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Relationship of the lunar cycle and seasonality with stroke

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Abstract

Background & Objective: Stroke is one of the leading causes of death. It is also one of the most important factors of long-term disability. We aimed to reveal the relationship of the lunar cycle and seasonality with stroke characteristics. *Methods:* Data, including the demographic characteristics of the patients, stroke types, stroke severity, etiological factors, accompanying diseases, intensive care needs, and mortality rate were evaluated, recorded, and compared according to seasonality and lunar phases. *Results:* The study included 538 patients. The stroke type of 468 patients was ischemic. The stroke severity of 231 patients was determined as minor. The ischemic stroke rate was higher in winter than in spring and summer. In spring, the rate of severe stroke was lower than in summer and winter. Posterior system strokes were found at a higher rate in the summer months. During the winter months, middle cerebral artery infarctions were detected more frequently. The intensive care needs of the patients were observed mostly in summer and winter in ischemic stroke patients. When the National Institutes of Health Stroke Scale (NIHSS) scores were compared according to season, no significant difference was found between the groups. There was also no significant difference in gender, age, stroke severity, involved arterial system, etiology, and NIHSS score according to moon phases. But the transient ischemic attack (TIA) rate was higher in the full moon than in the last quarter moon. *Conclusion:* Seasonal variations may affect ischemic stroke characteristics, such as type, severity and involved arterial system, but in our study, the lunar cycle was not found related to the investigated features.

Keywords: Stroke, moon phases, seasonality, stroke severity, arterial system.

INTRODUCTION

Stroke is one of the leading causes of death. It is also one of the most important factors of long-term disability.[1] According to the current definition of the World Health Organization, stroke is a clinical condition that develops suddenly as a result of focal infarction or hemorrhage in the cerebral, spinal cord or retina, leading to focal neurological dysfunction, lasting 24 hours or longer, and may result in death.[2] Stroke is divided into two main categories: ischemic if it is due to thrombosis, embolism, or systemic hypoperfusion; hemorrhagic if it is due to intracerebral or subarachnoid hemorrhage; transient ischemic attack (TIA) if there is transient neurological dysfunction that lasts less than an hour and develops focally due to brain, spinal and retinal ischemia, with no acute infarction on imaging. Worldwide, 87% of all stroke cases are ischemic while 13% are due to intracerebral hemorrhage.[3]

Numerous modifiable and unmodifiable risk factors have been identified for stroke. Although significant advances have been made in the treatment of stroke in recent years, the most effective treatment method in these patients remains primary prevention, which refers to the regulation of modifiable risk factors.

The change in clinical infections and their frequency with seasonality is well known. There have been many studies investigating the relationship between seasonality, temperature changes, and stroke incidence, but conflicting results have been revealed. It is known that the lunar cycle can affect sleep and other physiological processes. For this reason, there have been attempts to establish a relationship between

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the lunar cycle and diseases for many years; however, only few studies have been conducted to explore the relationship of the lunar cycle with the incidence of stroke.[4,5]

In this study, we aimed to reveal the relationship of seasonality and the lunar cycle with stroke and compare our data with the literature.

METHODS

The database of our education and research hospital was reviewed retrospectively and all patients diagnosed with a stroke between January 2019 and January 2020 were identified. The clinical and demographic data of the patients were recorded. The stroke type of the patients was evaluated under three groups: ischemic stroke (IS), hemorrhagic stroke (HS), and TIA. IS severity was evaluated according to the National Institutes of Health Stroke Scale (NIHSS) and grouped as minor (score, 0-4), moderate (score, 5-15), and severe (score, >15). The affected arterial system was determined as the middle cerebral artery (MCA), anterior cerebral artery, vertebrobasilar system, and the lacuna. The etiological classification was evaluated according to the Trial of ORG 10172 in Acute Stroke Treatment (TOAST) as large-artery atherosclerosis, small-vessel occlusion, cardioembolism, and cryptogenic stroke. The season and lunar phase in which the stroke had occurred were recorded. The timing of the seasons was created taking into account the dates, summer; 1 June-31 August, autumn; 1 September-30 November, winter; 1 December-28 February and spring; 1 March-31 May. Astronomical data were obtained from www.timeanddate.com. The lunar phases were defined as the new moon, the first quarter moon, the full moon, and the last quarter moon. The relationship of the lunar cycle and seasonality with stroke incidence, severity, epidemiological data, and accompanying diseases were investigated. The study was performed in accordance with the principles of the Declaration of Helsinki, and approval for the study was obtained from the ethics committee of our university. Date: 22.09.2020, Number: 2020/8-23

Statistical analysis

Statistical analyses were carried out using SPSS version 21.0. The compliance of the variables to normal distribution was examined using histogram graphics and the Kolmogorov-Smirnov test. Mean, standard deviation and median values were used while presenting descriptive analyses. Categorical variables were compared with the Pearson chi-square test. The Mann-Whitney U test was used to evaluate non-parametric groups. A p-value of less than 0.05 was evaluated as statistically significant.

RESULTS

A total of 538 patients, 278 men and 260 women, participated in the study. The mean age of the patients included in the study was 70.97 ± 12.75 years. All groups were similar in terms of age, gender, and accompanying diseases. The most common type of stroke was IS seen in 468 patients. The accompanying diseases of the patients were determined as follows; previous stroke in 90 patients, atrial fibrillation (AF) in 68, hypertension (HT) in 365, diabetes mellitus (DM) in 149, and hyperlipidemia (HL) in 109. While 41 of the patients died, 137 patients were hospitalized in the intensive care unit. The IS severity of 231 patients was minor. Atherosclerosis was the most common etiological factor detected in 285 IS and TIA patients. The mean NIHSS score of the IS patients was 6.82 ± 5.47 (Table 1).

The IS rate was higher in winter than in spring and summer (p = 0.036). When the NIHSS scores of the patients, large vessel occlusion rate and proportion of patients receiving recombinant tissue plasminogen activator (rTPA) treatment were compared according to the season, there was no significant difference between the groups. In the spring, the rate of severe stroke was lower than in summer and winter (p = 0.033). The rate of vertebrobasilar system involvement was higher in summer in patients with IS compared to the other seasons. Furthermore, the rate of stroke due to MCA involvement in winter was higher than in other seasons (p = 0.016). The rate of ischemic events (IS and TIA) due to atherosclerosis was higher in summer compared to the other seasons and the rate unknown causes (cryptogenic) was higher in autumn (p = 0.023) (Table 2).

We found no significant difference in gender, age, accompanying diseases, stroke severity, involved arterial system, etiology, large vessel occlusion rate, proportion of patients receiving rTPA treatment and NIHSS score according to the lunar phases. However, the TIA rate was higher in the full moon than in the last quarter moon (p = 0.031) (Table 3).

The rate of need for intensive care in IS patients was higher in summer and winter compared to spring and autumn (p = 0.001). There was no significant difference in the need for intensive care among the HS patients according to seasonality. There was also no significant difference in

Table 1: Sociodemographic and clinical characteristics of the stroke patients

		n	%
Age*		70.97 ± 12.75	72.00
Gender	Male	278	(51.67)
	Female	260	(48.33)
Season	Spring	100	(18.59)
	Summer	145	(26.95)
	Autumn	134	(24.91)
	Winter	159	(29.55)
Lunar phases	New moon	146	(27.14)
	First quarter moon	125	(23.23)
	Full moon	131	(24.35)
	Last quarter moon	136	(25.28)
Stroke type	Ischemic stroke	468	(86.99)
	Hemorrhagic stroke	32	(5.95)
	TIA	38	(7.06)
Ischemic stroke severity	Minor	231	(49.36)
	Moderate	173	(36.97)
	Severe	64	(13.68)
Arteries involved	MCA	203	(43.38)
	ACA	18	(3.85)
	Lacuna	131	(27.99)
	VBA	116	(24.79)
Etiology of ischemic stroke and TIA	Large-artery atherosclerosis	285	(56.32)
	Small-vessel occlusion	48	(9.49)
	Cardioembolism	83	(16.40)
	Cryptogenic	90	(17.79)
Comorbidities	Hypertension	365	(67.84)
	Diabetes mellitus	149	(27.70)
	Hyperlipidemia	109	(20.26)
	Stroke	90	(16.73)
	Atrial fibrillation	68	(12.64)
Large vessel occlusion		180	(38.46)
Hospitalization in intensive care		137	(25.46)
Hospital mortality rate		41	(7.62)
NIHSS score*		6.82 ± 5.47	

* mean ± standard deviation instead of n. Median is given instead of %.
NIHSS: National Institutes of Health Stroke Scale, TIA: Transient ischemic attack, MCA: Middle cerebral artery, ACA: Anterior cerebral artery, VBA: Vertebrobasilar artery

Table 2: Age, gender, stoke characteristics and comorbidities according to season

		Season								p
		Spring		Summer		Autumn		Winter		
		n	%	n	%	n	%	n	%	
Gender	Male	56	(56.00)	79	(54.48)	64	(47.76)	79	(49.69)	0.516
	Female	44	(44.00)	66	(45.52)	70	(52.24)	80	(50.31)	
Stroke type	Ischemic stroke	82	(82.00)	120	(82.76)	120	(89.55)	146	(91.82)	**0.036**
	Hemorrhagic stroke	8	(8.00)	12	(8.28)	6	(4.48)	6	(3.77)	0.259
	TIA	10	(10.00)	13	(8.97)	8	(5.97)	7	(4.40)	0.254
Stroke severity	Minor	47	(57.32)	55	(45.83)	67	(55.83)	62	(42.47)	0.059
	Moderate	30	(36.59)	47	(39.17)	40	(33.33)	56	(38.36)	0.788
	Severe	5	(6.10)	18	(15.00)	13	(10.83)	28	(19.18)	**0.033**
Artery	MCA	33	(40.24)	45	(37.50)	49	(40.83)	76	(52.05)	**0.016**
	ACA	5	(6.10)	8	(6.67)	3	(2.50)	2	(1.37)	
	Lacuna	29	(35.37)	33	(27.50)	41	(34.17)	28	(19.18)	
	VBA	15	(18.29)	34	(28.33)	27	(22.50)	40	(27.40)	
Etiology of ischemic events	Large-artery atherosclerosis	62	(67.39)	68	(51.13)	59	(46.09)	96	(62.75)	**0.023**
	Small-vessel occlusion	4	(4.35)	14	(10.53)	16	(12.50)	14	(9.15)	
	Cardioembolism	15	(16.30)	25	(18.80)	20	(15.63)	23	(15.03)	
	Cryptogenic	11	(11.96)	26	(19.55)	33	(25.78)	20	(13.07)	
Comorbidity	Hypertension	68	(68.00)	94	(64.83)	88	(65.67)	115	(72.33)	0.501
	Diabetes mellitus	30	(30.00)	43	(29.66)	35	(26.12)	41	(25.79)	0.802
	Hyperlipidemia	21	(21.00)	25	(17.24)	27	(20.15)	36	(22.64)	0.703
	Stroke	14	(14.00)	29	(20.00)	17	(12.69)	30	(18.87)	0.291
	Atrial fibrillation	14	(14.00)	18	(12.4)	15	(11.19)	21	(13.21)	0.924
Large vessel occlusion		31	(37,80)	52	(43,33)	38	(31,67)	59	(40,41)	0.285
rTPA		6	(7,32)	7	(5,83)	4	(3,31)	9	(6,16)	0.620
Age		69.72 ± 13.90		69.49 ± 12.64		72.13 ± 11.88		72.12 ± 12.71		0.144
NIHSS		5.67 ± 4.14		7.03 ± 5.85		6.18 ± 4.84		7.82 ± 6.11		0.059

Chi-square test

NIHSS: National Institutes of Health Stroke Scale, TIA: Transient ischemic attack, MCA: Middle cerebral artery, ACA: Anterior cerebral artery, VBA: Vertebrobasilar artery, rTPA: Recombinant tissue plasminogen activator

Table 3: Age, gender, stoke characteristics and comorbidities according to the lunar phase

		Lunar Cycles								p
		New moon		First quarter		Full moon		Last quarter		
		n	%	n	%	n	%	n	%	
Gender	Male	75	(51.37)	68	(54.40)	62	(47.33)	73	(53.68)	0.662
	Female	71	(48.63)	57	(45.60)	69	(52.67)	63	(46.32)	
Stroke type	Ischemic stroke	130	(89.04)	107	(85.60)	107	(81.68)	124	(91.18)	0.106
	Hemorrhagic stroke	6	(4.11)	10	(8.00)	8	(6.11)	8	(5.88)	0.608
	TIA	10	(6.85)	8	(6.40)	16	(12.21)	4	(2.94)	**0.031**
Stroke severity	Minor	67	(51.54)	49	(45.79)	53	(49.53)	62	(50.00)	0.846
	Moderate	43	(33.08)	45	(42.06)	37	(34.58)	48	(38.71)	0.483
	Severe	20	(15.38)	13	(12.15)	17	(15.89)	14	(11.29)	0.665
Arter	MCA	51	(39.23)	49	(45.79)	53	(49.53)	50	(40.32)	0.727
	ACA	5	(3.85)	5	(4.67)	5	(4.67)	3	(2.42)	
	Lacunar infarct	42	(32.31)	25	(23.36)	26	(24.30)	38	(30.65)	
	VBA	32	(24.62)	28	(26.17)	23	(21.50)	33	(26.61)	
Etiology	Large-artery atherosclerosis	82	(58.57)	62	(53.91)	64	(52.03)	77	(60.16)	0.470
	Small-vessel occlusion	15	(10.71)	14	(12.17)	11	(8.94)	8	(6.25)	
	Cardioembolism	17	(12.14)	17	(14.78)	28	(22.76)	21	(16.41)	
	Cryptogenic	26	(18.57)	22	(19.13)	20	(16.26)	22	(17.19)	
Comor-bidity	Hypertension	100	(68.49)	82	(65.60)	87	(66.41)	96	(70.59)	0.823
	Diabetes mellitus	46	(31.51)	32	(25.60)	34	(25.95)	37	(27.21)	0.671
	Hyperlipidemia	30	(20.55)	20	(16.00)	26	(19.85)	33	(24.26)	0.428
	Stroke	19	(13.01)	21	(16.80)	22	(16.79)	28	(20.59)	0.407
	Atrial fibrillation	16	(10.96)	11	(8.80)	23	(17.56)	18	(13.24)	0.175
Large vessel occlusion		50	(38,46)	38	(35,51)	45	(42,06)	47	(37,90)	0.803
rTPA		8	(6,15)	4	(3,70)	4	(3,74)	10	(8,06)	0.398
Age		71.26 ± 12.79		70.65 ± 13.79		71.36±12.27		70.57 ±12.28		0.940
NIHSS		6.77 ± 5.58		6.66 ± 5.21		7.46 ± 5.96		6.46 ± 5.13		0.739

Chi-square test

NIHSS: National Institutes of Health Stroke Scale, TIA: Transient ischemic attack, MCA: Middle cerebral artery, ACA: Anterior cerebral artery, VBA: Vertebrobasilar artery, rTPA: Recombinant tissue plasminogen activator.

Table 4: Rates of mortality and intensive care need according to season

Stroke type = Ischemic	Season								p
	Spring		Summer		Autumn		Winter		
	n	%	n	%	n	%	n	%	
Exitus	1	(1.22)	8	(6.67)	10	(8.33)	15	(10.27)	0.083
Hospitalization in intensive care	13	(15.85)	42	(35.00)	19	(15.83)	43	(29.45)	**0.001**
Stroke type = Hemorrhagic	**Season**								**p**
	Spring		**Summer**		**Autumn**		**Winter**		
	n	**%**	**n**	**%**	**n**	**%**	**n**	**%**	
Exitus	1	(12.50)	3	(25.00)	0	(.00)	3	(50.00)	0.176
Hospitalization in intensive care	7	(87.50)	7	(58.33)	2	(33.33)	4	(66.67)	0.217

Chi-Square Test

mortality between the stroke types according to seasonality (Table 4). The rate of need for intensive care in IS patients was higher in the new moon compared to the first moon ($p = 0.026$). There was no significant difference in the need for intensive care among the patients with HS according to the phases of the moon. Lastly, no significant difference was detected in mortality in any of the stroke groups according to the phases of the moon (Table 5).

DISCUSSION

The relationship between seasonality and acute stroke has been previously investigated in many studies; however, the effect of seasonal variations on stroke characteristics remains controversial. Some studies have shown that mortality and hospital stay due to stroke significantly increase, especially in winter.[6]

In our study, we found that the IS rate was higher in winter than in spring and summer as shown in previous studies.[7-10] However, some other studies have shown no association between seasonality and stroke.[11,12] In a study conducted in Van province, Turkey, Anlar *et al*. reported that both IS and HS cases occurred more frequently in the summer months.[13] This discrepancy between stroke incidence and seasonality cannot be explained solely by geographical differences. This is best supported by the studies undertaken in Finland and its neighbor Norway revealing seasonality between these countries. While the incidence of IS was the highest in winter in Finland, it was found to be higher in autumn

Table 5: Rates of mortality and intensive care needs according to the lunar phase

Stroke type = Ischemic	Lunar Cycle								p
	New moon		First-quarter		Full moon		Last quarter		
	n	%	n	%	n	%	n	%	
Exitus	10	(7.69)	7	(6.54)	10	(9.35)	7	(5.65)	0.732
Hospitalization in intensive care	39	(30.00)	18	(16.82)	34	(31.78)	26	(20.97)	**0.026**
Stroke type = Hemorrhagic	**Lunar Cycle**								**p**
	New moon		**First-quarter**		**Full moon**		**Last quarter**		
	n	**%**	**n**	**%**	**n**	**%**	**n**	**%**	
Exitus	1	(16.67)	0	(.00)	2	(25.00)	4	(50.00)	0.084
Hospitalization in intensive care	6	(100.00)	6	(60.00)	3	(37.50)	5	(62.50)	0.124

Chi-square test

in Sweden.[14,15] This may be related to ethnic differences as the seasonal patterns of stroke differ between African Americans and Caucasians, and furthermore Asian populations usually show very different seasonal stroke patterns compared to Caucasians.[16] Seasonal variations in the incidence of stroke may also vary depending on the different populations studied. Considering different results, regional climate differences, different genetic structures of races, air pressure, temperature, humidity, etc., meteorological parameters may also affect these results.

We found that in spring, the rate of severe IS was lower than in summer and winter, which is consistent with previous studies[9], and in IS patients, the rate of MCA involvement in winter was higher than in other seasons. At the same time, the rate of vertebrobasilar system involvement was higher in summer in patients with IS compared to the other seasons. The rate of need for intensive care in IS patients was higher in summer and winter compared to spring and autumn. It is known that cardiac and vascular complications increase in summer.[17] In our study, large vessel occlusion; for example basilar artery increasing in summer due to cardiac and vascular complications may have contributed to the increase in the number of the patients requiring intensive care. In addition, brainstem and thalamic lesions due to posterior circulation involvement, which are more common in the summer months, can explain intensive care patient admissions to some extent. The higher number of patients requiring intensive care during the winter months in our study may be due to the higher frequency of IS and MCA involvement and the higher frequency of pulmonary complications, such as pneumonia in this season. In the literature, we did not find any study investigating the relationship between the affected arterial system and seasonality. MCA involvement may be associated with the increase in the frequency of ischemic strokes during the winter months and MCA being the most affected artery in IS. However, it remains unclear why posterior circulation was more common in summer.

When we examined the mortality rates, we determined that no significant difference in any stroke group according to seasonality. The literature contains a single study examining the relationship between stroke severity and seasonal variations. In that study, the mortality rates increased during the winter months, which was attributed to increased complications during this period, such as pneumonia and sepsis.[18]

In our study, while IS due to atherosclerosis had a higher rate in summer, the rate of stroke due to unknown causes (cryptogenic) was higher in autumn. Examining the literature, studies investigating the TOAST classification and seasonality of IS are found to report conflicting results. Most of the studies did not find a significant relationship between etiological factors.[19] Fluid deficit, hypertensive attacks, and dehydration during the summer months may have facilitated the development of atherosclerosis that induced IS in our study.

The belief that certain parts of the body are associated with certain positions of the moon has been previously expressed with the Zodiac sign. Accordingly, it is believed that the success of surgical procedures related to the body region is lower in certain phases of the moon, such as the full moon. It has been reported that this situation affects the patients' decision concerning the operation day.[20] Although the relationship between the position of the moon and human health is not expected to be accepted in the modern world, it is seen that this belief continues even in developed countries, and there are many publications in the literature investigating the relationship between the lunar cycle and various diseases. In our study, when we evaluated the relationship between the lunar phases and stroke, we found no significant difference in terms of gender, age, stroke severity, involved arterial system, and etiology. We detected that the TIA rate was higher in the full moon than in the last quarter moon. To determine the impact of the lunar cycle on human health, changes that occur during the full moon are taken into account. It has been suggested that neurohormonal activity may be affected due to electromagnetic changes and gravitational changes in this period.[21] The effect of decreased melatonin levels and changes in sleep biorhythm during the full moon phase are known.[5] However, in the literature, there are conflicting results regarding the relationship between the lunar phases and stroke. While some researchers found no such relationship[4], there are also studies reporting that TIA and HS are more common in the first quarter moon compared to the new moon.[7] The reason for TIA being observed at different frequencies according to the lunar phases can be that this type of stroke is diagnosed clinically and there is no laboratory or imaging method to confirm this diagnosis. The scientific mechanism of this possible relationship between the lunar phases and stroke has not yet been revealed. It is still unknown whether it is a coincidental situation or related to distortions in

the electromagnetic field on the earth or the effect of gravity on water masses in the human body.[22] In our study, the rate of the need for intensive care in IS patients was higher in the new moon compared to the first moon. However, there was no significant difference in the need for intensive care in patients with HS according to the lunar phases. We found no significant difference in mortality in any stroke group according to the lunar phases.

The limitations of this study are as follows: The cases examined in this study were identified from the database of our education and research hospital, which did not provide information on lifestyle or social factors or details of admission neurological examination of the patients as shortcomings of a retrospective study. We were not able to evaluate patients who died before admission to the hospital or who were not admitted to the hospital due to a minor stroke. We also did not evaluate the treatment applied or the relationship of treatment with the lunar cycle and seasonal variations. Further studies with a prospective design, longer evaluation period, and a larger number of participants preferably from different countries can shed more light into this issue.

In conclusion, we found results that were consistent or contradictory to the literature. The differences we found in variables, such as the frequency of stroke, severity of stroke, need for intensive care, the arterial system involved, and the etiological factors between seasons may offer an idea about the implementation of close follow-up, aggressive treatment, and preventive measures for patients during these periods. However, there is a need for prospective and multicenter studies that include more participants to clarify the controversial findings.

DISCLOSURE

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