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Association of potassium and sodium parameters with the type of stroke

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The study was approved by the Ethics Committee of the Somalia Mogadishu Turkey Recep Tayyip Erdogan Training and Research Hospital (Decision No: 2022/486).
All procedures in this study involving human participants were performed in accordance with the 1964 Helsinki Declaration and its later amendments.

Conflict of Interest
No conflict of interest was declared by the authors.

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Abstract

Background/Aim: Stroke is a significant cause of death along with malignant neoplasm and cardiovascular disease. Comorbidities and laboratory abnormalities are common in stroke patients. Imaging methods are the gold standard in the differential diagnoses of stroke, but they are not used sufficiently to diagnose stroke, especially in underdeveloped countries. In this study, we aimed to examine the association between electrolytes and clinical outcomes in patients with hemorrhagic and ischemic stroke.

Methods: Patients diagnosed with a stroke in the emergency department for one year were reviewed for this retrospective cohort study. We separated the patients into two groups, hemorrhagic and ischemic stroke, according to their diagnosis. Demographic, clinical features, laboratory, and imaging results were compared for the two groups. Potassium and sodium variables and receiver operating characteristic (ROC) analysis were used to predict the stroke status of individuals.

Results: In total, we included 321 patients in our study; 114 (35.5%) patients had experienced a hemorrhagic stroke, and 207 (64.5%) patients had had an ischemic stroke. In the hemorrhagic stroke group, 64% were males, while 50.2% of the ischemic stroke group were males. The most common chronic disease was found to be hypertension in both groups (42.1% (hemorrhagic) and 33.3% (ischemic)). There was a statistically significant difference in the comparison of potassium and sodium parameters and diagnostic groups (P=0.021 and P=0.036). In addition, hypokalemia was found to be significant in the diagnosis of hemorrhagic stroke (P<0.001).

Conclusion: Using potassium levels in the differential diagnosis of ischemic and hemorrhagic stroke is especially useful in the management of patients who cannot undergo imaging.

Keywords: stroke, potassium, sodium, emergency department

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Introduction

The World Health Organization has defined stroke as a clinical condition that lasts longer than 24 hours or can result in death, resulting from sudden cessation of cerebral blood flow for various reasons and leading to neurological dysfunction [1,2]. It is classified as ischemic stroke (IS), which is caused by narrowing or occlusion of cerebral blood vessels and is more common with a rate of 85%, and hemorrhagic stroke (HS), which is caused by bleeding within the brain tissue or the membranes surrounding the brain (15%) [3]. The risk factors for stroke include age, hypertension, human immunodeficiency virus (HIV), dyslipidemia, diabetes mellitus, smoking, obesity, previous cerebral vascular disease, and heart disease [4].

Potassium (K) and sodium (Na) balance disorders have been reported as the most common electrolyte abnormalities in patients with stroke [5]. Making the differential diagnosis of IS and HS at an early stage in patients with suspected stroke is essential for the management of patient follow-up and treatment [6]. There are various studies in the literature about the relationship between hypokalemia and hyponatremia in patients diagnosed with stroke [7,8].

In this study, the demographic-clinical characteristics and laboratory results of patients diagnosed with stroke in the emergency department were examined, and the differences between the IS and HS diagnosis groups were compared. We aimed to search the usability of K and Na values in the differential diagnosis of HS and IS.

Materials and methods

For this retrospective cohort study, patients who were diagnosed with acute stroke between January 1 and December 31, 2021, in the emergency department of Somalia Mogadishu Turkey Recep Tayyip Erdogan Training and Research Hospital were analyzed. This study was approved by the Ethics Committee of Somalia Mogadishu Turkey Recep Tayyip Erdogan Training and Research Hospital (Ethics Committee Decision No: 2022/486).

A data set including demographic characteristics, chronic diseases, outcome status, laboratory tests, brain computerized tomography (CT), and diffusion magnetic resonance imaging (MRI) results of patients was created through the patient registration system. The patients who were accepted to the emergency department with a suspicion of stroke and diagnosed with acute stroke after a result of brain CT and diffusion MRI examinations were included in the study. Patients under the age of 18, and those with missing data entries in the registration system were excluded from the study.

Patients were divided into two groups, HS and IS, according to the type of stroke. Demographic data, laboratory findings, imaging results, chronic diseases, and outcomes were compared for both groups. The relationship of K and Na parameters with the diagnosis of HS and IS was investigated.

Statistical analysis

The conformity of the data to the normal distribution was evaluated with Histogram, Q-Q plots, and the Shapiro-Wilk test. The homogeneity of variance was tested with Levene's test. The Mann-Whitney U test and independent two-sample t-test were used for the comparison of quantitative variables between the two groups. Pearson $\chi 2$ analysis and Fisher exact $\chi 2$ test were used for the comparison of categorical data. Receiver operating characteristic (ROC) analysis was used to predict the stroke status of individuals with K and Na variables. The area under the curve is given with 95% confidence intervals. The Youden index was used to determine the optimum cut-off value of K and Na scores in determining the stroke status of individuals. Sensitivity and selectivity of cut-off values as well as positive and negative cut-off values were given with a 95% confidence interval. Analysis of the data was performed in software R 4.0.0 (www.r-project.org). The significance level was accepted as $P<0.05$.

Results

In total, 321 patients, who were diagnosed with acute stroke in the emergency department, were included in the study over one year. According to the results of radiological imaging, the patients were separated into two groups: HS with 114 patients (35.5%) and IS with 207 patients (64.5%). The HS group was comprised of 64% males, while the IS group had 50.2% males. The mean age of the patients was 53.40 (16.46) in the HS group and 63.35 (16.96) in the IS group. The patients were divided into three age groups: 19-44, 45-65, and >65 years. The highest number of patients in the HS group with a rate of 42.1% were between the ages of 45-65, and the highest number of patients in the IS group with a rate of 48.8% were >65 years old. Gender ($P=0.017$), mean age ($P<0.001$), and age groups ($P<0.001$) were compared, and a statistically significant difference was found. The presence of hypertension (HT), diabetes mellitus (DM), coronary artery disease (CAD), cerebrovascular disease (CVD), and chronic kidney failure (CRF) were investigated. The greatest number of comorbidities was found in the HT group (42.1% and 33.3%). Concomitant chronic diseases were compared and a statistically significant difference was only found for DM ($P=0.016$). 88.6% Of the patients in the HS group, 88.6% only had a brain CT and one patient had both a brain CT and diffusion MRI. Diffusion MRI was performed in 46.4% of the patients in the IS group, and both brain CT and diffusion MRI were performed in 30.9% of the cases. There was a statistically significant difference in the comparison of imaging methods and diagnostic groups ($P<0.001$) (Table 1). Patients were grouped according to their outcome status in the emergency department, admission to the ward, admission to the intensive care unit (ICU), leaving the hospital voluntarily, discharge, referral, and exitus in the emergency department. In both groups, it was detected that the patients were most commonly admitted to the ward (59.6% (HS) and 80.9% (IS)). Four patients tested positively for coronavirus and were referred due to the lack of space in the isolated service and intensive care units (Table 1).

Hemogram test results, glucose, creatinine, K, and Na values of the patients were compared for both groups (Table 2). There was a statistically significant difference in the comparison of K and Na parameters and diagnostic groups ($P=0.021$ and $P=0.036$). An ROC analysis graph was drawn to evaluate the relationship of K and Na parameters in the differentiation of HS and IS (Figure 1).

Figure 1: ROC analysis graph of Potassium and Sodium parameters

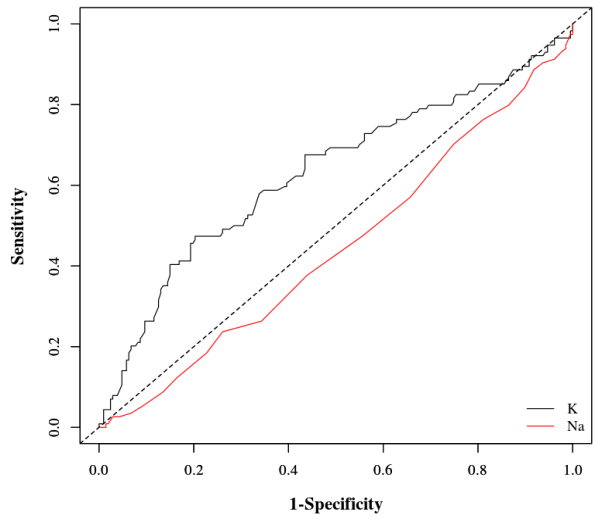

Table 1: Comparison of demographic and clinic data of patients with diagnosis groups

	Hemorrhagic Stroke n= 114 (%)	Ischemic Stroke n= 207 (%)	*P*-value
Gender			
Female	41 (36.0)	103 (49.8)	**0.017**
Male	73 (64.0)	104 (50.2)	
Age (years)	53.40 (16.46)	63.35 (16.96)	**<0.001**
Age range			
19-44	36 (31.6)	30 (14.5)	**<0.001**
45-65	48 (42.1)	76 (36.7)	
>65	30 (26.3)	101 (48.8)	
Medical history			
Hypertension	48 (42.1)	69 (33.3)	0.118
Diabetes Mellitus	8 (7.0)	36 (17.4)	**0.016**
Coronary Artery Disease	0	5 (2.4)	0.165
Cerebrovascular Disease	4 (3.5)	9 (4.3)	0.715
Chronic Kidney Disease	7 (6.1)	6 (2.9)	0.159
Radiology			
Brain CT	101 (88.6)	47 (22.7)	**<0.001**
Diffusion MRG	12 (10.5)	96 (46.4)	
Brain CT and Diffusion MRG	1 (0.9)	64 (30.9)	
Outcome			
Service	59 (59.6)	114 (80.9)	**<0.001**
ICU	40 (40.4)	27 (19.1)	
Discharged	13 (11.4)	63 (30.5)	
Referred	1 (0.9)	3 (1.4)	
Died	1 (0.9)	0	

* Data are expressed as mean (SD) and n (%).

Table 2: Comparison of laboratory results of patients with diagnosis groups

	Hemorrhagic Stroke n=114 (%)	Ischemic Stroke n=207 (%)	*P*-value
Hemoglobin (g/dL)	13.01 (2.28)	12.85 (2.39)	0.560
Hematocrit (%)	39.41 (6.63)	38.91 (6.83)	0.534
Leukocytes (x10^3/µl)	10.2 (7.4-13.5)	7.7 (5.8-10.9)	**<0.001**
Platelet (x10^3)	264 (212.8-340.3)	273 (207-348)	0.706
Glucoz (mg/dL)	126 (106.8-156.3)	123 (103-180)	0.975
Creatine (mg/dL)	0.9 (0.7-1.4)	0.9 (0.7-1.1)	0.241
Sodium (mEq/L)	141.07 (5.81)	139.75 (5.10)	**0.036**
Potassium (mEq/L)	4.22 (0.88)	4.44 (0.68)	**0.021**

***** Data are expressed as mean (standard deviation) and median (1st quartile-3rd quartile).

While the general performance of the K test level in determining the diagnosis of stroke was 0.63 by looking at the level of K and Na tests according to the area under the ROC curve, the general performance of Na level in determining the diagnosis was observed as 0.55. The cut-off value was calculated as K <4, Na >142. If the K value was less than 4, it was determined that the person had an HS with 47% sensitivity and 80% specificity (*P*<0.001). If the Na value was greater than 142, the person had an HS with 43% sensitivity and 66% specificity (*P*=0.100) (Table 3).

Table 3: ROC analysis and cut-off values of potassium and sodium

	ROC statistics		Diagnostic statistics			
	AUC (%95 GA)	*P*-value	Sensitivity (%95 GA)	Specificity (%95 GA)	PPV (%95 GA)	NPV (%95 GA)
K<4 (mEq/L)	0.63 (0.56-0.70)	**<0.001**	0.47 (0.38-0.57)	0.80 (0.74-0.85)	0.56 (0.48-0.65)	0.73 (0.65-0.80)
Na>142 (mEq/L)	0.55 (0.49-0.62)	0.100	0.43 (0.34-0.53)	0.66 (0.59-0.72)	0.41 (0.34-0.50)	0,68 (0.59-0.74)

Discussion

Approximately 15 million people worldwide are affected by stroke each year, making it the third leading cause of death after coronary artery disease and cancer [1,9]. Hypokalemia, hyponatremia, and hypernatremia are common electrolyte disturbances in patients with stroke [10,11].

The number of patients in the IS group was higher than in the HS group in our study. In previous studies, similar results were reported in which the prevalence and incidence of IS were higher than HS [12,13].

In a study conducted by Abdu et al. [3] in which types of strokes were compared, the mean age was 53 (9.6) years and most of the patients were female in the HS group. In the IS group, the mean age was 63.4 (9.6) years and the ratio of gender was equal. Similarly, in our study, the mean age was lower in the HS group than in the IS group. On the other hand, most of the patients in the HS group (64%) and in the IS group (50.2%) were male. When the diagnostic groups were compared in terms of age and gender, a significant difference was found.

Similar to the literature, hypertension is the most common risk factor for stroke in both groups [14,15]. When comorbid diseases were compared for HS and IS groups, only DM showed a significant difference, which is similar to the study of Rochemont et al. [12]. Since DM is a major factor in the development of atherosclerosis, it is thought to be detected at a higher rate in the IS group.

The non-contrast brain CT is the most commonly used diagnostic tool in the diagnosis of stroke, but it has been reported that diffusion MRI has more advantages, especially for the diagnosis of early ischemic stroke [16,17]. Consistent with our study, although the use of brain CT was common, diffusion MRI was preferred in the diagnosis of IS. Radiological imaging is important for the differential diagnosis of HS and IS, but in cases where CT and MRI are not available or the patient is not compatible with radiological imaging, laboratory findings are thought to be helpful in the differential diagnosis and patient management.

In this study; laboratory results and diagnostic groups were compared, and it was detected that the mean K value in the HS group and the mean Na value in the IS group were statistically significantly lower. In the study of Mansoor et al. [5] in which stroke diagnosis groups and laboratory results were compared, the mean Na value was low in the IS group similar to our study, but the K value was higher in the HS group. Although there are studies in the literature reporting that hyponatremia is more common in the IS group, there are also studies reporting that it is more common in the HS group [8,18]. It was thought that different results were obtained in the studies due to reasons, such as the inhomogeneity of the diagnostic groups, the late presentation of the patients, and the change in laboratory parameters as a result of chronic diseases.

In the ROC analysis performed to evaluate the use of K and Na parameters in the differential diagnosis of HS and IC, hypokalemia was significant in the diagnosis of HS in this study. Fukaguchi et al. [6] also evaluated the use of the K parameter in the differential diagnosis of stroke and reported that hypokalemia was associated with a higher risk of HS. We thought that the use of easily accessible, low-cost, and fast testing results might be beneficial in the differential diagnosis of HS and IS.

Limitations

The most important limitation of the study is that it was retrospective and employed a single-center design. Since all data could not be accessed through the registry system, a more detailed analysis could not be made regarding the time from the beginning of the complaints to the time of application.

Conclusion

Rapid differential diagnosis of stroke is important, as it will change the treatment and management of the patient. It has been shown in our study as well as many others in the literature that especially potassium and sodium parameters can be used for the differential diagnosis of stroke. Particularly in cases where radiological imaging cannot be performed, mortality and prognosis will be positively affected by rapid intervention due to the availability of laboratory tests in determining the type of stroke. Multicenter, more comprehensive, and detailed studies are needed in this regard.

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