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ORIGINAL ARTICLE

DEMOGRAPHIC, CLINICAL AND RADIOLOGICAL CHARACTERISTICS OF PATIENTS WITH ACUTE ISCHEMIC STROKE AND ACUTE SYMPTOMATIC SEIZURES

DEMOGRAFSKE, KLINIČKE I RADIOLOŠKE KARAKTERISTIKE PACIJENATA SA AKUTNIM ISHEMIJSKIM MOŽDANIM UDAROM I AKUTNIM SIMPTOMATSKIM NAPADIMA

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Abstract

Introduction: A growing number of stroke survivors face various stroke complications, including acute symptomatic seizures. Symptomatic seizures are associated with longer hospitalizations, negative functional outcomes, and lower quality of life for patients after a stroke, and a better understanding of risk factors for their occurrence can facilitate their early identification and improve treatment.

Aim: Identification of demographic, clinical, and radiological characteristics of patients with an acute ischemic stroke and acute symptomatic seizures, as well as identification of predictors of their occurrence in this patient population.

Material and methods: A retrospective study of cases and controls was conducted, which included 21 patients treated for acute symptomatic seizures after an acute ischemic stroke in the Department of Emergency Neurology, Clinic for Neurology, University Clinical Center of Serbia. The control group consisted of 149 randomly selected patients treated for ischemic stroke, but no acute symptomatic seizures treated during the same period. From an electronic database, data on risk factors for stroke, localization, severity, and treatment of stroke, as well as EEG findings, were collected.

Results: Acute symptomatic seizures following ischemic stroke were observed in 2.65% of subjects, 13 (61.9%) male and 8 (38.1%) female. Out of these, 16 (76.2%) patients had acute epileptic seizures, while 5 (23.8%) patients had an acute status epilepticus. The average age of patients at the time of a stroke with an acute symptomatic seizure was 68.9 ± 15.3 years. A significant correlation of acute symptomatic seizures was established with the age of the subjects at the time of a stroke ($\tau = 0.3799$, $p = 0.0148$) and with mRS at discharge ($\tau = 0.383$, $p < 0.001$).

Conclusion: There was an association between the age of the subjects at the time of a stroke and mRS at discharge with the occurrence of an acute symptomatic seizure after stroke.

Keywords:
acute ischemic stroke,
acute symptomatic seizures,
epileptic seizures,
status epilepticus

The authors declare no conflicts of interest.

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Sažetak

Uvod: Sve više pacijenata suočava se sa različitim komplikacijama moždanog udara, uključujući akutne simptomatske epileptičke napade. Oni su povezani sa dužom hospitalizacijom, negativnim funkcionalnim ishodom i lošijim kvalitetom života pacijenata nakom moždanog udara, a bolje razumevanje faktora rizika za njihovu pojavu može olakšati njihovu ranu identifikaciju i unaprediti lečenje.

Cilj: Cilj rada je identifikacija demografskih, kliničkih i radioloških karakteristika obolelih od akutnog ishemijskog moždanog udara i akutnih simptomatskih epileptičkih napada, kao i identifikacija prediktora njihovog nastanka u ovoj populaciji pacijenata.

Materijal i metode: Urađena je retrospektivna studija slučajeva i kontrola, koja je obuhvatila 21 pacijenta lečenog zbog akutnih simptomatskih epileptičkih napada nakon akutnog ishemijskog moždanog udara na Odeljenju urgentne neurologije Klinike za neurologiju Univerzitetskog Kliničkog centra Srbije. Kontrolnu grupu je sačinjavalo 149 nasumično selektovanih pacijenata lečenih u istom periodu zbog ishemijskog moždanog udara, ali bez akutnih simptomatskih epileptičkih napada. Iz elektronske baze podataka prikupljeni su podaci o faktorima rizika za moždani udar, lokalizaciju, težinu i lečenje moždanog udara, kao i podaci nalaza elektroencefalograma (EEG).

Rezultati: Akutni simptomatski epileptički napadi nakon ishemijskog moždanog udara su zabeleženi kod 2,65% obolelih, 13 (61,9%) muškaraca i 8 (38,1%) žena. Od toga, 16 (76,2%) pacijenata je imalo akutni epileptički napad, dok je 5 (23,8%) pacijenata imalo akutni status epilepticus. Prosečna starost pacijenata u vreme moždanog udara sa akutnim simptomatskim epileptičkim napadom iznosila je 68,9 ± 15,3 godina. Utvrđena je značajna korelacija akutnih simptomatskih epileptičkih napada sa godinama ispitanika u vreme moždanog udara ($\tau = 0,3799$, $p = 0,0148$) i sa mRS na otpustu ($\tau = 0,383$, $p < 0,001$).

Zaključak: Uočena je povezanost starosti ispitanika u vreme moždanog udara i mRS skora pri otpustu sa nastankom akutnog simptomatskog epileptičkog napada nakon moždanog udara.

Ključne reči:
akutni ishemijski moždani udar,
akutni simptomatski epileptički napadi,
epileptički napad,
status epilepticus

Introduction

A stroke is the third most common cause of death and the most common cause of disability in developed countries. It is estimated that 3 - 6 million strokes occur yearly (1). People who have experienced a stroke have an increased risk of developing symptomatic epileptic seizures, and a stroke is a major cause of acquired epilepsy with onset in adulthood (2).

Symptomatic epileptic seizures after a stroke occur in about 6 - 8% of adults with ischemic stroke (3). They can increase metabolic stress and cell death, leading to an increase in infarct size, mortality, negative functional outcomes of patients (4), and negatively affect quality of life (5).

Symptomatic epileptic seizures after a stroke are defined by the International League Against Epilepsy, divided into acute or early and late symptomatic seizures. Acute symptomatic seizures (ASSs) occur during the first 7 days after a stroke. Late symptomatic seizures are considered unprovoked seizures that occur more than 7 days after a stroke. Under this definition, one late symptomatic seizure carries a > 60% risk for developing subsequent unprovoked seizures within 10 years and is sufficient for diagnosis of epilepsy. Acute symptomatic seizure is thought to be induced by the toxic and/or metabolic effects of stroke and carries a ten-year risk of subsequent unprovoked seizures of 33%. Thus, ASS alone is not sufficient to make a diagnosis of epilepsy (6, 7).

Some acute seizures may be overlooked due to subtle clinical semiology and difficult-to-assess changes in consciousness in patients with a disorder of consciousness or speech within the clinical picture of a stroke, leading to inadequate treatment, prolonged hospitalization, and extensive neuronal damage (8-10).

Some studies have shown that strokes affecting the temporal and frontal lobes are associated with a higher risk of developing ASS (11), while others have found this link in strokes located in the irrigation territory of the posterior cerebral artery (12). Stroke severity is quantified using the National Institute of Health's Stroke Assessment Scale. The National Institutes of Health Stoke Scale (NIHSS) is also listed as a risk factor for ASS (12). In some studies, reperfusion therapy has been associated with a higher incidence of ASS, but these studies have failed to explain their relationship (13, 14). This connection is an important issue to study, as reperfusion therapy is increasingly available to a large number of patients worldwide. A better understanding of the risk factors for ASS after a stroke can facilitate detection, and therefore significantly improve the treatment and functional outcome of patients with acute ischemic stroke.

This research aimed to identify demographic, clinical, and radiological characteristics of patients with an acute ischemic stroke and acute symptomatic attacks, as well as to identify the predictors of their occurrence in this patient population.

Material and methods

Respondents

The design study corresponds to a retrospective study of cases and controls. A retrospective analysis of all patients over the age of 18 treated for acute ischemic stroke, in the Department of Emergency Neurology, Clinic for Neurology, University Clinical Center of Serbia, in the period from January 1, 2020 to December 31, 2022 was performed. Among these were the patients identified as those who had a recorded occurrence of ASS during hospitalization and they formed the target group of subjects. The control group consisted of randomly selected patients treated for an ischemic stroke in the same period, who did not have ASS. Patients with a previous diagnosis of epilepsy before a stroke, acute hemorrhagic stroke, transient ischemic attack, previous stroke, as well as other potential causes of epilepsy (intracranial tumors, cerebral venous thrombosis, severe head trauma, hydrocephalus, arteriovenous malformations, brain surgery, brain aneurysms, etc.) were excluded from the research.

According to the current definition of ASS, the analysis is limited to attacks in the first 7 days after the stroke.

Data collection

Demographic, clinical, and radiological data of patients was collected from the electronic database of medical documentation.

From demographic characteristics, data was collected on the sex and age of the subjects at the time of a stroke. The etiology of a stroke is categorized according to the TOAST (Trial of ORG 10172 in Acute Stroke Treatment) classification (15). Infarction of the cerebral cortex and/or vascular territory was determined by computed tomography (CT) and/or magnetic resonance imaging (MRI). Reperfusion therapy for stroke is classified as intravenous thrombolysis (IVT) and mechanical thrombectomy (MT).

The severity of the neurological deficit was expressed using NIHSS scores on admission and discharge, and patients were classified according to the severity of a stroke into one of three categories: mild (≤3), moderate (4-10), and severe (≥11) (16). The degree of functional recovery at release is expressed using a modified Rankin Scale (mRS) (17).

Electroencephalographic (EEG) findings, within the first 7 days of a stroke, are classified as a. neat; b. global electrocortical dysfunction (ECD); c. focal ECD; d. generalized epileptiform interical activity (EIIA); e. focal EIIA; f. generalized epileptic ictal activity (EIA); focal EIA. The EEG finding is classified according to localization and distribution as 1. bilateral; 2. lateralized; 3. frontotemporal (FT); 4. frontocentrotemporal (FCT); 5. centrotemporparietal (CTP); 6. temporoparietooccipital (TPO). Antiseizure therapy has also been reported.

Statistical analysis

The paper used methods of descriptive and analytical statistics; the analysis was conducted using the IBM SPSS-Statistics package version 26.0 (IBM Corp.). Descriptive characteristics are represented using means and standard deviations for continuous variables and frequencies with percentages for categorical variables. The normal distribution of variables was evaluated using the Kolmogorov-Smirnov test. A comparison of parametric variables with the normal distribution was performed using the Student's t-test for two independent samples. Variables without a normal distribution were compared using an unpaired nonparametric two-sided Mann-Whitney U test. Categorical variables were examined using Fisher's exact test or chi-square test and represented as absolute numbers (frequency, percentage).

The values $p < 0.05$ were thought to indicate statistically significant differences. Attention was paid to protecting patients' privacy and adhering to the Helsinki Declaration. The research was approved by the Ethics Commission for scientific research of students.

Results

Number of 791 patients were identified as those who were hospitalized for an ischemic stroke in the Department of Emergency Neurology of the Neurology Clinic of the University Clinical Center of Serbia in the period from January 1, 2020 to December 31, 2022. Acute symptomatic seizure occurred in 21 (2.65%) patients. The study included 170 patients with an acute ischemic stroke.

Of the 21 (12.4%) patients who developed ASS, there were 13 (61.9%) male and 8 (38.1%) female patients. The mean age of patients at the time of a stroke with ASS was statistically significantly higher than the control group (68.9 ± 15.3 vs 60.7 ± 14.4, $p = 0.001$). There was no statistically significant difference in stroke localization, foreign lesion, temporal lobe involvement, or NIHSS score at admission. In more than half of the ASS patients, the most common localization of a stroke was in the anterior circulation as well as the right hemisphere. The temporal lobe was affected in nearly half of patients with ASS (47.6%), while the etiology of a stroke was most often undetermined (42.9%) and more than half (62.5%) had an NIHSS score ≥11 (**table 1**) at admission.

Patients with ASS were significantly more likely to have a rank score of 6 compared to the control group (52.9% vs 10.3%, $p < 0.001$), who had a significantly more common Rank score of 0-2 (53.0% vs 11.8%, $p = 0.001$). No statistically significant differences were found in the other clinical and Radiological characteristics analyzed between the two groups of patients (**table 2**).

Out of a total of 21 patients with ASN, 16 (76,2%) patients had acute epileptic seizures, while 5 (23.8%) patients had an acute status epilepticus. Electroencephalography imaging was performed in 17 (81.0%) patients. Pathological EEG activity was found in 14 (66.7%) patients. It was most commonly lateralized (19.0%), bilateral (14.3%), and localized regionally FCT (14.3%).

Two patients had localized CTP (9.5%), while one patient each had localized FT (4.8%) and TPO (4.8%). In a quarter of patients (28.6%) focal EIIA was described, focal ECD was described in 4 patients (19.0%), as well as generalized EIIA (19.0%). Global ECD was described in one patient (4.8%), as was focal EIA (4.8%), while two patients were described with generalized EIA (9.5%). The EEG findings were orderly in three patients (14.3%). Most patients have started taking antiepileptic therapy after the attack, with levetiracetam being the most commonly prescribed medication (**table 3**).

A correlation analysis was conducted between ASS

Table 1. Presentation of the basic characteristics of patients with and without acute symptomatic attacks after ischemic stroke

Variable		Patients with an acute ischemic stroke		p-value
		Without ASS N= 149 (87.65%)	With ASS N = 21 (12.35%)	
Gender	Male	97 (65.1%)	13 (61.9%)	0.774
	Female	52 (34.9%)	8 (38.1%)	
Age		60.7 ± 14.4	68.95 ± 15.3	**0.001**
Location of a stroke				
Anterior basin		105 (70.5%)	14 (66.7%)	0.722
Posterior basin		32 (21.5%)	6 (28.6%)	0.465
Multiple		1 (0.7%)	1 (4.8%)	0.104
Indeterminates		11 (7.4%)	0 (0.0%)	0.198
Side of the brain				
Right hemisphere		67 (45.0%)	11 (52.4%)	0.523
Left hemisphere		59 (39.6%)	4 (19.0%)	0.068
Bilaterally		23 (15.4%)	6 (28.6%)	0.134
Temporal lobe		57 (38.3%)	10 (47.6%)	0.411
Etiology of a stroke				
Atherosclerosis of large blood vessels		33 (22.1%)	4 (19.0%)	0.747
Small blood vessels		11 (7.4%)	0 (0.0%)	0.198
Cardioembolism		58 (38.9%)	7 (33.3%)	0.621
Other causes		77 (7.4%)	1 (4.8%)	0.661
Undetermined causes		36 (24.2%)	9 (42.9%)	0.069
NIHSS at admission				
≤ 3		25 (19.4%)	1 (12.5%)	0.630
4 - 10		59 (45.7%)	2 (25.0%)	0.252
≥ 11		45 (34.9%)	5(62.5%)	0.115

Table 2. Showing the radiological and clinical differences between patients who developed an acute symptomatic attack after an ischemic stroke versus those who did not

Variable	Patients with an acute ischemic stroke		p-value
	Without ASS N = 149 (87.6%)	With ASS N = 21 (12.4%)	
Reperfusion treatment			
Intravenous thrombolysis	47 (31.5%)	3 (14.3%)	0.104
Mechanical thrombectomy	40 (26.8%)	3 (14.3%)	0.215
NIHSS at discharge			
≤ 3	85 (64.4%)	4 (40.0%)	0.124
4 - 10	32 (24.2%)	3 (30.0%)	0.664
≥ 11	15 (11.4%)	3 (30.05%)	0.088
mRS at discharge			
0 - 2	62 (53.0%)	2 (11.8%)	**0.001**
3 - 5	43 (36.8%)	6 (35.3%)	0.907
6	12 (10.3%)	9 (52.9%)	**< 0.001**

Table 3. Presentation of EEG characteristics and antiepileptic therapy in patients with an acute symptomatic attack after an ischemic stroke

Variable	N = 21
Acute epileptic seizure	16 (76.2%)
Acute status epileptic	5 (23.8%)
EEG	17 (81.0%)
EEG	
normal	3 (14.3%)
global EKD	1 (4.8%)
focal EKD	4 (19.0%)
generalized EIIA	4 (19.0%)
focal EIIA	6 (28.6%)
generalized EIA	2 (9.5%)
focal EIA	1 (4.8%)
EEG localization	
Bilaterally	3 (14.3%)
Lateralized	4 (19.0%)
Frontotemporal	1 (4.8%)
Frontocemtrotemporal	3 (14.3%)
Centrotemporoparietal	2 (9.5%)
Temporoparietooccipital	1 (4.8%)

and different demographic, clinical, and radiological characteristics of the subjects. The occurrence of ASS was associated with the elderly age of patients at the time of a stroke ($\tau = 0.379$, $p = 0.0148$), as well as with higher mRS at discharge ($\tau = 0.383$, $p < 0.001$) (**table 4**).

When stroke patients younger than 55 years were compered, no statistically significant difference was found in the frequency of early symptomatic epileptic seizures (85.2% vs 14.8%, p = 0.168). No statistically significant difference was found in the frequency of early symptomatic epileptic seizures in group of patients older than 55 (92.7% vs 7.3%, p = 0.348) (**table 5**).

Discussion

Approximately 40% of all epileptic seizures occur in individuals who experience an acute brain stroke without a prior history of epilepsy. These seizures, known as acute symptomatic seizures, generally manifest within the first 7 days after a stroke. These are known to be associated with other factors such as metabolic, infectious, toxic and other systemic causes, but they were not specifically analyzed in this study (6).

After an ischemic stroke, ASS was observed in 2.65% of subjects, slightly less than the results of other studies in which this percentage ranged from 3.3 to 12.7% (18-22). The likely explanation for this phenomenon lies in the relatively younger patient population at our center, which is also consistent with our results showing that age is associated with a higher risk of ASS. At the same time, most studies did not link a specific age or gender to an increased incidence of ASS (20), one population study of about 140,000 cases identified age and female gender as a risk factor (23).

The results of this study indicated that the incidence of anterior basin involvement was 66.7% and posterior 28.6% in patients with ASS after stroke. However, no association between ASN and stroke localization was observed, which is likely due to the relatively small number of subjects. Multiple studies have shown that strokes in the anterior basin are associated with a higher risk for ASS (24), while one multicenter study found a link to strokes in the posterior basin (20). Also, these studies have shown the Association of lesions of the cerebral cortex, regardless of localization, with a higher risk of developing ASS,

Table 4. Analysis of the correlation of acute symptomatic seizures with demographic, clinical, and radiological characteristics of subjects

Variable 1	Variable 2	Correlation coeficient	p value
ASS	Age	0.184	**0.016**
ASS	Gender	0.022	0.776
	Location of a stroke		
ASS	Anterior basin	-0.027	0.724
	Posterior basin	0.056	0.468
	Multiple	0.125	0.105
	Indeterminates	-0.099	0.200
	Side of the brain		
ASS	Right hemisphere	0.049	0.526
	Left hemisphere	-0.140	0.069
	Bilaterally	0.115	0.136
ASS	Temporal lobe	0.063	0.414
	Etiology of a stroke		
ASS	Atherosclerosis large blood vessels	-0.025	0.749
	Small blood vessels	-0.099	0.200
	Cardioembolism	-0.038	0.624
	Other causes	-0.034	0.663
	Undetermined causes	0.139	0.070
	Reperfusion treatment		
ASS	Intravenous thrombolysis	-0.125	0.105
	Mechanical thrombectomy	-0.095	0.217
ASS	NIHSS at admission	0.112	0.124
ASS	NIHSS at discharge	0.155	0.065
ASS	mRS at discharge	0.383	**< 0.001**
ASS	EEG localization	0.308	0.186

Table 5. Distrobution of ASS by age groups

Age group	Without ASS 149 (87.6%)	With ASS 21 (12.4%)	Total (N,%)	p-value
< 55 years	98 (85.2%)	17 (14.8%)	115 (100%)	0.168
≥ 55 years	51 (92.7%)	4 (7.3%)	55 (100%)	0.348

compared to lesions of subcortical structures.

It has been hypothesized that reperfusion therapy after a stroke may directly or indirectly cause ASS (25). However, large studies (13, 20) and systematic reviews (26) have not linked reperfusion therapy to an increased risk of acute seizures, except in cases of hemorrhagic transformation. This link was not found in this study.

Various studies suggest that high NIHSS at admission is a risk factor for ASS development after a stroke (27). Although more than half of patients (62.5%) with ASS after an ischemic stroke had NIHSS ≥ 11 on admission, no association with the onset of acute seizures was observed. However, an association with the value of mRs at discharge has been observed, suggesting an association of poor functional stroke outcome with the occurrence of ASS.

Electroencephalography is now the gold standard for detecting seizures and assessing the risk of their occurrence in post-stroke patients. The most common early EEG pattern in patients with an acute ischemic stroke is focal slowing, although extensive areas or multifocal ischemia affecting both hemispheres can cause generalized slowing (28). A recent study evaluated conventional EEG in patients with an acute ischemic stroke with no previous history of seizures and 43.5% of subjects showed focal slowdown (29). In this study, the largest number of subjects had focal EIIA on electroencephalography (28.6%). Meta-analysis revealed ictal in 7% and interictal epileptiform activity on EEG after a stroke in 8% of patients (30). Non-convulsive seizures are often difficult to recognize by clinical supervision alone and their detection requires continuous EEG monitoring. (31). In some studies where patients had EEG follow-up after an ischemic stroke 11% of patients had convulsive seizures, 9% non-convulsive, and 6% non-convulsive epileptic status (32). Long-term EEG monitoring can help identify an epileptic status, even in patients without typical clinical signs.

The main disadvantage of this study is the small sample size. For the results to be more accurate, a study should be conducted with a larger number of subjects and an adequate follow-up period. An additional disadvantage can be considered inadequate matching of demographic and clinical characteristics of the studied and control groups.

Conclusion

In this research group, ASS occurred in 2.65% of respondents. No association has been observed between the occurrence of acute seizures and gender, etiology, severity of a stroke, localization, and types of stroke treatment as risk factors. There was an association between the age of the subjects at the time of a stroke, mRs recent discharge with the onset of ASS after a stroke. This is a very important topic and the results of this research can help to pay more attention to patients who are at increased risk, which are certainly older patients and patients with a higher mRS score, as well as to pay even more attention to additional factors that could provoke their attack.

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