panel. Hypomagnesemia was present in 68 patients or 11.0%, and hypermagnesemia occurred in 58 patients or 9.3%.

Dyselectrolytemia led to greater morbidity and mortality in ICU patients. The mean ICU stay was prolonged in the study patients compared to those without electrolyte imbalance. The mean ICU stay was 7 $\pm$ 1 day in the study group whereas the mean ICU stay was 4 $\pm$ 1 day in those without electrolyte imbalance.

The highest mortality occurred in patients who had potassium imbalance (Hypokalemia and Hyperkalemia). Their combined mortality was 7% of the study population. 3% of the study population with phosphate imbalance died. This was followed by disorders of serum sodium [Hyponatremia + Hypernatremia], was associated with death in 2% of the study patients. Patients with electrolyte disorders of Magnesium and calcium had least mortality (1% each) in our study.

There were a total of 10 deaths (10%) in the study population, compared a total of 3 deaths (3.06%) in those ICU admissions who did not have electrolyte imbalance during the study period. 6 deaths occurred in patients with single electrolyte imbalance (16 out of 64 patients) while 4 deaths occurred in patients with more than 1 electrolyte imbalance (4 out of 36 patients). However the difference was not statistically significant.

In my study maximum deaths occurred in patients with potassium imbalance, 3 patients (16.66%) of the hypokalemic patients died and 2 patients (11.53 %) of hyperkalemia died. 2 patients (9.09%) with hyponatremia died. 2 patients (11.76%) with hypophosphatemia died and 1 patient with hyperphosphatemia (6.25%) died. One patient with hypocalcemia (7.14%) and one patient with hypomagnesemia died (9.09%). There were no deaths in patients with hypercalcemia, hypermagnesemia and hypernatremia.

Pfortmüller CA et al: in their study found that almost 40% of patients presenting with hyperkalemia died during hospitalization[8].

Rao et al[9] in their study concluded that the mortality rate among those with hyponatremiawas 20%. Vandergheynst F et al[10] in their study concluded that dysnatremias had higher hospital mortality rates than in those with normal sodium levels and were directly related to the severity of dysnatraemia. This association between dysnatraemia and mortality was similar in infected and noninfected patients. Padhi R et al[11] found that hyponatremic patients had longer ICU stay, had longer ventilator days and had an increased mortality. Darmon M et al, in their study found that even with only slightly elevated serum sodium levels, mortality was elevated as compared with the normonatremic controls (15% versus 30%) [12].

Multiple studies show an association between hypophosphatemia and increased mortality [13, 14].

However, hypophosphatemia has not been associated with increased mortality after cardiac surgery[15]

Haider et al[16]., in their study found that there was no association between hypophosphatemia and mortality in contrastonly hyperphosphatemia was an independent risk factor for mortality, of the

ISSN: 0975-3583, 0976-2833 VOL14, ISSUE 06, 2023

20% hypophosphatemic patients 3.5% died, of the 9% hyperphosphatemic patients and 10.7% of them died, where as only 37 patients (2.2%) with normal phosphate died[17].

Shor R et al[18], found that severe hypophosphatemia predicts an increase of up to 8-fold in mortality in sepsis patients [19].Suzuki et al., in their study found that hypophosphatemia behaves like a general marker of illness severity and not as an independent predictor of ICU or in-hospital mortality in critically ill patients. Hoffmann M et al[20], in their study found that severe hypophosphatemia is associated with a very high mortality (30%).

Lee CT et al[21], in their study found that the total mortality rate among patients with hypercalcemia was 23.1%, and that serum calcium was independent risk factors for mortality. Chernow B et al, found hypocalcemic patients do less well clinically than normocalcemic patient. Desai TK et al., found that the mortality of the hypocalcemic patients (44 percent) was significantly greater ($p < 0.05$) than the mortality of the normocalcemic patients (17 percent) [19].

Zafar et al[5], found that mortality of hypomagnesemic group was 74.47% while that of normomagnesemic group was 36% ($P = 0.004$). Limayeet al[6], detected a higher mortality rate for hypomagnesemia patients when compared with normomagnesemic patients (57% vs. 31%).

Our center provides tertiary health services in its region as an Indian Armed Forces hospital, and particularly deals with clinically advanced diseases and complicated patients. Therefore, we particularly investigated electrolyte imbalances in our patients carefully, with an awareness of clinical importance of this entity. We determined Potassium imbalance in 50 % of our patients, and 48% of them had hypokalemia and 52% had hyperkalemia.Therefore, it is suggested that clinician working in emergency department should have good knowledge of fluid and electrolyte balance dynamics.

CONCLUSION

Our center provides tertiary health services in its region as an Indian Armed Forces hospital, and particularly deals with clinically advanced diseases and complicated patients. Therefore, we particularly investigated electrolyte imbalances in our patients carefully, with an awareness of clinical importance of this entity. We determined Potassium imbalance in 50 % of our patients, and 48% of them had hypokalemia and 52% had hyperkalemia. Therefore, it is suggested that clinician working in emergency department should have good knowledge of fluid and electrolyte balance dynamics.

Source of funding: Self

Conflict of interest: None.

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