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Evaluation of the effect of potassium abnormalities based on the Revised Trauma Score (RTS) in the multiple Trauma

Amin Saberinia[1], **Saeed Safari**[1], **Mohammad Mehdi Forouzanfar**[1], **Anita Sabzghabaei**[1], **Sahar Mirbaha**[1], **Elham Gholami Kelishami**[1]✉

[1]Department of Emergency Medicine, School of Medicine, Shahid Beheshti University of Medical Sciences, Shohadaye Tajrish Hospital, Tehran, Iran

✉**Corresponding author**
Department of Emergency Medicine, School of Medicine, Shahid Beheshti University of Medical Sciences,
Shohadaye Tajrish Hospital, Tehran, Iran
Email: drelhamgholamimd@gmail.com

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ABSTRACT
Background and objective: A trauma causes changes, which are known as the metabolic responses to an injury. In this regard, extracellular potassium level abnormalities can cause various clinical problems in trauma patients. Here, the main objective of this

research was to evaluate the effect of potassium abnormalities on the severity of the trauma (based on RTS scoring system) in multiple trauma patients. *Material and Methods:* In the current study, a total of 311 multiple trauma cases, who were transferred by Emergency Medical Services *(*EMS) to the emergency ward of Shohadaye Tajrish Hospital in 2017, were examined. The patients were assessed against the exclusion criteria and 203 patients eventually participated in the research. Also, a checklist containing the following information was also completed for each patient: gender, age, trauma type (blunt-penetrating), patient transportation method, arrival Venous blood gases (VBG), and RTS. Thereafter, the therapeutic and surgical considerations were recorded. In this study, blood samples of the patients were collected upon arrival to measure Potassium (K), VBG, Creatinine (Cr), Calcium (CA), Blood urea nitrogen (BUN), and Blood sugar (BS). *Results:* The severity of the trauma (RTS) varied between 3 and 4 in 12% of the patients. It also varied between 5 and 6 and from 7 to 8 in 30% and 58% of the participants, respectively. As seen, the severity of the trauma in more than half the patients ranged from 7 to 8. Moreover, the average values of the RR, BUN, Cr, VBG, and PR variables were 18.77±6.14, 21.05±14.72, 1.06±0.31, 7.31±0.13, and 94.25±24.92, respectively. The Glasgow Coma Scale (GCS) values in 55, 25, and 20 % of the patients ranged from 11 to 15, 6 to 10, and 3 to 5, respectively. The potassium level was normal in 81% of the other patients. There was no statistically significant difference between the trauma severity scores (RTS) using different levels of potassium (p=0.110). In addition, there was no significant difference between the different levels of potassium in terms of mortality rates (p=0.634). Also, Hypokalemia (K<3.5 mEq/L) and hyperkalemia (K> mEq/L) were observed in 15 and 4 % of the patients, respectively. *Conclusion:* In general, the results from the present research suggest that hypokalemia cannot serve as a prognostic predictor of trauma severity in multiple trauma patients. However, definitive assessments call for more extensive studies.

Keywords: Multiple trauma, Potassium abnormalities, RTS.

1. INTRODUCTION

Various criteria are available for assessing trauma patients such as the criteria for assessing the conscious state of patients suffering from skull injuries, assessment based on the severity of anatomic injuries (AIS), and assessment based on the revised trauma score (RTS). The latter is a physiologic rating system based on vital signs. In RTS, three criteria namely GCS, systolic blood pressure, and RR (respiratory rate) are measured. These criteria are classified into four categories by quality, and a number between zero (the worst case) and four (the best case) is assigned to each criterion (Champion HR et al., 1989 and de Munter et al., 2017). Nonspecific signs such as tachycardia, tachypnea, or minor changes in consciousness must be assumed signs of serious injuries unless proven otherwise. However, the injury mechanism can pose potential risks without the signs of a severe trauma, which must be carefully taken into account (Perkins et al., 2007). In trauma patients, various criteria can be employed to accelerate the diagnosis of patients in need of life-saving measures. GCS is designed for the clinical assessment of isolated patients suffering from traumatic brain injuries, who are stable in hemodynamic terms and oxygenation, six hours following the onset of a trauma. However, GCS suffers from limitations especially in the first six hours following the incidence of a trauma. These limitations result from factors such as hypotension, hypoxia, and intoxication that underestimate GCS (Desborough JP, 2000 and Bouillon and Neugebauer, 1998). The prognostic factors predicting survival or severity of incident can also determine the disease prognosis in trauma patients. After the result is confirmed, the emergency ward can diagnose patients with bad prognosis more rapidly and can take life-saving actions more quickly, thereby preventing the mortality of trauma patients (Keel and Trentz, 2005). A trauma causes changes, which are known as metabolic responses to an injury, and their extent and duration are directly determined in proportion to the severity of the trauma. Moreover, extracellular potassium level abnormalities can cause various clinical problems in trauma patients. Despite the extensive research on potassium abnormalities and their consequences in trauma patients (Minto and Biccard, 2013 and Piper and Kaplan, 2012 and Şimşek et al., 2014 and Buse et al., 2017). The assessment of potassium abnormalities upon arrival calls for further research. Hence, the present research was an attempt to answer the following question: "can electrolyte abnormalities help physicians as reliable prognostic predictors of the survival and severity of the trauma and eventually reduce mortality rates?"

2. MATERIAL AND METHODS

The present research is an observational retrospective study conducted on the levels of potassium in trauma patients visiting Shohadaye Tajrish Hospital. This hospital is a medical, treatment, and training center located in the north of Tehran, the capital of Iran. Besides, with 380 active beds, this hospital operates under the supervision of Shahid Beheshti Medical Sciences University.

In this study, a total of 311 multiple trauma cases, who were transferred by EMS to the emergency ward of Shohadaye Tajrish Hospital in 2017, were examined. The patients were assessed against the exclusion criteria and 203 patients eventually participated in the research.

The exclusion criteria were as follows:

- The experience of cardiopulmonary arrest in the patients upon arrival
- The presence of burns in patients
- The failure to visit the hospital 24 hours after the accident or later
- An arrival Cr higher than 2 mg/dl
- The lack of Venous blood gases (VBG) upon arrival

A checklist containing the following information was completed for each patient: gender, age, trauma type (blunt-penetrating), patient transportation method, arrival VBG, and RTS. The therapeutic and surgical considerations were also recorded. In this study, blood samples of the patients were collected upon arrival to measure K, Mg, VBG, Cr, CA, BUN, and BS. In addition, the other recoded information included death (regardless of the reason) during hospitalization and any surgery within 24 hours. The normal potassium level varied from 3.5 to less than 5 mEq/L, and the potassium levels were classified as follows: Less than 3; 3 to less than 3.5; 3.5 to less than 4; 4 to less than 4.5; 4.5 to less than 5 and more than 5.

The normal potassium level was in the range between 135 and 145. The BS levels were also classified as follows: Less than 100; between 100 and 150 mg/dl; between 150 and 200 mg/dl; between 200 and 250 mg/dl; between 250 and 300 mg/dl; more than 300 mg/dl.

Data Analysis

Data analysis was carried out in SPSS-25 in this research. Research data was described using the mean, standard deviation, median, range, frequency, and percentage measures, resulting in tables and charts. The quantitative variables were expressed as mean (SD) values, while the qualitative variables were expressed as quantities and percentages. The results were compared through Fisher's exact test and chi-squared tests. Finally, the group-wise comparison of the results was carried out through the one-way ANOVA (analysis of variance) method.

3. RESULTS

Before presenting the results, it is worth mentioning that only the data on the potassium levels in patients were analyzed in this research because the data on calcium, magnesium, and phosphorous was not analyzable due to the small volume of this data.

A total of 311 medical records were analyzed, and 203 patients finally met the inclusion criteria. Besides, 81% (165 patients) of the patients were male and 17% (35 patients) were female. The average age of the patients was 41.65±21.16 years with a minimum and maximum age of 3 and 91 years, respectively (Table 1).

Table 1 The age information of the study participants

Average (year)	Standard deviation	Maximum (Year)	Minimum(Year)
41.65	21.16	91	3

As seen in Table 2, the severity of the trauma (RTS) varied between 3 and 4 in 12% of the patients (25 patients). It also varied between 5 and 6 and from 7 to 8 in 30% (60 patients) and 58% (118 patients) of the participants, respectively. As seen, the severity of the trauma in more than half the patients ranged from 7 to 8 (Table 2 and Figure 1).

Table 2 RTS

RTS	Quantity	Percentage
3-4	12	21
2-0	03	33
7-5	225	25
Total	133	233

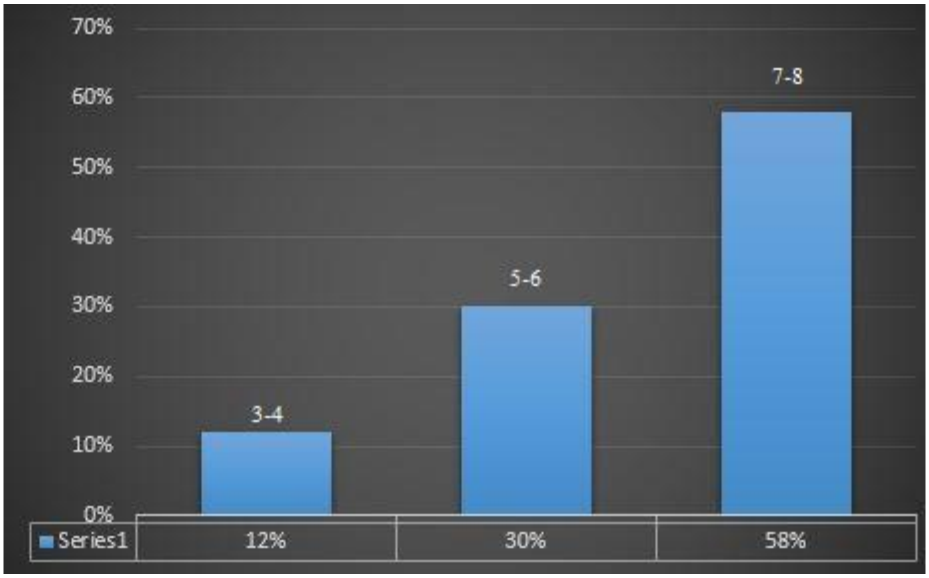

Figure1 RTS data

The average values of the RR, BUN, Cr, VBG, and PR variables 18.77±6.14, 21.05±14.72, 1.06±0.31, 7.31±0.13, and 94.25±24.92, respectively. The GCS values in 55% (112 cases), 25% (51 cases), and 20% (40 cases) of the patients ranged from 11 to 15, 6 to 10, and 3 to 5, respectively. According to the medical records, the blood sugar level (BS) in 48% (98 patients), 23% (46 patients), 12% (24 patients), and 7% (14 patients) of the participants was 100-150, 150 200, 200- 250, less than 100, more than 300, and 250-300, respectively.

Considering the reported data, the mortality rate in the participants was 80% (162 cases) while 20% (41 patients) of the participants experienced recovery. The frequencies of surgeries, blood prescriptions, and complications in the study patients were also 80% (163 cases), 13% (26 cases), and 5% (10 cases), respectively. Moreover, the levels of potassium in 33% (67 cases), 32% (64 cases), 16% (33 cases), 14% (29 cases), and 4% (9 cases) of the patients were 3.5-4, 4 4.5, 4.5-5, less than 3.5, 5, and less than 3, respectively (Table 3 and Figure 2). Therefore, 15% (30 patients) and 4% (9 patients) of the participants were diagnosed with hypokalemia (K<3.5) and hyperkalemia (K>5), respectively. Besides, potassium levels were normal in 81% of the patients (164 cases) (Table 3).

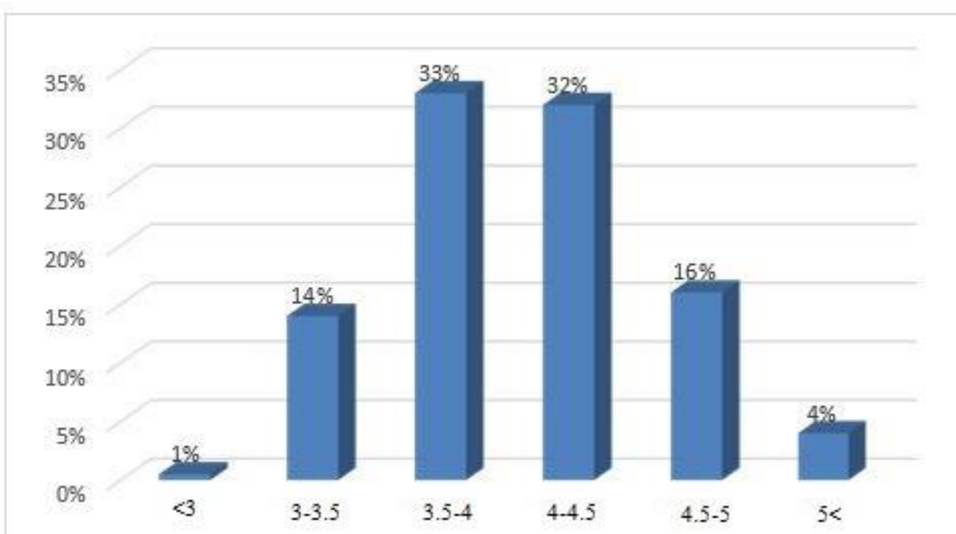

Figure 2 The K levels in the participants

Table 3 Potassium levels

Hypo or hyperkalemia	Percentage	Quantity	K (mEq/L)
K<3.5 = hypokalemia	2 24 33	2 12 07	3 < 2.3 < 4 < -2.3
5>K> 3.5= normal	31	04	2.4<-4
	20	33	2<-2.4
hyperkalemia= 5>K	4	2	2 ≥
-	233	133	Total

Based on the one-way ANOVA results, there was no statistically significant difference between the potassium levels in terms of trauma severity (p=0.110). In addition, there was no significant relationship between different potassium levels and mortality rates (p=0.634) (Figures 3 and 4), yet the difference between trauma severity (RTS) and mortality was statistically significant (p=0.000) (Tables 4 and 5).

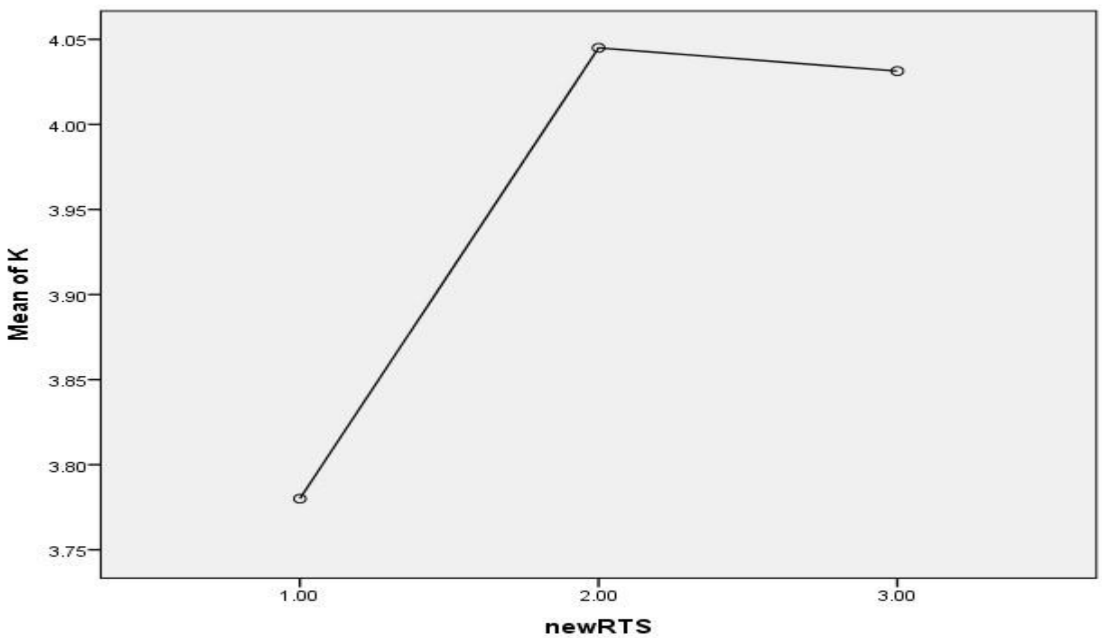

Figure 3 the relationship between trauma severity RTS and potassium levels in patients

Table 4 The relationship between RTS and mortality rate

		RTS			Total
		Group 1	Group 2	Group 3	
Mortality	No	2	4	30	42
	Yes	14	20	51	201
Total		12	03	225	133

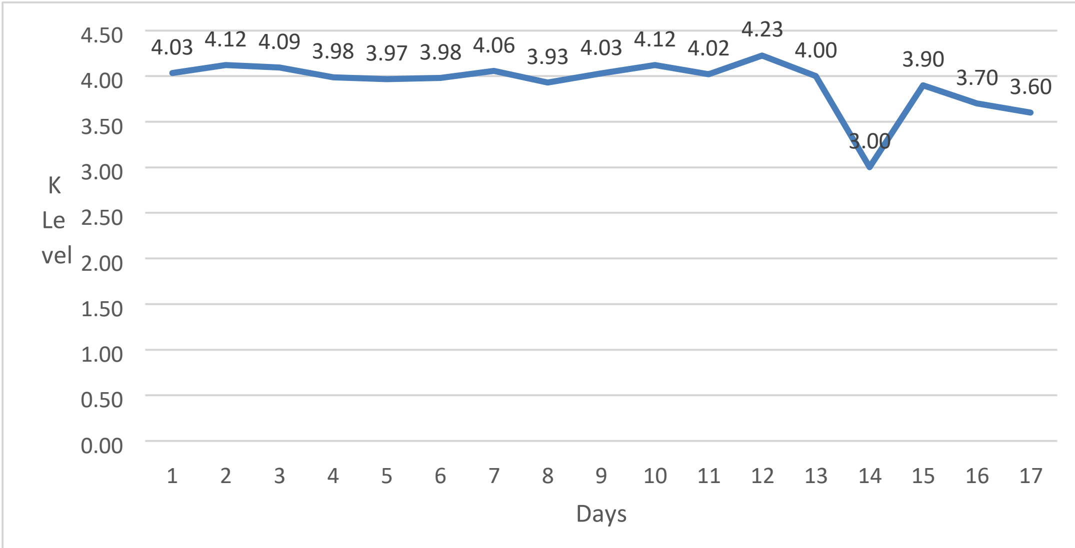

Figure 4 Variations of K in the patients during hospitalization

Table 5 The relationship between potassium levels and mortality rate

		Potassium levels group						Total
		Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	
Mortality	No	3	4	20	23	2	1	42
	Yes	2	12	22	24	14	7	201
Total		2	12	07	04	33	2	133

4. DISCUSSION

In this research, 311 medical records were analyzed, and eventually a total of 203 multiple trauma patients were included in the research using the inclusion criteria. Moreover, 81% (165 cases) and 17% (35) of the participants were male and female, respectively. The ratio of men to women was almost 5/1 in this study. The results from this research suggest that trauma mainly occurs in men, thereby hurting them. The results from the previous studies such as the studies by (Champion et al., 1990 and Clark and Ryan, 1997 and Bouillon et al., 1997), also confirm this finding. This finding can be attributed to the higher level of involvement of men with accident-prone activities such as driving and difficult jobs. According to the report by (Al Ahmed et al., 2004) the men/women trauma ratio varies from 1/3 to 1/5.4. The ratio resulting from this research compares to the results from other global studies. According to the research findings, this ratio is 3/1, 2.5/1, and 1/1 in Canada and New Zealand, Australia, and Jordan, respectively (Maliska et al., 2009). Although smaller ratios were reported in Greece, this ratio equals 16.9-1, 25-1, and 32-1 in Nigeria, Turkey, and Pakistan, respectively (Kamulegeya et al., 2009). The difference between the ratios in different countries could be attributed to the social, cultural, and economic differences between these societies. Moreover, the higher level of involvement of men, especially in the developing countries, originates from the social nature of their societies and the main role of men in financing families, outdoor activities, and difficult jobs. Hence, men are more exposed to the risks of accidents, fights, and occupational hazards. This ratio is extremely lower in the developed countries such as Canada, New Zealand, and Australia given the public opinion and outdoor job conditions for women (Yazdani et al., 2007). The average age of the patients in the present study was 41.65 21.16 years, with a minimum and maximum age of 3 and 91 years, respectively. Moreover, the average age of the patients in our study was similar to the average age reported in previous studies (Al Ahmed HE et al., 2004 and Chalya et al., 2011 and Venugopal et al., 2010 and Mohajerani and Ebrahimzadeh, 2005 and Van Wagoner, 1961). The higher frequency of trauma at this age could be attributed to the fact that these people are involved with sports activities and difficult jobs or use high-speed vehicles more than the other age groups or use vehicles. In general, the larger load of trauma in this age group plays a major role in the lost years of life and mortality and disability costs. Moreover, this group represents a population that is considered economically active. Therefore, the lower frequencies in the adolescent age group or the elderly group are caused by the fewer activities in these age groups (Chalya et al., 2011).

Unintentional accidents are the second cause of death in Iran. With an annual mortality rate of 28000 deaths, this country is among the countries with the highest rate of casualties in car accidents. However, traumatic injuries (especially car accidents) are the seventh cause of death in the developed countries such as the United States (Blair et al., 1969). The rate of car accidents in Iran is 20 times the average global rate, and every 19 minutes one person dies in a car accident in Iran. Poisoning, falling, drowning, and burning are also the next causes of death by unintentional accidents (Van Wagoner, 1961). In a review by Oikarinen et al. (Oikarinen et al., 2004), a comparison was drawn between the etiologic differences between multiple trauma rates in Kuwait, Canada, and Finland. These researchers found out that car accidents account for 55%, 33%, and 7% of bone fractures in Kuwait, Finland, and Canada, respectively. These findings comply with the findings reported by Kuwaiti researchers, who pointed out the failure to observe traffic laws in the Eastern countries. However, the rates of injuries resulting from fights in Kuwait, Finland, and Canada are 12%, 37%, and 54%, respectively.

In the present study, 15% (30 cases) and 4% (9 cases) of the patients were diagnosed with hypokalemia (K<3.5 mEq/L) and hyperkalemia (K>5 mEq/L), respectively. The potassium level was also normal in 81% (164 cases) of the participants. In the research by Ookuma et al. (Ookuma et al., 2015), the frequencies of hypokalemia (<3.5 mEq/L) and hyperkalemia (≥ 5.0 mEq/L) in the trauma patients were 43.7% and 1.3% upon arrival, respectively. In their studies, the mortality rate was significantly higher in trauma patients suffering from hypokalemia. Beal et al. (Beal et al., 2002) reported the prevalence of hypokalemia in trauma patients and linked it to a lower age, head traumas, a lower GCS, and a higher ISS. In an observational study, (Wu et al., 2015) concluded that hypokalemia unfolds 24 hours after an accident in brain trauma patients. The results reported by Bibak et al. (Bibak et al., 2007) also revealed the development of cytotoxic edema (with cellular origins) 24 hours following head traumas. Cytotoxic edema was caused by the sodium-potassium pump imbalance and accumulation of liquids in cells. Salehpoor et al. (Salehpoor et al., 2015) analyzed the clinical and experimental symptoms of traumatic brain injuries (TBIs) in children and concluded that the levels of serum potassium were lower in patients with bad prognosis as compared to patients with good prognosis, reflecting the higher prevalence of hypokalemia in patients with bad prognosis. In the research by Singh et al. (Ram Ranjan Singh et al., 2016), the variations of serum electrolyte levels in trauma patients were analyzed and an increase in extracellular potassium level upon arrival was reported. The increase continued one day following the surgery, but it gradually decreased and reached the normal level on the fourth day following the surgery. According to our findings (based on RTS), there was no statistically significant relationship between different potassium levels in terms of trauma severity (p=0.110). In addition, there was no significant relationship between different potassium levels and mortality (p=0.634), while there was a statistically significant difference between trauma severity and mortality (p=0.000). Similar to our research, there was no significant relationship between the mean potassium concentrations and severity of brain injuries in the study by Suman et al. (Suman et al., 2016). The minimum and maximum mean plasma potassium concentrations in traumatic brain injury (TBI) patients were 3.6, 0.3 and 4 0.4 mEq/L, respectively. The research by Adiga et al. (Adiga et al., 2012) also revealed the lack of a significant relationship between the mean electrolyte concentrations and the severity of brain injuries. Moreover, Reinert et al. (Reinert et al., 2000) explored the relationship of the increase in extracellular potassium concentration and trauma severity. These researchers reported a higher extracellular potassium level in patients with GCS ≤ 8 and a higher ICP. Based on the results from their research, Gorji et al. (Gorji et al., 2006) stated that extensive neural depolarization occurs in neurons in patients suffering from severe traumatic brain injuries, resulting in an increase in extracellular potassium concentration and intracranial pressure and exacerbation of the patient’s condition. Also, hypernatremia (plasma sodium concentration higher than 145 mEq/L) and hyponatremia (plasma sodium concentration lower than 135mEq/L) were observed in 32% (65 cases) and 10% (20 cases) of the patients, respectively. Paiva et al. (Paiva et al., 2011) analyzed sodium abnormalities in 650 traumatic brain injury patients. The serum sodium abnormalities were observed in 191 patients (29.4% of the patients). The mortality rate in patients suffering from sodium abnormalities was 39.8% (76 patients), while it was 5.7% (26 cases) in patients with normal sodium levels. Finally, the results from the multivariate regression analysis indicated that the serum sodium level, age, and BNU/Cr ratio are among the factors involved in the survival of trauma patients.

5. CONCLUSION

The current study was an attempt to determine whether there is a significant relationship between hypokalemia and trauma severity. The findings (based on RTS) reflected the lack of a significant relationship between potassium levels and trauma severity (p=0.110). There was also no significant relationship between hypokalemia and mortality (p=0.634). Hence, it is concluded that hypokalemia cannot serve as a prognostic predictor of trauma severity in multiple trauma patients. However, it is recommended to repeat the present study on several treatment centers with larger samples during consecutive years to improve the accuracy of the results. Nevertheless, the results from this research pave the way for effective steps in reducing the mortality of trauma patients in the future.

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Conflicts of Interest: The authors declare no conflict of interest.

Ethical Considerations

The medical records and personal information of the patients remained confidential, and any use of the aforesaid information for other purposes was prevented. The ethical approval code is IR.963136.

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