ORIGINAL ARTICLE / ÖZGÜN ARAŞTIRMA MAKALESİ

Effects of Average Air Temperatures on Patients' Urea, Creatinine, eGFR, Sodium and Potassium Levels

Ortalama Hava Sıcaklığının Hastalarda Üre, Kreatinin, eGFR, Sodyum ve Potasyum Düzeylerine Etkileri

Mahmut Taş[1], Abdullah Şen, Öner Avınca[1], Yenal Karakoç[1]

ABSTRACT

Aim: In this study, we aimed to investigate whether the seasonal effects of the weather conditions are associated with electrolyte imbalance in the patients presenting to the emergency department.

Material and Methods: A total of 21942 patients were included in the study, and these patients were divided into two groups: Group 1 consisted of 10953 patients presenting to our emergency department in the summer months when the weather is warm; while Group 2 comprised 10989 patients admitted to the emergency department in the winter months when the weather is cold.

Results: The groups were compared with each other in terms of electrolytes and eGFR, and urea and creatinine values were found to be higher in Group 1 while Sodium, potassium and eGFR values were recorded to be lower in the same group (p<0.001). Correlation analysis was performed in order to assess whether there was a correlation between the change in daily temperature, age, urea, creatinine, sodium, potassium, and eGFR of the patients. It was also observed that the changes in daily temperature had a positive correlation with urea and creatinine and that it had a negative correlation with the age, sodium, potassium, and eGFR.

Conclusion: We consider that this study gives significant results in terms of demonstrating the relationship between electrolyte imbalances resulting from seasonal changes of temperature in the patients presenting to the emergency department.

Keywords: Electrolyte Imbalance, emergency department, seasonal temperatures effects.

ÖZ

Amaç: Bu çalışmada acil servise başvuran hastalarda hava koşullarının mevsimsel etkilerinin elektrolit dengesizliği ile ilişkili olup olmadığını araştırmayı amaçladık.

Gereç ve Yöntemler: Çalışmaya 21942 hasta dahil edildi ve bu hastalar iki gruba ayrıldı: Grup 1, havanın sıcak olduğu yaz aylarında acil servisimize başvuran 10953 hastadan, Grup 2 ise havanın soğuk olduğu kış aylarında acil servise başvuran 10989 hastadan oluşuyordu.

Bulgular: Gruplar elektrolitler ve eGFR açısından birbirleriyle karşılaştırılmış ve Grup 1'de üre ve kreatinin değerleri daha yüksek, sodyum, potasyum ve eGFR değerleri ise aynı grupta daha düşük olarak bulunmuştur (p <0.001). Hastaların günlük sıcaklık, yaş, üre, kreatinin, sodyum, potasyum ve eGFR'deki değişim arasında bir korelasyon olup olmadığını değerlendirmek için korelasyon analizi yapıldı. Günlük sıcaklıktaki değişikliklerin üre ve kreatinin ile pozitif, yaş, sodyum, potasyum ve eGFR ile negatif korelasyon gösterdiği gözlendi.

Sonuç: Bu çalışmanın acil servise başvuran hastalarda mevsimsel sıcaklık değişikliklerinden kaynaklanan elektrolit dengesizlikleri arasındaki ilişkiyi göstermesi açısından anlamlı sonuçlar verdiğini düşünüyoruz.

Anahtar Kelimeler: Elektrolit dengesizliği, acil servis, mevsimsel sıcaklık etkileri

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[1] Health Sciences University, Gazi Yasargil research and training Hospital, Emergency Department, Diyarbakır, Turkey.

Corresponding Author: Mahmut Taş, MD **Address:** Health Sciences University, Gazi Yasargil research and training Hospital, Emergency Department, Diyarbakır, Turkey **Phone:** +90 532 227 31 26 **e-mail**: drmahmuttas@gmail.com

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Introduction

It is known that electrolyte imbalance may occur during periods of seasonally high temperatures due to fluid loss resulting from insufficient fluid consumption and perspiration and that deterioration may be observed in renal functions because of the activation of compensatory regulatory mechanisms [1].

Although the risk of developing a medical condition due to high temperature is more commonly seen in the elderly population, individuals having chronic diseases, disabled people and people who live alone; it has been reported in different studies in the literature that the rate of heat related illness also increases in the young population who work in open areas as a part of their professions or who are exposed to high temperatures for a long time during open-air activities [2-4].

The studies have demonstrated that the changes in ambient temperature have a direct impact on the hospitalizations, morbidity, and mortality [5]. During the heat wave which hit Europe in August 2003 and killed more than 70,000 people, France was reported to be the most affected country with 14,729 deaths. Most of the cases observed in elderly patients and were due to dehydration and renal failure [6-9].

In recent years, the expected consequences of climate change have emerged due to the increase in temperature resulting from global warming [10]. It is observed that the weather temperature in our region and country continue to increase over the years and more dramatically in the summers. In this study, we aimed to investigate whether the seasonal effects of the weather conditions ambient temperature are associated with renal dysfunction and electrolyte imbalance in patients presenting to the emergency department.

Material and Methods

Study area and population

In this study, we examined retrospectively the patients presenting to the Emergency Department. The study was approved by the Clinical Research Ethics Committee of a tertiary hospital with the decision number 115 on 29 June 2018. A total of 110580 patients were admitted to our emergency department between January and December 2017. A number of 21942 patients were included in the study, and these patients were divided into two groups: Group 1 consisted of 10953 patients presenting to our emergency department in the summer (June, July, August) when the weather is warm and Group 2 comprised 10989 patients admitted to the emergency department in the winter (December, January, February) when the weather is cold.

Meteorological evaluation

Daily minimum, maximum and mean temperature changes occurring during the study period were obtained from the data recorded by the Directorate General of Meteorology of the Turkish Ministry of Agriculture and Forestry.

Exclusion criteria

The non-trauma patients under 18 years of age were excluded from the study because they were not admitted to the emergency department of our hospital. Patients who were admitted to the emergency room in spring and autumn when the weather temperature values were within normal limits were excluded.

Data collection and measurements

We recorded the serum urea, creatinine, sodium (Na), potassium (K) and Estimated Glomerular Filtration Rate (eGFR) values of the patients included in the study according to the seasonal temperature in summer and winter. We also recorded their sociodemographic data such as age and gender, and the highest daily temperature at the time of admission.

The blood samples of the patients are taken with BD Vacutainer® SST ™ II Advance Tubes (BD SST ™ II Advance) blood collection tubes in our emergency department. Biochemical data are determined with the use of a Cobas c 501 Automated Chemistry Analyzer (in Roche Hitachi Cobas C 501 System).

Statistical Analysis

The results were given as mean+SD and N (%). Univariate statistical analyses were performed by using a chi-square test for categorical variables and Student-t-test for continuous variables. Spearman's rho correlation analysis was used in order to evaluate whether there was an association between the collected data and ambient temperature. $P < 0.05$ was accepted to be statistically significant.

Results

A total of 21942 eligible patients presented to the Emergency Department the during a one-year study period. Of 10953 patients admitted to the emergency department in the summer, 5823 (53,2%) patients were female while 5130 (46,8%) were male. Of 10989 patients admitted to the emergency department in the winter, 5877 (53.5%) patients were female while 5112 (46.5%) were male. The mean age of the participants was 48.72 ± 20.29 in Group 1 and 50.31 ± 20.15 in Group 2. The average temperature was 38.13 ± 3.27 °C in Group 1 and 10.01 ± 4.57 °C in Group 2.

In the summer group 867 (7.9%) out of 10,953 patients and 647 (5.9%) in the winter group had hyponatremia. That difference was statistically significant ($p<0.001$). When groups were compared in terms of electrolytes, eGFR, urea and creatinine values were found to be significantly higher in Group 1 while sodium (Na), potassium (K), and eGFR

values were recorded to be lower in the same group (p<0.001). Table 1 shows the urea, creatine, sodium, potassium and eGFR averages of the groups.

	Group1 (Summer) N=10953 mean ± ss	Group 2 (Winter) N=10989 mean ± ss	P value
Urea (mg/dl)	37.56 ± 21.02	34.88 ± 19.47	<0.001
Creatine (mg/dl)	0.92 ± 0.39	0.86 ± 0.35	<0.001
Sodium (mmol/L)	139.30 ± 3.80	140.87 ± 4.04	<0.001
Potassium (mmol/L)	4.34 ± 0.53	4.38 ± 0.55	<0.001
eGFR (ml/min/1.73m^2)	79.89 ± 17.40	81.22 ± 16.30	<0.001
Age	48.72 ± 20.29	50.31 ± 20.15	

eGFR: Estimated Glomerular Filtration Rate

Table 1. Mean Values of Urea, Creatine, Sodium, Potassium, eGFR and Age

Spearman's rho correlation analysis was performed in order to assess whether there was a correlation between the change in daily temperature, age, urea, creatinine, sodium, potassium, and eGFR of the patients. When we evaluated the results, we found that there was a negative correlation between eGFR and the age, urea, creatinine, and potassium of the patients while eGFR had a positive correlation with the sodium value. It was also observed that the changes in daily weather temperature had a positive correlation with urea and creatinine and that it had a negative correlation with the age, sodium, potassium, and eGFR. Table 2 shows the correlation between the change in daily temperature at the time of admission and eGFR values, and the age, urea, creatinine, Na, and K values of the patients.

Parameters	eGFR	Daily temperature ^{0}C
Age	r = -0.658 p< 0.001	r = -0.044 p< 0.001
Urea (mg/dl)	r = -0.588 p< 0.001	r = 0.073 p< 0.001
Creatine (mg/dl)	r = -0.662 p< 0.001	r = 0.085 p< 0.001
Sodium (mmol/L)	r = 0.064 p< 0.001	r = -0.214 p< 0.001
Potassium (mmol/L)	r = -0.179 p< 0.001	r = -0.034 p< 0.001
Daily temperature (Degrees Celsius,C^0)	r = -0,033 p< 0.001	
eGFR (ml/min/1.73m^2)		r = -0,033 p< 0.001

eGFR: Estimated Glomerular Filtration Rate, r: Correlation confident, °C: Degrees Celsius

Table 2. Spearman's rho correlation analysis

Discussion

We consider that this study gives significant results in terms of demonstrating the relationship of electrolyte imbalances resulting from changes of weather temperature in the patients presenting to the emergency department, a city located in southeastern region of Turkey where the continental climate is observed. As a result of the investigations that we carried out while planning our research, we have seen that global warming has become an increasing problem over the years. Although there is limited evidence on the seasonal changes of weather temperature and electrolyte imbalances in the literature, there is evidence that more people are affected by the diseases related to the ambient temperature every year.

Diseases developing due to the increase in temperature may vary from the conditions that can be treated with simple medical interventions (such as sunburn, redness, edema, syncope, and cramps) to the potentially life-threatening forms (such as heat stroke and heat exhaustion resulting from the deterioration of thermoregulation mechanisms [11]). The studies in the literature have shown that there is a causal relationship between the increase in ambient temperature and renal dysfunction [9, 12-14].

Physiological mechanisms of the body try to regulate the electrolyte and water balance in the event of hyperthermia and dehydration. Renal failure may occur as noted by the decrease in the glomerular filtration rate. The elderly patients are more vulnerable to the development of heat-induced renal disease due to decreased thermotolerance and weakened thirst and many medications [7, 9]. Studies conducted by Hansen et al. [12] have shown that the patients at or over the age of 85 constitute the highest risk group in terms of the electrolyte and renal dysfunctions, resulting from heat fluctuations. Comparing to the patients at the age of 15-64 in our study, the values of urea and creatinine were found to be significantly higher in the summer while the Na, K, and eGFR values were lower. In accordance with the literature, we found that the incidence of hyponatremia is higher in summer than in winter. We consider that this condition occurs due to the loss of water and salt through perspiration and inadequate fluid or sodium (salt) replacement intake during the hot summer season in our region.

Masugata et al. [15] compared the estimated glomerular filtration rates (eGFR) in 102 hypertensive patients with and without chronic renal disease in their article published in 2011, and they demonstrated that eGFR decreased in the summer in both groups. Ranucci et al. [16] carried out a single-center retrospective study regarding the effects of ambient temperature changes on renal function in 16,203 patients undergoing cardiac surgery over a period of ten years. They found that the eGFR values were significantly lower in the preoperative and postoperative measurements of the patients operated in the warmest months while their serum creatinine levels were higher. There was a direct correlation between the temperature and serum creatinine. Pfortmueller et al. [2] conducted a study on the effect of excessive temperatures on the prevalence of electrolyte failure in patients admitted to the emergency department in 2014. They found that the prevalence of hyponatremia was

significantly higher during the periods of high temperature and that there was a weak inverse correlation between daily maximum weather temperature changes and serum sodium and potassium. In a 10-year retrospective study Zhao et al. [17] concluded that sodium levels were significantly lower in August than the rest of the year. Similarly, we also found that eGFR had a negative correlation with age, urea, creatinine and potassium and a positive correlation with sodium level. We saw that daily changes in weather temperature had a positive correlation with urea, creatinine and a negative correlation with sodium, potassium, and eGFR. We think that an increase in the urea and creatinine levels of the patients was due to the decrease in fluid consumption in high temperatures and increased fluid losses and resulting in a decrease in eGFR values. We think that serum sodium value decreases due to an increase in the amount of fluid and salt excretion through sweating because of high temperature. The serum potassium levels decrease as a result of the regulatory mechanisms being activated because of the fluid loss. Although there is limited information on the decrease in serum potassium value in the literature, it has been reported that the decrease in potassium may be caused by the volume decrease arising from the fluid loss due to sweating and the subsequent increase in aldosterone [1]. In conclusion, In our research found that patients presenting to the emergency department during the warmest months are more likely to suffer from electrolyte imbalance. We wish to draw the attention of the physicians to the high-temperature fluctuations due to global warming and climate change. These have become increasingly important in recent years leading to increases in the heat-related diseases that may develop because of this situation. Necessary precautions must be taken in order to protect the individuals who are exposed to heat for a long time in warmer months. We should raise the awareness of this issue to society.

Limitations

There a few limitations of this study. First, we did not correlate our study variables to clinical parameters like incidence of organ dysfunction and mortality rate. Secondly, we could not perform long-term follow-up to identify the development of clinically significant acute kidney injury in patients included in the study. However, we confirmed that patients may develop electrolyte disturbance due to temperature increase. Thirdly this is a single-center study, so the generalizability of our findings is limited.

Conflict of Interest: The authors declare no any conflict of interest regarding this study.

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Authors' Contribution: Conceptualization, Data curation, Project administration, Resources, Supervision, Roles/Writing - original draft, Writing - review & editing (MT, ÖA) Formal analysis, Methodology, Validation, Visualization (AŞ) Funding acquisition, Investigation, Methodology, Project administration, Software (MT, YK)

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All authors declared that they follow the rules of Research and Publication Ethics.

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