Original Article DOI: 10.22114/ajem.v0i0.197

The Correlation of Serum Chloride Level and Hospital Mortality in Multiple Trauma Patients

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Published online: 2019-08-11

Abstract

Introduction: Electrolyte disorder is a prevalent complication in multiple trauma patients; nevertheless, the role of chloride has been rarely addressed in literature when evaluating serum electrolytes.

Objective: The present study was conducted to determine the correlation between serum chloride changes and hospital mortality in multiple trauma patients.

Method: The present cross-sectional study measured serum chloride levels in 100 multiple trauma patients upon their admission to the emergency department and 24 hours later. All these patients were followed up in terms of hospital mortality using their medical records. Exact logistic regression was used to measure the effects of independent variables on hospital mortality in the patients.

Results: Hospital mortality was found to be 15 (15%), and the mean serum chloride level to be 106.37±4.53 mmol/l upon admission and 112.18±6.16 mmol/l 24 hours later. Although the univariate analysis suggested that serum chloride levels were independently associated with mortality 24 hours after admission (P=0.005), this correlation was insignificant in the multivariate analysis.

Conclusion: The present study rejected the hypothesis suggesting the potential role of serum chloride levels in predicting hospital mortality in multiple trauma patients.

Key words: Chlorides; Correlation of Data; Hospital Mortality; Multiple Trauma; Serum

Cite this article as: Jahanipour A, Asadabaddi **S**, Torabi M, Mirzaee M, Jafari E. The Correlation of Serum Chloride Level and Hospital Mortality in Multiple Trauma Patients. Adv J Emerg Med. 2020;4(1):e4.

INTRODUCTION

Despite being a major cause of disability in developing countries, it seems that trauma and its complications have not been well addressed yet (1, 2). Multiple trauma defined as an injury severity score (ISS) of over 16 is a major cause of mortality every year. Given the complexity of trauma scoring systems, laboratory tests may provide a proper predictor of mortality in these patients (3).

At the start of the treatment, most trauma patients require intravenous (IV) fluid resuscitation, which helps hemodynamically-unstable patients provide appropriate responses using 1-2 liters of an isotonic solution as per Advanced Trauma Life Support (ATLS) guidelines (4). Fluids with high chloride concentrations are often used to compensate for the volume loss in these patients (5, 6). As an essential component for assessing many pathological conditions, chloride plays a key role in regulating body fluids, maintaining electrolyte balance and preserving electrical neutrality and acid-base status. Chloride contributes to one-third of the extracellular fluid tonicity, and plays a pivotal role in acid-base balance and osmosis (7). Given their potential loss of lots of body fluids, multiple trauma patients are vulnerable to hyperchloremia in the post-recovery phase. These patients are also at a greater risk of death associated with the serious complications of hyperchloremia, i.e. alarmingly high serum levels of chloride, as an electrolyte disorder following fluid resuscitation, which may also contribute to the lethal triad of hypothermia, coagulopathy and acidosis (8-10). Given the complications of hyperchloraemia, large volumes of crystalloid solutions must be avoided in critical patient fluid resuscitation (11, 12).

Despite the potential induction of hyperchloremia by fluid resuscitation in multiple trauma patients and the importance of the physiological level of chloride, this ion has rarely been addressed in literature compared to other ions, and it is not routinely measured in these patients (13). The present study was therefore conducted to determine the relationships of the levels and

variations in serum chloride with hospital mortality in multiple trauma patients presenting to the emergency department (ED).

METHODS

Study design and setting

The present cross-sectional research was performed on multiple trauma patients who were referred to Level II Trauma Center in Bahonar teaching hospital in southeastern Iran between 1 December 2017 and 1 September 2018. The present study was approved by the Ethics Committee of Kerman University of Medical Sciences, Kerman, Iran [IR.KMU.REC.1397.015]. The patients or their relatives first completed and signed informed consent forms.

Study Population

The eligible candidates comprised multiple trauma patients aged at least 18 years with an ISS of over 16. The cases with underlying diseases that contribute to chloride disorders such as kidney injuries, those with serum chloride levels over 110 mmol/l upon admission and those dying within 24 hours of admission to the ED were excluded.

Data Gathering

Blood samples were then collected from the patients to determine their serum chloride levels, and they were properly treated and underwent intravenous fluid therapy according to ATLS guidelines under the supervision of a treatment team (13). Blood samples were collected 24 hours after hospitalization, and serum chloride was re-measured with an electrolyte analyzer made by XT Co., China, and delta chloride was calculated as ΔCL=Serum chlorine level upon admission - Serum chloride 24 hours after admission. An already-designed questionnaire was used to record age, gender, the Glasgow Coma Scale (GCS) score, hemodynamic parameters, base excess (BE) and chloride levels upon admission and 24 hours later in all the patients. All the patients were also followed up after admission until their hospital discharge or mortality. Hospital mortality was investigated as an outcome in these patients using their medical records.

Statistical analysis

The data obtained were ultimately analyzed in STATA 12. Given the low mortality, exact logistic regression was used to analyze the effects of the independent variables on the outcomes in the patients. The univariate model was initially used, followed by selecting the variables with the univariate P<0.2 to be included in the multivariate backward model. The variables with P<0.05 remained in the final multivariate model (14).

RESULTS

According to figure 1, after excluding 60 from 160 patients, 100 multiple trauma patients, including 84 males and 16 females, were included in the present study.

These 100 patients were 18-92 years old, and had a mean age of 36.87±17.87 years. The mean age of the males was 35.17±16.6 years and that of the females 45.81±21.99, suggesting a significant difference (P=0.028).

Their GCS score was also 3-5 with a mean of 12.61±3.87. Moreover, their mean serum chloride level was 106.37±4.53 upon admission and 112.18±6.16 twenty-four hours later, suggesting a ΔCl of 5.83±4.27.

Fifteen (15%) of these 100 patients died, including 14 (93.3%) males and 1 (6.7%) female. Table 1 presents the mean of the other variables and their

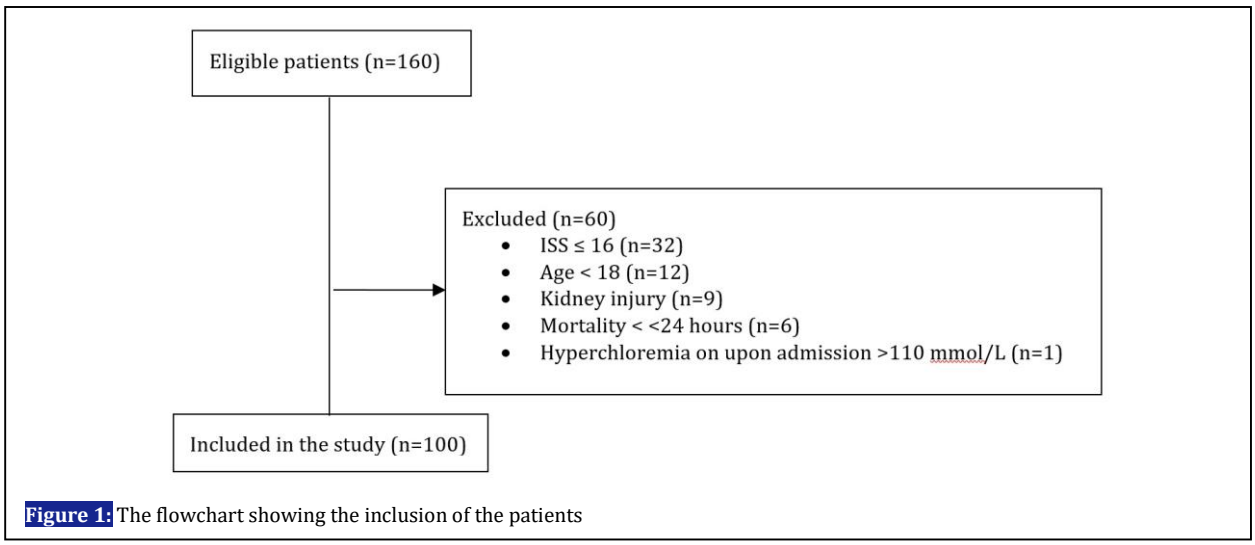

Figure 1: The flowchart showing the inclusion of the patients

Table 1: Basic characteristics and their associations with hospital mortality based on the univariate analysis

Variable	Overall (Mean±SD)	Mortality (Mean±SD)		P
		Yes	No	
Age (year)	36.87±17.87	51.88±24.16	34.29±15.66	0.012
Respiratory rate (1/min)	14.93±10.48	11.77±3.99	15.52±11.89	0.045
Heart rate (beat/min)	93.82±21.88	97.11±20.24	94.98±21.27	0.765
Systolic blood pressure (mmHg)	119.73±22.38	98.66±27.07	120.98±18.55	0.294
Diastolic blood pressure (mmHg)	73.43±15.66	74.93±15.78	67.00±17.40	0.494
Glasgow coma scale	12.61±3.87	7.22±4.96	13.44±3.03	<0.001
Base excess (meq/lit)	-3.39±4.33	-5.80±3.36	-3.04±4.41	0.026
Serum chloride upon admission (meq/lit)	106.37±4.53	108.80±6.90	105.71±4.58	0.509
Serum chloride 24 hours after admission (meq/lit)	112.18±6.16	118.11±9.07	111.45±5.36	0.005
ΔChloride*	5.83±4.27	7.22±4.65	5.66±4.22	0.244

* Serum chloride level upon admission-that 24 hours later

Table 2: Basic characteristics and their associations with hospital mortality based on the univariate analysis

Variable	Crude OR (%95 CI)	P	Adjusted OR with method enter (%95 CI)	P	Adjusted OR using the backward method (%95 CI)	P
Age (year)	1.04 (1.01-1.07)	0.005	1.06 (1.02-1.1)	0.003	1.06 (1.02-1.1)	0.003
Gender (male)	0.34 (0.007-2.55)	0.517	-	-	-	-
Respiratory rate (1/min)	0.70 (0.44-0.95)	0.015	0.92 (0.32-2.58)	0.874	-	-
Heart rate (beat/min)	0.98 (0.96-1.01)	0.362	-	-	-	-
Systolic blood pressure (mmHg)	0.97 (0.95-1.00)	0.114	0.93 (0.8-1.08)	0.387	-	-
Diastolic blood pressure (mmHg)	0.98 (0.94-1.00)	0.318	-	-	-	-
Glasgow coma scale	0.73 (0.63-0.84)	<0.001	0.59 (0.35-0.97)	0.04	0.69 (0.58,0.82)	<0.001
Base excess (meq/lit)	0.89 (0.78-1.01)	0.082	1.01 (0.66-1.56)	0.93	-	-
Serum chloride upon admission (meq/lit)	1.14 (1.01-1.3)	0.021	1.67 (0.63-4.4)	0.295	-	-
Serum chloride 24 hours after admission (meq/lit)	1.12 (1.02-1.25)	0.011	0.78 (0.38-1.59)	0.507	-	-
ΔChloride	1.07 (0.92-1.23)	0.314	-	-	-	-

* The variables with a P<0.2 were included in the univariate regression

relationships with hospital mortality obtained using the univariate analysis. According to the univariate model, the mortality of the subjects with high serum chloride levels upon admission was not higher than that of the patients with normal baseline chloride levels, and serum chloride levels 24 hours after admission was significantly correlated with hospital mortality (P=0.005). Moreover, hospital mortality was found to be significantly correlated with age, respiratory rate, GCS score and base excess.

According to the final model and the multivariate analysis using the backward conditional method, only age (P=0.003) and GCS score (P<0.001) were significantly related to hospital mortality (table 2).

Discussion

The present research was performed to determine the relationship of hospital mortality with serum chloride levels and their changes in multiple trauma patients presenting to the ED. Fifteen (15%) patients died within the first 24 hours of their admission to the ED. Investigating serum chloride levels upon admission and delta chloride in both the alive group and those dying after 24 hours did not suggests significant correlations

between hyperchloremia and hospital mortality in the patients. Other parameters such as age and GCS score can help predict hospital mortality in multiple trauma patients.

Multiple trauma patients often require significant fluid resuscitation, involving 0.9% normal saline containing 154 mmol/l of chloride and Ringer's lactate containing 98-112 mmol/l of chloride. Given the HCO_3 dilution, chloride-rich solutions developed hyperchloremic acidosis in these patients, which can be harmful in certain inpatients. The acidosis induced was not a benign self-limiting metabolic disturbance. Furthermore, hyperchloremia alters the peripheral blood, reduces the splanchnic blood flow, renal blood flow and hemoglobin oxygen binding, and causes organ damage. The excessive administration of chloride-rich solutions can cause detrimental consequences for the kidney, alter coagulation parameters, predispose patients to bleeding and cause neutrophil dysfunction [15-19]. Moreover, hyperchloremia can cause progressive renal vasoconstriction, decrease the glomerular filtration rate (GFR) [20-21] and increase circulating inflammatory mediators such as IL-6, IL-10 and TNF [22]. Research suggests associations between hyperchloremia and mortality in critically-ill and postoperative patients [15, 18 and 22-23]. To the best of the authors' knowledge, only one study suggested potential associations between elevated chloride levels and mortality in major trauma patients. Lee et al. found hyperchloremia to be associated with poor outcomes and increased mortality in major trauma patients. Hyperchloremia 48 hours after admission and the associated Δchloride were also found to be associated with 30-day mortality in these patients. These indices can be considered useful prognostic markers [19]. Meanwhile, the present study found hospital mortality not to be significantly related to serum chlorine levels upon admission and 24 hours after admission and delta-chloride. Although the present research identified a significant relationship in the univariate model between hyperchloremia 24 hours after admission and hospital mortality, this relationship was insignificant in the multivariate model. This discrepancy can be explained by the rare occurrence of this event considering the study sample size and the significant correlation between the variables and hospital mortality, which suggest the insignificant role of these variables in determining patient mortality. In other words, the significant role of hyperchloremia dominated that of the other variables to which it was significantly correlated. Further studies are therefore recommended to be conducted using larger samples to investigate this seemingly-contradictory finding.

Limitation

The present study faced several limitations, including the unicenter type of the study, its small sample, the impossibility of evaluating serum chloride levels in the hospital and the need for transferring the blood samples to an external laboratory, the impossibility of measuring chloride levels at all hours of the day and unwillingness of some of the patients or their relatives to participate in the study.

Conclusions

Given the key role of chloride in regulating water and electrolyte, monitoring serum chloride levels is crucial in critically-ill patients. Although measuring serum chloride levels appeared helpful in predicting hospital mortality in multiple trauma patients, the present study did not confirm this hypothesis. Given the present study limitations, further studies are recommended to be conducted with larger samples to obtain more compelling conclusion and evidence.

Acknowledgements

None.

Authors' contribution

All the authors met the standards of authorship based on the recommendations of the International Committee of Medical Journal Editors.

Conflict of interest

None declared.

Funding

The present study was supported by Kerman University of Medical Sciences, Kerman, Iran.

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