


## RESEARCH ARTICLE

# A cross-sectional study on the prevalence of electrolyte abnormalities in multiple trauma patients in Hamedan, Iran

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**Abstract**

**Introduction:** Evaluation of electrolyte status and homeostasis is one of the most important components of evaluation and treatment of critically ill patients, especially those with multiple trauma. Electrolyte imbalance can be associated with a bad prognosis and the need of specialized consultancy.

**Aim:** The aim of this study was to evaluate and determine the electrolyte status of patients with multiple trauma and evaluate the relationship of electrolyte disorders with patient outcome.

**Methods:** In this cross-sectional study, 370 patients who were referred to the emergency department of Besat Hospital in Hamadan, Iran with multiple trauma were studied. Demographic parameters clinical characteristics such as blood pressure, heart rate, respiratory rate, consciousness score and body temperature, paraclinical characteristics including radiographic status, ultrasound, and electrocardiography and serum levels of sodium, potassium, creatinine, hemoglobin, hematocrit, and BUN and urine analysis was performed. Data regarding the discharge from emergency department or referral to other units were also complete in a questionnaire for each patient. Statistical analyses were performed using SPSSv24.

**Results:** Three hundred seventy patients with multiple trauma were studied where 73% of patients were men and 27% were women. One hundred ninety-six patients were discharged from the emergency department, and 174 patients were referred to other units of the hospital. The most common electrolyte abnormalities were hypotension (62.7%), hypernatremia (9.5%), hypokalemia (6.8%), and hypercreatinine (4.6%). The results of independent *t*-test showed that heart rate and potassium level were significantly higher in patients referred to other units than in patients discharged from the emergency department and respiratory rate and hematocrit were significantly lower in patients referred to other units.

**Conclusion:** Hypotension, hypernatremia, hypokalemia, hypercreatinine, and abnormal urine analysis were more frequent in patients referred to other units than in patients discharged from the emergency department. These variables can be considered in predicting patient status for referral to other units and delayed hospital discharge.

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## KEYWORDS

abnormalities, electrolyte, emergency department, hospital discharge, multiple trauma

## 1 | INTRODUCTION

Electrolyte imbalance is one of the key issues in maintaining homeostasis and is an independent predictor of mortality.<sup>1</sup> It plays important role in protecting acid-base balance, tissue perfusion, cellular function, and the management of several clinical conditions.<sup>2</sup> The prevalence of electrolyte imbalance in the emergency department has been associated with an increased risk of mortality.<sup>3</sup> Alterations in electrolytes are associated with a number of clinical conditions and prompt diagnosis of electrolyte imbalance and treatment are crucial in the management of patients admitted to the emergency department.<sup>4,5</sup>

The kidney and aldosterone, parathyroid hormone, antidiuretic hormone, and other factors such as physiological stress play important roles in electrolyte balance and regulating fluid in the body.<sup>6,7</sup>

Disturbances in electrolytes are measurable by biochemical parameters in the bloodstream that determines the clinical manifestations of interactions between metabolic events such as hormones,<sup>8,9</sup> medications,<sup>10</sup> renal physiology,<sup>11,12</sup> sepsis,<sup>13</sup> hydration deficiencies,<sup>14</sup> and vascular events.<sup>15</sup>

Most common electrolyte imbalances are hypo- and hyper-states of potassium, magnesium, sodium, and calcium.<sup>16</sup> Disorders of serum potassium and sodium have been found to be presented in more than 10% of patients and are common in outpatients.<sup>17</sup> Dyskalemia and dysnatremias are commonly shown in hospitalized patients, and the data regarding the prevalence of these in the emergency department is limited.<sup>18</sup> Many factors have been found to be associated with the development of dyskalemia and dysnatremia.<sup>19</sup>

Hyperkalemia often is due to renal insufficiency and/or various medications (diuretics, ACE inhibitors/angiotensin receptor blockers) whereas hypokalemia most often is a consequence of diuretic therapy.<sup>20</sup> Hyponatremia is mostly due to inadequate fluid therapy in critically ill patients or dehydration in ambulatory patients while hyponatremia can be a consequence of diuretic therapy, the syndrome of inadequate vasopressin secretion, or a low effective circulating volume as in cirrhosis of the liver or heart failure.<sup>21,22</sup>

Recent studies have shown that electrolyte imbalance is often associated with disorders such as severe cardiovascular events like myocardial infarctions, acute or chronic renal failures, and diabetes mellitus.<sup>23,24</sup> Based on our knowledge, studies are generally focused on imbalances of specific electrolytes, and most of the studies recruited patients of a specific disease or risk group.<sup>25</sup> Recently, age-related differences in electrolyte imbalance have been reported in the emergency department.<sup>26,27</sup> In some studies, age and female gender might predispose to the development of hypokalemia.<sup>28</sup> The association between electrolyte imbalance with systemic disease in the emergency department and the need for the referral to other wards (units) has yet to be reported.<sup>29</sup>

The aim of this study was to evaluate the general characteristics and the prevalence of electrolyte imbalance among patients admitted

to our emergency department and their association with patients' outcome in referral to other units, or emergency room discharge.

## 2 | METHODS

### 2.1 | Study design and participants

In this cross-sectional study, all the patients (during the study period) with multiple trauma who were referred to the emergency department of Besat hospital in Hamadan during 2017 were evaluated. This is a single center study conducted at one of the largest public hospitals in the region.

### 2.2 | Inclusion and exclusion criteria

All patients included in the present study were referred to the Emergency Department of Besat Hospital of Hamadan in 2017 with multiple trauma, aged between 12 and 22 years, and consented to participate in the study. Patients with a history of metabolic disorder or a history of chronic kidney disorders, including congenital or acquired disorders that led to electrolyte dysfunction, as well as patients who did not consent to participate in the study were excluded. Incomplete files/records were excluded from the study.

### 2.3 | Study subjects

Multiple traumas in the patients were identified using whole-body multiple slice computed tomography according to the triage rule, as indicated in other studies.<sup>30,31</sup> Routine tests, including serum electrolytes at admission, were obtained from all patients with inclusion criteria and exclusion criteria. The outcome of patients in the emergency department was recorded that included emergency discharge or referral to other departments for treatment.

### 2.4 | Variables

The variables evaluated in this study included demographic characteristics, clinical characteristics (blood pressure, heart rate, respiratory rate, consciousness score, and body temperature), paraclinical characteristics including radiographic status, ultrasound and electrocardiography (normal and abnormal), serum electrolytes (sodium, potassium, creatinine, hemoglobin, hematocrit, and BUN), and urine analysis. Electrolytes were measured by photometric method, where the electrode was inserted into the sample containing the electrolyte and electric flow was established between the electrodes. As a result of

the passage of ions through the membrane, there was a potential difference on the sides of the membrane. The voltage of this current is proportional to the logarithm of the electrolyte concentration.

Electrolytes were quantitated and recorded, and the status of disturbance in sodium, potassium, hemoglobin, and creatinine in electrolytes was assessed as follows:

Hemoglobin: normal range: (12-15 mg/dL), Upper than this range: hyperhemoglobinemia.

Creatinine: normal range: (0.7-1.1 mg/dL), Upper than this range: hypercreatinine.

Potassium: normal range: (3.6-5.4 mg/dL), Upper than this range: hyperkalemia.

Sodium: normal range: (135-145 mg/dL), Upper than this range: hypernatremia.

Systolic blood pressure: normal range: (>100 mmHg). Lower than this range: hypotension. A questionnaire-based form was designed for all the patients where these variables were recorded.

## 2.5 | Statistical analysis

The data were collected in the form of checklists and were entered into the software and analyzed using SPSS version 24. The information analyzed was presented using tables. Mean  $\pm$  SD (standard deviation) was used to report the quantitative variables. Frequency index (percent) was also used to present qualitative variables. Chi-square test was used to compare the qualitative variables among patients based on emergency discharge or referral to other departments. Quantitative variables were also compared between these patients using t-Student test. Also, the relationship between patient outcome and the presence of electrolyte abnormalities was evaluated using dual and multiple logistic regression. Significant level was considered less than .05 in all cases.

## 2.6 | Ethical approval

The design was approved by the Ethics Committee of Hamadan University of Medical Sciences. Participants entry into the study was voluntary. Prior to initiation of the study, informed consent was obtained from each patient to access patient information. The patients' information was dealt with confidentiality. Codes were used to identify individuals to prevent patients' identity disclosure. Researchers adhered to the principles of the Helsinki Declaration throughout the research period.

## 3 | RESULTS

In this study, 370 patients with multiple trauma fulfilled the inclusion criteria. 73% of patients were men and 27% were women. The mean age of the patients was  $16.65 \pm 2.3$  years (12-22 years). The cause of the trauma was an accident in 153 patients (41.35%), fall in 23 patients (6.19%), and burns in 194 patients (52.43%). Of these patients, 196 patients (53%), after receiving the emergency services, had no

serious complications and were discharged. One hundred seventy-four patients (47%) were referred to other units of the hospital for further treatment. The most common electrolyte abnormalities were hypotension in 62.7%, hypernatremia in 9.5%, hyperkalemia in 6.8%, and hypercreatinine in 4.6%, respectively.

As shown in Table 1, electrocardiography was normal in all patients. The results of Chi-square test showed that there was no statistically significant relationship between patient's outcome at emergency ward or discharge from emergency department with sex ( $P = .414$ ), ultrasound ( $P = .905$ ), hemoglobin ( $P = .118$ ), and potassium ( $P = .078$ ). However, a statistically significant association between patient's outcome at emergency department referral or discharge from the emergency department and radiography ( $P < .01$ ), creatinine ( $P = .046$ ), sodium ( $P = .002$ ), urine analysis ( $P < .01$ ), and blood pressure ( $P = .027$ ) was seen.

As shown in Table 2, the results of independent t-test showed that mean systolic blood pressure ( $P = .116$ ), diastolic blood pressure ( $P = .888$ ), body temperature ( $P = .615$ ), consciousness level score ( $P = .568$ ), hemoglobin ( $P = .353$ ), creatinine ( $P = .560$ ), BUN ( $P = .312$ ), and sodium ( $P = .106$ ) in patients discharged from the emergency department, were similar to patients referred to other units and there was no statistically significant difference between the two groups ( $P > .05$ ). However, heart rate ( $P = .022$ ) and potassium level ( $P = .002$ ) were significantly higher in patients referred to other unit than patients discharged from the emergency department ( $P < .05$ ). Also, respiratory rate ( $P = .008$ ) and hematocrit ( $P = .041$ ) was significantly lower in patients referred to other units than in patients discharged ( $P < .05$ ).

## 4 | DISCUSSION

Water and electrolyte therapy in patients with multiple trauma is still under discussion.<sup>32</sup> In the emergency department, electrolyte imbalance is a common disorder with a prevalence of about 13% to 15%.<sup>33</sup> Hyponatremia is the most common electrolyte disorder, accounting for 44% of all electrolyte abnormalities in patients referred to the emergency department.<sup>34</sup> Electrolyte abnormalities are a common complication in trauma patients that can be treated.<sup>35</sup> Rapid and appropriate fluid therapy is one of the major interventions and is essential to prevent water and electrolyte disturbances.<sup>36</sup> Subsequent complications can be prevented with appropriate and timely treatment and a significant number of morbidities and mortalities can be prevented.<sup>37</sup> Assessment of water and electrolyte status and its homeostasis is one of the most important components in the evaluation and treatment of severely ill patients, especially those with multiple trauma.<sup>38,39</sup>

One of the primary duties of emergency medicine physicians is to diagnose and treat related disorders.<sup>40,41</sup> Because this issue is often overlooked in primary care in the emergency department due to lack of sufficient knowledge and understanding, the present study aimed to evaluate and determine the electrolyte status of patients with multiple trauma referred to the emergency department of Besat hospital in Hamadan and aimed to evaluate the association of patients outcome with electrolyte abnormalities among these patients.

**TABLE 1** Percentage and frequency of clinical information of patients under study based on types of variables and by department referral status, or emergency discharge

		Referred to wards Frequency (%)	Emergency Discharge Frequency (%)	P-value	OR	95% CI
Gender	Man	130 (74.7%)	139 (70.9%)	.414	0.825	0.521 to 1.308
	Female	44 (25.3%)	57 (29.1%)			
Radiography	Normal	38 (21.8%)	178 (90.8%)	<.001*	35.392	19.354 to 64.723
	Abnormal	136 (78.2%)	18 (9.2%)			
Sonography	Normal	172 (98.9%)	194 (99%)	.905	1.128	0.157 to 8.094
	Abnormal	2 (1.1%)	2 (1%)			
Electrocardiography	Normal	100 (100%)	100 (100%)	-	-	-
	Abnormal	0 (0%)	0 (0%)			
Hemoglobin	Normal hemoglobin	143 (82.2%)	148 (75.5%)	.118	0.668	0.403 to 1.109
	Hyperhomoglobin	31 (17.8%)	48 (24.5%)			
Creatinine	Normal creatinine	162 (93.1%)	191 (97.4%)	.046*	2.83	0.976 to 8.201
	Hyperkreatinine	12 (6.9%)	5 (2.6%)			
Potassium	Normal potassium	158 (90.8%)	187 (95.4%)	.078	2.1	0.905 to 4.892
	Hyperkalemia	16 (9.2%)	9 (4.6%)			
Sodium	Normal sodium	149 (85.6%)	186 (94.9%)	.002*	3.12	1.453 to 6.702
	Hypnatremia	25 (14.4%)	10 (5.1%)			
Urine analysis	Normal	134 (77%)	188 (95.9%)	<.001*	7.01	3.181 to 15.469
	Abnormal	40 (23%)	8 (4.1%)			
Blood pressure	Normal	60 (34.7%)	79 (40.2%)	.027*	1.28	0.840 to 1.959
	Hypotension	114 (65.3%)	117 (59.8%)			
Total		174 (100%)	196 (100%)			

\*P value of 0.05 Significant.

**TABLE 2** Mean and standard deviation of clinical information of patients under study based on types of variables and by department referral status, or emergency discharge

	Referred to wards mean $\pm$ SD	Emergency discharge mean $\pm$ SD	P-value
Systolic blood pressure	110.9 $\pm$ 12.3	108.8 $\pm$ 13.7	.116
Diastolic blood pressure	110.9 $\pm$ 12.3	67.9 $\pm$ 8.4	.888
Heart rate	77.3 $\pm$ 8.8	74.6 $\pm$ 13.3	.022*
Breath rate	16.3 $\pm$ 1.3	17 $\pm$ 3.3	.008*
Body temperature	37 $\pm$ 0.12	37 $\pm$ 0.14	.615
Level of consciousness	14.7 $\pm$ 1.2	14.8 $\pm$ 1.6	.568
Hematocrit	39.3 $\pm$ 5.6	40.5 $\pm$ 5.3	.041*
Hemoglobin	13.2 $\pm$ 2	13.4 $\pm$ 1.9	.353
Creatinine	0.94 $\pm$ 0.17	0.93 $\pm$ 0.14	.56
BUN	14.4 $\pm$ 1.4	14 $\pm$ 3.6	.312
Potassium	4.1 $\pm$ 0.59	3.9 $\pm$ 0.22	.002*
Sodium	140.7 $\pm$ 2.5	141.1 $\pm$ 2	.106

\*P value of 0.05 Significant.

In this study, 370 patients younger than 21 years of age who were referred to the emergency department were evaluated, and their electrolyte status was assessed and its relation to the outcome of the

disease, including emergency discharge or referral to other departments was evaluated. Results of data analysis showed that 47% of patients referred to emergency room with multiple trauma were

referred to hospital wards for treatment. On the other hand, the amount of potassium in patients referred to other units was significantly higher than the amount of potassium in patients discharged from the emergency department. Hypotension was also the most common disorder in these patients (62.7%). Hyponatremia and hypercreatinin were significantly higher in patients referred to other units than in patients discharged from the emergency department. Finally, the results of regression analysis showed that hyponatremia can be considered as a predictor variable for referral of patients from emergency department to other wards.

A few studies have been conducted to investigate electrolyte abnormalities in multiple trauma patients in the emergency department. In 2013, a cross-sectional study was conducted by Balci et al to investigate the status of electrolyte abnormalities in patients referred to the emergency department. In this study, 996 patients over 18 years of age with electrolyte abnormalities referred to the emergency department with various traumas were evaluated. The results of this study showed that hyponatremia (60%) was the most frequent disorder. Hypokalemia (15%), hyperkalemia (8%), and hypernatremia (5%) were seen, respectively. Also, hypocalcemia (51%), hypercalcemia (4%), hypomagnesemia (5%), and hypermagnesemia (1%) were reported. Finally, they concluded that electrolyte abnormalities are an important issue in patients referred to the emergency department and that emergency medicine physicians should have sufficient knowledge regarding fluid and electrolyte balance dynamics in these patients. In our study, the prevalence of hypernatremia was 9.5%, which is higher than that of Balci et al. study, but hyperkalemia was reported in 6.8% of our patients, which was almost similar to Balci et al study.<sup>42</sup> The reason for these differences can be attributed to the differences in the age group of patients under study.

Giordano et al investigated the prevalence of sodium and potassium disorders in emergency department patients in different age groups and according to the comorbidity of various diseases. The results of this study showed that 13.7% of these patients had electrolyte abnormalities, of which 44% had hyponatremia, 33% hypokalemia, 13% hyperkalemia, and 4.4% hypernatremia. The majority of patients with electrolyte abnormalities had comorbidities, the most prominent being cardiovascular disease (22.7%), pulmonary disease (12.4%), and gastrointestinal disease (12.4%). The study concluded that the presence of comorbidities and advanced age would complicate the status of electrolyte abnormalities in the emergency department patients and increase the burden of these disorders.<sup>43</sup> The results of this study are different from the results of our study.

Another study was conducted by Lindner et al in Switzerland, aimed to investigate age-related changes in electrolyte levels and the prevalence of dysnatremia and dyskalemia in patients referred to the emergency department.<sup>44</sup> In this study, data on 20 667 patients referred to emergency department during 2009 and 2010 were evaluated and serum potassium and sodium levels were recorded. The results of this study showed that in the age group of 16 to 20 years, hyponatremia in 2.3%, hypernatremia in 2.3%, hypokalemia in 11.8%, and hyperkalemia in 0.8% were observed. It was also reported that

most of these disorders were more prevalent with increasing age. They also observed that the prevalence of hyponatremia and hyperkalemia increased significantly with increasing age, whereas there was no significant relationship between advanced age and the increased prevalence of hypernatremia and hypokalemia.

Di Somma et al conducted a study evaluating and managing patients' fluids and electrolytes in the emergency department. The results of this study showed that hydration and homeostasis of water and electrolytes are one of the most important components of the evaluation and treatment of critically ill patients in the emergency department, and the emergency medicine physician should promptly diagnose and treat these disorders.<sup>45</sup>

Pfennig et al investigated the role of sodium abnormalities in the outcome of patients in the emergency department. The results of this study showed that sodium abnormalities can be challenging in the emergency room and the lack of proper treatment of these abnormalities can lead to higher mortality in patients referred to the emergency department.<sup>46</sup>

The outcomes of these studies show that sodium and potassium disorders are common in these patients. Hydration status and homeostasis of water and electrolytes have been one of the most important components of the evaluation and treatment of critically ill patients in the emergency department, and the emergency medicine physician should promptly identify and treat these disorders.

Despite discrepancies, the results of our study are in line with the results of these studies that sodium deficiency is common and important in traumatic patients referring to the emergency department and considering these disorders, when treating these patients in an emergency department, can be very insightful.

According to the results of these studies and the present study, electrolyte abnormalities are common in trauma patients referred to the emergency department and should be considered. It is also suggested that, given the type of studies and differences in the samples studied in it, and the limitations of the present study, further studies are needed to investigate the relationship between electrolyte abnormalities and the eventual outcomes in patients with multiple trauma referred to the emergency department.

## 5 | CONCLUSION

Overall, the results of the present study indicate that hypotension, hypernatremia, hypokalemia, and hypo/hyper creatinine are the most common electrolyte abnormalities in patients with multiple trauma in the emergency room, which should be evaluated. The patients in this study were young, without underlying disease. Other electrolyte abnormalities such as hyperkalemia and hypokalemia, hyponatremia, and creatinine were not significantly prevalent. In addition, no complication related to electrolyte disturbance was observed in multiple trauma patients. Therefore, in patients with multiple trauma, hypernatremia after hypotension is one of the most common dysfunctions that should be considered in the emergency department.

## 6 | LIMITATIONS

The limitations of the present study include the lack of: follow-up data, data regarding the final outcomes of patients referred to other units, and analysis among the patients with different types of traumas, and small sample size, that led to the division of small number of patients in sub-group, affecting the power of correlation.

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### CONFLICT OF INTEREST

The authors deny any conflict of interest in any terms or by any means during the study.

### TRANSPARENCY STATEMENT

The [lead author/manuscript guarantor] affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

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### HUMAN AND ANIMAL RIGHTS

No animals were used in this research. All human research procedures followed were in accordance with the ethical standards of the

committee responsible for human experimentation (institutional and national), and with the Helsinki Declaration of 1975, as revised in 2013.

### CONSENT FOR PUBLICATION

Informed consent was obtained from each participant.

### DATA AVAILABILITY STATEMENT

All relevant data and materials are provided within manuscript.

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