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ORIGINAL ARTICLE

Clinical characteristics of early seizures after ischemic stroke in patients with and without atrial fibrillation

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ABSTRACT

Objectives: This study aimed to analyze clinical characteristics of patients who developed early seizures after ischemic stroke and to explore differences between patients with and without atrial fibrillation (AF).

Patients and methods: This retrospective study evaluated 120 patients with ischemic stroke who developed early seizures, comprising 60 patients with AF and 60 without AF, between February 2023 and February 2024. Demographic and clinical characteristics, including stroke localization, stroke severity, and timing of seizure onset, were compared between the groups. Binary logistic regression analysis was performed to identify independent predictors of early seizures in patients with AF.

Results: The mean age of patients with AF and without AF were 69.00 ± 8.97 and 66.59 ± 10.52 years, respectively. Males were more frequent in the AF group (n = 38, 63.3%), whereas females were more frequent in those without AF (n = 32, 53.3%). Patients with AF more frequently had cortical involvement (65.0% *vs.* 43.3%, $p = 0.017$), severe strokes (National Institute of Health Stroke Scale score ≥ 16: 48.3% *vs.* 25.7%, $p = 0.041$), and seizures occurring within 24 h of stroke onset (68.3% *vs.* 48.3%, $p = 0.026$). In multivariate logistic regression analysis, stroke severity emerged as the only independent and statistically significant predictor of early seizures in patients with AF (odds ratio = 19.15; 95% confidence interval: 4.49-81.70; $p < 0.001$).

Conclusion: Among patients who developed early seizures following ischemic stroke, atrial fibrillation was associated with more severe neurological deficits and a higher frequency of cortical involvement. Stroke severity was the strongest independent factor associated with atrial fibrillation in this cohort.

Keywords: Atrial fibrillation, early seizures, post-stroke epilepsy, stroke severity.

The quality of life in patients with poststroke epilepsy (PSE) is significantly impaired, as epileptic seizures typically occur in individuals with severe neurological deficits and multiple comorbidities.[1] Seizures that develop within seven days of stroke onset are defined as early seizures (ESs) and are associated with an increased risk of developing late, unprovoked seizures and PSE.[1,2] Epileptic seizures occur in 3 to 6% of patients with ischemic stroke, most commonly on the first day after stroke, and in approximately one-third of cases, they predict the development of PSE.[3]

Well-documented clinical risk factors for ESs include cortical infarct localization, stroke severity, hemorrhagic transformation, involvement of multiple brain lobes, and infarcts in the anterior cerebral circulation.[4,5] Atrial fibrillation (AF) is a well-established risk factor for ischemic stroke, particularly large vessel occlusion, increasing the risk of stroke fivefold. Anticoagulant therapy can reduce this risk by approximately two-thirds.[6,7] Moreover, patients with AF tend to experience more severe strokes and poorer recovery outcomes compared to those without AF.[8] Previous studies suggested a possible association between AF and

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the occurrence of ESs in patients with ischemic stroke.[7,9,10] Early detection of post-stroke seizures is crucial for developing individualized treatment strategies, improving patient quality of life, and enhancing survival.[11]

Considering that AF often leads to more severe strokes, we examined other established risk factors for ESs, such as infarct localization, stroke severity, vascular territory, and timing of seizure onset, to evaluate their association with AF. This study aimed to analyze clinical characteristics of patients who developed ESs after ischemic stroke and to compare clinical features between patients with and without AF.

PATIENTS AND METHODS

The retrospective study was conducted with 120 patients diagnosed with ESs following ischemic stroke, defined as seizures occurring within the first seven days of stroke onset, at the General Hospital Nikšić between February 2023 and February 2024. Stroke was defined as a clearly documented neurological deficit lasting at least 1 h, confirmed by brain imaging (computed tomography or magnetic resonance imaging). Sixty patients were diagnosed with AF, while the remaining 60 did not have AF. Patients with other neurological or metabolic conditions that could cause seizures, as well as those with a history of epilepsy prior to the stroke, were excluded from the study. Written informed consent was obtained from all patients prior to participation. The study protocol was approved by the General Hospital Nikšić Ethics Committee (Date: February 15, 2024, Approval No. 1176). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Data were collected from the electronic database of the hospital. For each patient, demographic data (age and sex) and clinical stroke severity (National Institutes of Health Stroke Scale, NIHSS) at admission were recorded. Based on the NIHSS score, stroke severity was categorized as mild (≤ 7), moderate (8-15), and severe (≥ 16). All patients underwent cardiological evaluation, and the presence of AF was confirmed by electrocardiography.

Statistical analysis

Statistical analysis was performed using the IBM SPSS version 25.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to present frequencies, percentages, means, and standard deviations of numerical data. The independent samples t-test was used to compare the mean age between groups. The chi-square test was applied to examine associations between categorical variables. The distribution of numerical variables was graphically presented. Binary logistic regression analysis was used to evaluate factors associated with AF among patients who developed ESs after ischemic stroke. Variables that showed statistical significance in group comparisons (localization, stroke severity, and time of seizure onset) were included in the multivariable logistic regression model, with AF as the dependent variable. The number of variables included in the multivariable model was three, with an events-per-variable ratio of 20. Multicollinearity was assessed and was not significant. Due to the limited sample size, formal model fit statistics were not additionally evaluated. A p-value < 0.05 was considered statistically significant.

RESULTS

The mean age of patients with AF was 69.00 ± 8.97 years, while it was 66.59 ± 10.52 years in those without AF, with no statistically significant difference (p = 0.212). In the AF group, males were more frequently represented (n = 38, 63.3%), whereas in the non-AF group, females were more prevalent (n = 32, 53.3%), although this difference did not reach statistical significance (p = 0.066; Table 1). The numerical and percentage distribution of clinical characteristics in patients with ESs with and without AF are shown in Table 2.

Patients with AF had significantly more frequent cortical localization compared to patients without AF (65.0% *vs.* 43.3%, p = 0.017).

In the group of patients with AF, severe strokes (NIHSS score ≥ 16) were more frequent compared to those without AF (48.3% *vs.* 25.7%, p = 0.041).

Seizures occurring within the first 24 h after stroke onset were more frequent in patients with AF than in those without AF (68.3% *vs.* 48.3%, p = 0.026). There was no statistically significant difference between the groups in terms of cerebral circulation territory (anterior *vs.* posterior; p = 0.206; Table 2). The numerical values of the clinical variables of interest are presented in Figure 1.

The association between selected clinical variables (localization, stroke severity, and time of ESs onset) and the presence of AF among

TABLE 1
Demographic characteristics of the study population with ESs after stroke (n = 120)

	Stroke with AF (n = 60)			Stroke without AF (n = 60)					
	n	%	Mean ± SD	n	%	Mean ± SD	χ^2	df	*p*
Age (year)			69.00 ± 8.97			66.59 ± 10.52			0.212
Sex							3.367	1	0.066
Male	38	63.3		28	46.7				
Female	22	36.7		32	53.3				

ESs, early seizures; AF, atrial fibrillation; SD, standard deviation. Statistically significant at $p < 0.05$.

TABLE 2
Clinical characteristics of patients with ESs with and without AF (n = 120)

	Stroke with AF (n = 60)		Stroke without AF (n = 60)				
	n	%	n	%	χ^2	df	*p*
Localization					5.673	1	0.017*
Cortical	39	65.0	26	43.3			
Subcortical	21	35.0	34	56.7			
Stroke severity					6.379	2	0.041*
NIHSS ≤ 7	19	31.7	30	50.0			
NIHSS (8-15)	12	20.0	14	23.3			
NIHSS ≥ 16	29	48.3	16	26.7			
Time of onset ESs					4.937	1	0.026*
Within 24 h	41	68.3	29	48.3			
From 2 to 7 days	19	31.7	31	51.7			
Brain circulation					1.600	1	0.206
Anterior	48	80.0	42	70.0			
Posterior	12	20.0	18	30.0			

ESs, early seizures, AF, atrial fibrillation; NIHSS, National Institute of Health Stroke Scale score; *, significant at $p < 0.05$.

patients who developed ESs after ischemic stroke was analyzed. The results of the binary logistic regression are presented in Table 3.

Multivariable logistic regression showed that only stroke severity, assessed by the NIHSS, was independently associated with AF among our cohort (odds ratio [OR] = 19.15; 95% confidence interval [CI]: 4.49-81.70; $p < 0.001$). Patients with severe neurological deficits (NIHSS score ≥ 16) had significantly higher odds of having AF compared to

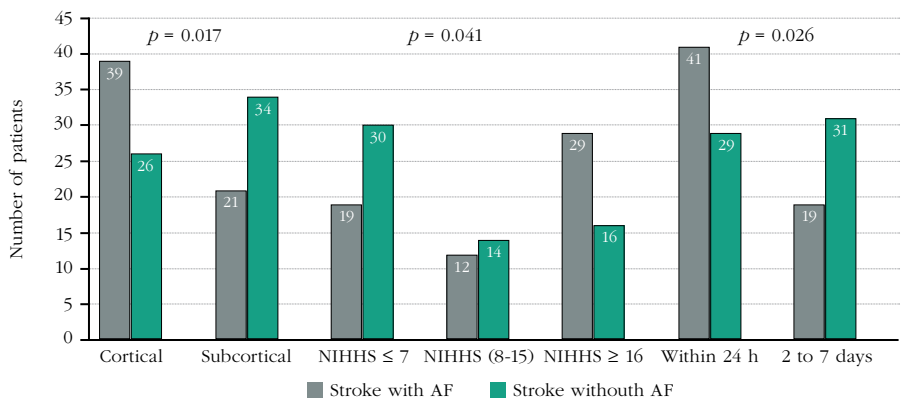


Figure 1. Distribution of clinical predictors of ESs after stroke in patients with and without AF.

ESs, early seizures; AF, atrial fibrillation.

TABLE 3
Binary logistic regression analysis of factors associated with AF in patients with ESs after ischemic stroke

Variables	B (coefficient)	SE	*p*	OR (Exp(B))	95% CI for OR
Localization	2.874	2.210	0.193	17.712	0.232-1349.315
Stroke severity	2.952	0.740	0.0001*	19.150	4.488-81.704
Time of onset ESs	2.544	2.215	0.250	12.737	0.165-978.901

AF, atrial fibrillation; ESs, early seizures; SE, standard error; OR, odds ratio; CI, confidence interval *, significant at $p < 0.05$.

those with mild or moderate deficits. Localization and timing of seizure onset showed high ORs (OR = 17.71 and OR = 12.73, respectively), but these were not statistically significant ($p > 0.05$). The wide confidence intervals observed for some variables likely reflected the limited sample size of the study population.

DISCUSSION

The results demonstrated that patients with stroke and AF were slightly older than patients without AF, although this difference did not reach statistical significance ($p = 0.212$). Nevertheless, this finding is consistent with epidemiological data indicating that AF is more common among older individuals[8] and that advanced age is a well-established risk factor for stroke.[12]

This study revealed that patients who developed ESs after stroke with AF were more often male, with the difference being at the borderline of statistical significance ($p = 0.066$), suggesting that with a larger sample size, this difference could become significant. Our findings are consistent with the results of a national study conducted in USA by Desai et al.,[13] which demonstrated that males with epilepsy were more prone to developing cardiac arrhythmias compared to females. Furthermore, the authors reported that arrhythmias were present in nearly one-quarter of patients with epilepsy and were associated with prolonged hospitalization and life-threatening complications.

In our study, cortical localization was significantly more frequent in patients who developed ESs after stroke with AF compared to those without AF (65.0% *vs.* 43.3%; $p = 0.017$). Similar results were reported in other studies, which attributed this association to the embolic nature of these strokes, including reports from neurological intensive care unit settings, where ESs were more frequent in patients with cortical involvement and hemorrhagic transformation.[14] Emboli originating from the left atrium in patients with AF often distribute into the middle cerebral artery, which perfuses a large portion of the cortex, thereby increasing the likelihood of epileptogenic potential.[11,15] Early seizures were also more frequently observed in patients with AF, as reported by Brigo et al.[15] Unlike Brigo et al.,[15] we did not specifically examine the impact of thrombolysis. However, the higher frequency of seizures in patients with AF, who are more often candidates for thrombolysis due to cardioembolic stroke, could indirectly support this association. However, in our multivariable regression analysis, cortical localization was not independently associated with AF among patients with ESs. This finding differs from the results of the systematic meta-analysis by Ma et al.,[16] in which cortical localization was identified as a strong predictor of ESs (OR=5.00, 95% CI: 2.85-8.74, $p < 0.00001$).

In our study, patients with AF developed ESs significantly more frequently within the first 24 h after ischemic stroke compared to patients without AF (68.3% *vs.* 48.3%; $p = 0.026$). This finding is consistent with the study by Šmigelskytė et al.,[17] who also reported a higher number of ESs. However, in their study, the presence of AF was not identified as a statistically significant factor.

Although cortical localization and early onset of ESs within the first 24 h did not reach statistical significance in logistic regression, their ORs (OR = 17.71 and OR = 12.73, respectively) suggest potential clinical relevance. The lack of statistical significance may be related to the limited sample size. This association between AF and clinical characteristics among patients with ESs, including cortical involvement and earlier seizure onset, may support the need for careful neurological assessment and closer monitoring with electroencephalography (EEG) during the acute phase of ischemic stroke.

In the present study, patients with AF had a significantly more severe form of stroke compared to those without AF ($p = 0.041$), consistent with the

findings of Miljkovic et al.[8] and Galovic et al.,[2] who also reported higher mean NIHSS scores in patients with AF.

Similar to the findings reported by Šmigelskytė et al.,[17] stroke localization (anterior *vs.* posterior circulation) was not significantly different between in those with and without AF in our study, although anterior circulation involvement was slightly more common in both groups. This finding is also consistent with other studies.[18,19]

In the logistic regression analysis, stroke severity (assessed by the NIHSS) was independently associated with AF among patients who developed ESs after ischemic stroke (OR = 19.15; 95% CI: 4.49-81.70; $p < 0.001$). This finding is consistent with the results of other studies,[9,18] supporting the association between more severe strokes and the presence of AF among patients with ESs. Potential mechanisms underlying the association between AF, severe stroke, and ESs may include larger cortical lesions, metabolic dysfunction, and stronger inflammatory responses.

Despite the existence of studies that did not confirm the significance of AF or stroke localization as significant factors associated with ESs,[16,17] our findings suggest that patients with ESs and AF tended to have higher NIHSS scores. These findings highlight the importance of careful neurological and EEG monitoring in patients with severe stroke. Nevertheless, further prospective studies are required to better define the relationship between AF and ESs before antiepileptic treatment strategies can be considered.

Given that ESs further worsen stroke outcomes by increasing both mortality and morbidity, their early detection and monitoring are of significant clinical importance. Previous studies have reported an association between higher NIHSS scores at admission and the occurrence of ESs after stroke.[20] Future research may explore neuroprotective strategies and agents with potential antiepileptic properties; however, current evidence remains insufficient to support preventive treatment approaches. Identifying patients at higher clinical risk may be useful primarily for closer monitoring and individualized follow-up.[21]

Since AF is frequently associated with larger embolic cortical strokes, recognizing patients with more severe clinical profiles within ESs cohort may be important for closer neurological follow-up and individualized clinical management. Our findings particularly highlight the relevance of early stroke severity assessment using the NIHSS score among patients with ESs, particularly those with AF-related stroke.

Patients with severe neurological deficits (NIHSS score ≥ 16) may warrant closer neurological monitoring. However, the present findings do not provide sufficient evidence to recommend prophylactic antiseizure treatment, and the potential role of early EEG monitoring in this subgroup requires further investigation.

This study had several limitations. Because the study population included only patients who developed ESs, the study design precluded direct evaluation of predictors of seizure occurrence after ischemic stroke. In addition, the relatively small sample size may have influenced the precision of the regression estimates.

In conclusion, stroke severity assessed by the NIHSS was independently associated with AF among patients who developed ESs after ischemic stroke. These findings suggest the need for closer neurological and EEG monitoring in this subgroup; however, causal relationships and implications for preventive treatment require further investigation.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: V.D.: Data collection, statistical analysis, and manuscript review; Z.P.: Study conception and design, data analysis and interpretation, and manuscript preparation.

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REFERENCES

1. Phan J, Ramos M, Soares T, Parmar MS. Poststroke seizure and epilepsy: A review of incidence, risk factors, diagnosis, pathophysiology, and pharmacological therapies. Oxid Med Cell Longev 2022;2022:7692215. doi: 10.1155/2022/7692215.

2. Galovic M, Ferreira-Atuesta C, Abraira L, Döhler N, Sinka L, Brigo F, et al. Seizures and epilepsy after stroke: Epidemiology, biomarkers and management. Drugs Aging 2021;38:285-99. doi: 10.1007/s40266-021-00837-7.
3. Bryndziar T, Sedova P, Kramer NM, Mandrekar J, Mikulik R, Brown RD Jr, et al. Seizures following ischemic stroke: Frequency of occurrence and impact on outcome in a long-term population-based study. J Stroke Cerebrovasc Dis 2016;25:150-6. doi: 10.1016/j.jstrokecerebrovasdis.2015.09.008.
4. Beghi E, D'Alessandro R, Beretta S, Consoli D, Crespi V, Delaj L, et al. Incidence and predictors of acute symptomatic seizures after stroke. Neurology 2011;77:1785-93. doi: 10.1212/WNL.0b013e3182364878.
5. Nandan A, Zhou YM, Demoe L, Waheed A, Jain P, Widjaja E. Incidence and risk factors of post-stroke seizures and epilepsy: Systematic review and meta-analysis. J Int Med Res 2023;51:3000605231213231. doi: 10.1177/03000605231213231.
6. Rydén L, Sacuiu S, Wetterberg H, Najar J, Guo X, Kern S, et al. Atrial fibrillation, stroke, and silent cerebrovascular disease: A population-based MRI study. Neurology 2021;97:e1608-19. doi: 10.1212/WNL.0000000000012675.
7. D'Souza A, Butcher KS, Buck BH. The multiple causes of stroke in atrial fibrillation: Thinking broadly. Can J Cardiol 2018;34:1503-11. doi: 10.1016/j.cjca.2018.08.036.
8. Miljkovic S, Blagojevic A, Petrusic T. Relationship between atrial fibrillation as a risk and the outcome of ischemic stroke. Scripta Medica 2018;49:6-12. doi: 10.18575/msrs.sm.e.18.01.
9. Feher G, Gurdan Z, Gombos K, Koltai K, Pusch G, Tibold A, et al. Early seizures after ischemic stroke: Focus on thrombolysis. CNS Spectr 2020;25:101-13. doi: 10.1017/S1092852919000804.
10. Doege C, Luedde M, Kostev K. Atrial fibrillation is associated with a subsequent epilepsy diagnosis independent of stroke: A retrospective matched administrative cohort study on 149,632 patients. Epilepsy Behav 2022;132:108721. doi: 10.1016/j.yebeh.2022.108721.
11. Tanaka T, Ihara M, Fukuma K, Mishra NK, Koepp MJ, Guekht A, et al. Pathophysiology, diagnosis, prognosis, and prevention of poststroke epilepsy: Clinical and research implications. Neurology 2024;102:e209450. doi: 10.1212/WNL.0000000000209450.
12. Kelly-Hayes M. Influence of age and health behaviors on stroke risk: Lessons from longitudinal studies. J Am Geriatr Soc 2010;58:S325-8. doi: 10.1111/j.1532-5415.2010.02915.x.
13. Desai R, Ruparelia C, Patel U, Naqvi S, Patel S, Lunagariya A, et al. Burden of arrhythmias in epilepsy patients: A nationwide inpatient analysis of 1.4 million hospitalizations in the United States. Cureus 2017;9:e1550. doi: 10.7759/cureus.1550.
14. Gümüşyayla S, Vural G. Early seizures after stroke: neurology intensive care unit experience. Turk J Neurol 2018;24:49-54. doi: 10.4274/tnd.72687.
15. Brigo F, Schneider M, Wagenpfeil G, Ragoschke-Schumm A, Fousse M, Holzhoffer C, et al. Intravenous thrombolysis with tPA and cortical involvement increase the risk of early poststroke seizures: Results of a case-control study. Epilepsy Behav 2020;104:106312. doi: 10.1016/j.yebeh.2019.04.056.
16. Ma S, Fan X, Zhao X, Wang K, Wang H, Yang Y. Risk factors for early-onset seizures after stroke: A systematicreview and meta-analysis of 18 observational studies. Brain Behav 2021;11:e02142. doi: 10.1002/brb3.2142.
17. Šmigelskytė A, Gelžinienė G, Jurkevičienė G. Early epileptic seizures after ischemic stroke: Their association with stroke risk factors and stroke characteristics. Medicina (Kaunas) 2023;59:1433. doi: 10.3390/medicina59081433.
18. Castro-Apolo R, Huang JF, Vinan-Vega M, Tatum WO. Outcome and predictive factors in post-stroke seizures: A retrospective case-control study. Seizure 2018;62:11-6. doi: 10.1016/j.seizure.2018.09.007.
19. Ferreira-Atuesta C, Döhler N, Erdélyi-Canavese B, Felbecker A, Siebel P, Scherrer N, et al. Seizures after ischemic stroke: A matched multicenter study. Ann Neurol 2021;90:808-20. doi: 10.1002/ana.26212.
20. Zöllner JP, Misselwitz B, Kaps M, Stein M, Konczalla J, Roth C, et al. National Institutes of Health Stroke Scale (NIHSS) on admission predicts acute symptomatic seizure risk in ischemic stroke: A population-based study involving 135,117 cases. Sci Rep 2020;10:3779. doi: 10.1038/s41598-020-60628-9.
21. Kumar S, Singh G, Chhikara M, Shukla S, Khatri R, Dar MO, et al. Neuroprotective role of acamprosate and rasagiline in epilepsy: in silico and in vivo study. Scripta Medica 2025;56:441-50. doi: 10.5937/scriptamed56-54329.