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Frequency and Types of Seizures among Patients Presenting with Stroke

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ABSTRACT

Stroke is a leading cause of death and disability worldwide, particularly in low- and middle-income countries. Post-stroke seizures represent an important neurological complication that may occur early or late after the event. However, limited data are available regarding their frequency and characteristics in the local population. **Objective:** To determine the frequency and types of seizures among patients presenting with stroke. **Methods:** This analytical cross-sectional study was conducted in the Department of Emergency Medicine, Lady Reading Hospital, Peshawar, over six months from May 2023 to November 2023. A total of 177 patients aged 20–80 years with radiologically confirmed stroke were enrolled using non-probability consecutive sampling. Patients with prior epilepsy or metabolic derangements known to precipitate seizures were excluded. Post-stroke seizures were classified as early (≤14 days) or late (>14 days to 3 months). Data were analyzed using SPSS version 26.0. Frequencies, percentages, chi-square tests, and logistic regression were applied, with $p < 0.05$ considered statistically significant. **Results:** The mean age was 49.7 ± 18.1 years, and 61.0% were male. Ischemic stroke occurred in 73.4% of patients. Post-stroke seizures were observed in 14.1% (n=25). Among these, 48.0% were early, and 52.0% were late seizures. No statistically significant associations were found between seizures and stroke subtype (p=0.197), gender (p=0.150), or age category (p=0.320). **Conclusions:** Post-stroke seizures occurred in 14.1% of patients, with nearly equal early and late distribution. Structured surveillance during acute and subacute phases is warranted.

INTRODUCTION

Stroke is a major cause of both death and disability worldwide and represents a significant public health burden, particularly in low- and middle-income countries (LMICs) [1]. Approximately 16 million first-ever strokes occur annually, resulting in nearly 5.7 million deaths globally. The burden of stroke is disproportionately higher in LMICs, where limited access to early diagnosis, acute stroke care, and rehabilitation services contributes to increased morbidity and mortality. In Pakistan, the prevalence of stroke has been reported to be approximately 6.4%, underscoring its substantial impact on the national healthcare system [2, 3]. Stroke is associated with numerous systemic and neurological complications, including aspiration pneumonia, dehydration, urinary tract infections, deep vein thrombosis, and pulmonary embolism [4]. Among neurological complications, epileptic seizures represent an important yet often under-recognized consequence. Post-stroke seizures may occur in the acute phase or during the chronic recovery period, reflecting distinct underlying pathophysiological mechanisms [5, 6]. Early post-stroke seizures are generally attributed to acute neuronal injury resulting from cerebral ischemia or hemorrhage. Mechanisms include excitotoxic glutamate release, disruption of ionic homeostasis, blood–brain barrier breakdown, cytotoxic edema, and acute inflammatory responses leading to transient cortical hyperexcitability. In contrast, late post-stroke seizures are believed to arise from chronic structural and functional alterations such as gliosis, synaptic reorganization,

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cortical remodeling, and the formation of permanent epileptogenic foci following neuronal injury [7, 8]. Thus, early seizures are typically considered acute symptomatic events, whereas late seizures may reflect the development of post-stroke epilepsy due to long-term cortical reorganization. Stroke is recognized as one of the leading causes of newly acquired seizures in older adults. Large cohort studies report that approximately 10–20% of stroke survivors experience seizures, including both early and delayed manifestations [5, 9]. However, reported prevalence varies widely across regions, with higher variability observed in LMICs due to delayed presentation, limited neuroimaging access, underutilization of electroencephalography (EEG), and suboptimal follow-up systems. In countries such as Pakistan, where healthcare resources may be constrained, post-stroke seizures may be underdiagnosed or inadequately documented, potentially leading to delayed treatment and worse neurological outcomes.

Despite the recognized clinical importance of post-stroke seizures, there is limited published data from Pakistan regarding their frequency, temporal distribution, and association with demographic and clinical variables. Most available evidence originates from high-income settings with advanced neurodiagnostic facilities, limiting generalizability to local populations. The absence of region-specific epidemiological data restricts the development of context-appropriate surveillance strategies and management protocols. Therefore, the present study was conducted to determine the frequency and temporal distribution (early versus late) of post-stroke seizures among patients presenting with radiologically confirmed stroke at a tertiary-care hospital in Peshawar. Additionally, the study aimed to evaluate the association between post-stroke seizures and selected demographic and clinical variables.

METHODS

This analytical cross-sectional study was conducted in the Department of Emergency Medicine at Medical Teaching Institution (MTI), Lady Reading Hospital (LRH), Peshawar, a tertiary-care referral center serving the population of Khyber Pakhtunkhwa. The study was conducted over 6 months, from May 2023 to November 2023. Ethical approval was obtained from the Institutional Review Board of Lady Reading Hospital (Ref No: 764/LRH/MTI; dated 25th May, 2023). The study was conducted in accordance with the Declaration of Helsinki, and written informed consent was obtained from all participants or their legal guardians before enrollment. The sample size was calculated using the WHO sample size calculator to estimate a single population proportion. A previously reported prevalence of 8% early post-stroke seizures was used as the expected frequency [10]. With a 95% confidence interval and a margin of error of 4%, the minimum required sample size was calculated to be 177 patients. A non-probability consecutive sampling technique was employed, whereby all eligible patients presenting during the study period were enrolled until the required sample size was achieved. Patients aged between 20 and 80 years of either gender presenting with clinical features suggestive of acute stroke were eligible for inclusion, provided that the diagnosis was confirmed radiologically by computed tomography (CT) scan of the brain. Stroke was operationally defined as the sudden onset of focal or global neurological deficit persisting for more than 24 hours due to a vascular cause. Ischemic stroke was identified by the presence of hypodense lesions or normal early CT findings consistent with ischemia, whereas hemorrhagic stroke was diagnosed based on hyperdense intracranial lesions on CT imaging. To minimize confounding bias and ensure that seizure events were attributable to stroke rather than metabolic abnormalities, patients with a prior history of epilepsy were excluded. In addition, patients with metabolic derangements known to precipitate seizures, including hypoglycemia (fasting blood glucose <80 mg/dL or random blood glucose <120 mg/dL), hyponatremia (serum sodium <135 mmol/L), hypocalcemia (serum calcium <9 mg/dL), and uremia (serum urea >50 mg/dL), were excluded from the study. Post-stroke seizures were defined clinically as transient episodes of abnormal motor activity, altered consciousness, sensory disturbance, or autonomic manifestations suggestive of abnormal cortical electrical activity, as determined by clinical history and neurological examination. Seizures were temporally classified into early and late categories. Early seizures were defined as those occurring within 14 days (≤2 weeks) of stroke onset, whereas late seizures were defined as those occurring after 14 days and up to three months following the stroke [11]. These temporal definitions were based on contemporary neurological literature and established clinical classifications of post-stroke seizures. All enrolled patients received standard institutional stroke management and were admitted for stabilization and treatment as per hospital protocol. Following discharge, patients were followed for a total duration of three months to identify seizure occurrence. Follow-up was conducted through scheduled outpatient department visits as well as weekly telephonic contact to ensure systematic monitoring. Any reported seizure episode was documented in a structured proforma, and the timing (early versus late) and clinical characteristics of the seizure were recorded. All clinical assessments and follow-up evaluations were supervised by a consultant physician with a minimum of five years of clinical experience. Demographic data, clinical findings, laboratory

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investigations, imaging results, and seizure characteristics were recorded using a pre-designed structured data collection form. CT brain scans were reviewed by qualified radiologists for confirmation of stroke subtype. Detailed imaging parameters such as lesion size, cortical versus subcortical involvement, and stroke severity scores were not consistently available in emergency records and, therefore, were not included in the analysis.

Data were entered and analyzed using the Statistical Package for Social Sciences (SPSS) version 26.0. Continuous variables were summarized as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. Associations between post-stroke seizures and categorical variables such as gender, age category, and stroke subtype were assessed using the Chi-square test, and Fisher's exact test was applied where appropriate. Effect size was evaluated using Cramer's V to assess the strength of associations. To adjust for potential confounding variables, binary logistic regression analysis was performed, including age (continuous), gender, and stroke subtype. Odds ratios with 95% confidence intervals were calculated. A p-value of less than 0.05 was considered statistically significant. The study was powered to estimate the frequency of post-stroke seizures rather than detect subgroup differences; therefore, multivariable analysis was interpreted cautiously due to the limited number of seizure events.

RESULTS

A total of 177 patients with radiologically confirmed stroke were included in the study. The demographic characteristics are presented in Table 1. The mean age was 49.7 ± 18.1 years (range 20–80 years). The majority of patients belonged to the 40–59 years age group (35.0%), followed by 60–80 years (33.3%) and 20–39 years (31.6%). Males constituted 61.0% of the study population (Table 1).

Table 1: Demographic Characteristics of Stroke Patients (n=177)

Variables	n (%)
Age (Years)	
Mean ± SD	49.7 ± 18.1
Minimum–Maximum	20–80
Age Category	
20–39 years	56 (31.6%)
40–59 years	62 (35.0%)
60–80 years	59 (33.3%)
Gender	
Male	108 (61.0%)
Female	69 (39.0%)

The distribution of stroke subtype and CT findings is shown in Table 2. Ischemic stroke was observed in 73.4% of patients, while 26.6% had hemorrhagic stroke. CT brain findings corresponded with stroke subtype (Table 2).

Table 2: Stroke Characteristics of Patients (n=177)

Variables	n (%)
Type of Stroke	
Ischemic	130 (73.4%)
Hemorrhagic	47 (26.6%)
CT Brain Finding	
Hypodense lesion	130 (73.4%)
Hyperdense lesion	47 (26.6%)

The overall frequency of post-stroke seizures was 14.1% (n=25) among the studied patients (Table 3).

Table 3: Frequency of Post-Stroke Seizures (n=177)

Post-Stroke Seizures	n (%)
Yes	25 (14.1%)
No	152 (85.9%)
Total	177 (100.0%)

Among patients who developed seizures, 48.0% experienced early seizures (≤14 days), while 52.0% had late seizures (>14 days to 3 months) (Table 4).

Table 4: Types of Post-Stroke Seizures (n=25)

Types of Seizure	n (%)
Early seizures	12 (48.0%)
Late seizures	13 (52.0%)
Total	25 (100.0%)

No statistically significant association was observed between seizures and gender (χ^2=2.074, p=0.150; Fisher's exact p=0.185). The effect size was small (Cramer's V=0.108). Females demonstrated a higher seizure proportion (18.8%) compared to males (11.1%), but the difference was not statistically significant (OR=0.538, 95% CI: 0.230–1.261). Similarly, no significant association was observed between seizure occurrence and age category (χ^2=2.281, p=0.320). The effect size was small (Cramer's V=0.114), indicating minimal practical association. Stroke subtype was not significantly associated with seizure development (p=0.197) (Table 5).

Table 5: Association of Post-Stroke Seizures with Demographic and Clinical Variables (n=177)

Variables	Categories	Seizures Yes, n (%)	Seizures No, n (%)	Total, (n)	χ^2 (df)	p-value
Type of Stroke	Ischemic	21 (16.2%)	109 (83.8%)	130	1.66 (1)	0.197
	Hemorrhagic	4 (8.5%)	43 (91.5%)	47		
Gender	Male	12 (11.1%)	96 (88.9%)	108	2.07 (1)	0.150
	Female	13 (18.8%)	56 (81.2%)	69		
Age Category	20–39 years	7 (12.5%)	49 (87.5%)	56	2.28 (2)	0.320
	40–59 years	12 (19.4%)	50 (80.6%)	62		
	60–80 years	6 (10.2%)	53 (89.8%)	59		
Total		25 (14.1%)	152 (85.9%)	177	–	

To adjust for potential confounding, binary logistic

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regression was performed, including age (continuous), gender, and stroke subtype. The overall model was not statistically significant (χ^2=4.329, df=3, p=0.228), explaining 4.3% of the variance (Nagelkerke R^2=0.043). Age was not independently associated with post-stroke seizures (OR = 1.005, 95% CI: 0.981–1.030, p=0.672). The female gender showed higher odds compared to males (OR=2.021, 95% CI: 0.843–4.841, p=0.115), although this did not reach statistical significance. Hemorrhagic stroke demonstrated lower odds compared to ischemic stroke (OR = 0.453, 95% CI: 0.146–1.411, p=0.172) (Table 6).

Table 6: Binary Logistic Regression Analysis for Predictors of Post-Stroke Seizures

Variables	OR	95% CI	p-value
Age	1.005	0.981–1.030	0.672
Female Gender	2.021	0.843–4.841	0.115
Hemorrhagic Stroke	0.453	0.146–1.411	0.172

DISCUSSION

Current study determined the frequency and temporal pattern of post-stroke seizures in patients presenting with radiologically confirmed stroke at a tertiary-care hospital in Peshawar. Post-stroke seizures were observed in 14.1% of patients, a finding that falls within the globally reported range of 10–20%. This consistency supports the external validity of our findings and suggests that the burden of post-stroke seizures in our setting is comparable to international data. Misra *et al.* reported a similar prevalence of seizures after stroke and highlighted their association with poorer functional outcomes and increased mortality [11]. Likewise, Freiman *et al.* documented post-stroke seizures in approximately 15% of stroke survivors in a hospital-based cohort [12]. These comparisons reinforce that post-stroke seizures remain a clinically significant neurological complication across diverse populations. Regarding temporal distribution, late seizures (52.0%) were slightly more frequent than early seizures (48.0%). The nearly equal distribution between early and late events is clinically important, as it reflects the dual-phase pathophysiology of seizure development following stroke. Early seizures are primarily attributed to acute biochemical disturbances, excitotoxic neurotransmitter release, and transient cortical hyperexcitability, whereas late seizures are associated with chronic structural remodeling, gliosis, synaptic reorganization, and formation of epileptogenic foci. Tanaka *et al.* emphasized that late post-stroke seizures are often markers of long-term cortical reorganization and may predict the development of post-stroke epilepsy [13]. Similarly, Ryu *et al.* reported that delayed seizures frequently reflect irreversible neuronal network alterations [14]. Current findings therefore support the need for continued surveillance beyond the acute hospitalization period, as seizure risk persists during the subacute recovery phase. In our cohort, seizures were more frequent in ischemic stroke (16.2%) compared to hemorrhagic stroke (8.5%), although the difference did not reach statistical significance (p=0.197). This lack of statistical significance may be explained by the relatively small number of seizure events (n=25), which limits statistical power for subgroup comparisons. The literature regarding stroke subtype and seizure risk remains heterogeneous. Guo *et al.* in a meta-analysis of seizures following intracerebral hemorrhage, reported considerable variability across cohorts [9]. Lin *et al.* similarly observed inconsistent associations between hemorrhagic stroke and seizure occurrence [15]. These findings suggest that seizure risk is multifactorial and may depend more strongly on cortical involvement, lesion size, and stroke severity rather than stroke subtype alone. Since detailed imaging variables were not systematically available in our dataset, subtype-specific differences should be interpreted cautiously. Gender-based analysis demonstrated a higher proportion of seizures among females (18.8%) compared to males (11.1%), although this difference was not statistically significant (p=0.150). Logistic regression showed approximately two-fold higher adjusted odds among females (OR=2.021), but the confidence interval was wide and crossed unity, indicating statistical uncertainty. The small effect size (Cramer's V = 0.108) further suggests minimal practical association. Previous studies have shown inconsistent gender effects. Sarfo *et al.* reported no independent association between gender and post-stroke seizures in a multicenter African cohort [16]. Similarly, Federico *et al.* found no significant sex-related differences in seizure risk following ischemic stroke [17]. Thus, our findings align with the broader evidence indicating that gender alone is unlikely to be a strong independent predictor of post-stroke seizures. Age-stratified analysis showed the highest seizure proportion in the 40–59-year group (19.4%), followed by 20–39 years (12.5%) and 60–80 years (10.2%), but these differences were not statistically significant (p=0.320). The absence of age-related significance may reflect the multifactorial nature of seizure development and the limited statistical power for subgroup detection. Lidetu and Zewdu similarly reported no independent age-based association after adjusting for stroke characteristics [18]. Smigelskyte *et al.* also concluded that age alone does not reliably predict early post-stroke seizures following ischemic stroke [19]. These findings collectively suggest that demographic variables may have limited predictive value when considered independently. Importantly, the 14.1% overall seizure incidence and the nearly equal early–late distribution have practical implications. These

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findings highlight the necessity for structured seizure surveillance not only during the acute admission period but also throughout the early recovery phase. Routine follow-up and patient education regarding seizure recognition are essential components of post-stroke care. Furthermore, the absence of routine electroencephalographic monitoring in our study may have resulted in under-detection of subclinical or non-convulsive seizures. Gururangan *et al.* demonstrated that point-of-care EEG can improve detection of occult epileptiform activity in acute stroke settings [20]. AlGaeed *et al.* emphasized the value of continuous EEG monitoring in identifying epileptiform discharges among ischemic stroke patients [21].

Strengths of this study include radiologically confirmed stroke diagnosis, clearly defined operational seizure classifications, exclusion of metabolic confounders, and a structured three-month follow-up to capture both early and late events. The use of logistic regression further allowed adjustment for potential confounding variables. However, several limitations should be acknowledged. First, the single-center design may limit generalizability. Second, the study was powered to estimate seizure frequency rather than detect subgroup differences, and the relatively small number of seizure events (n=25) limits statistical power for multivariable modeling. Third, detailed imaging parameters such as lesion size, cortical versus subcortical involvement, and standardized stroke severity scores were not available. Finally, electroencephalography was not routinely performed, which may have resulted in an underestimation of seizure burden. These limitations should be considered when interpreting the findings. Future studies incorporating systematic EEG evaluation may provide more accurate seizure incidence estimates and better risk stratification.

CONCLUSIONS

Post-stroke seizures were observed in 14.1% of patients presenting with radiologically confirmed stroke, with a nearly equal distribution between early and late seizure onset. Although ischemic stroke and female gender showed numerically higher seizure proportions, no statistically significant independent predictors were identified. These findings suggest that post-stroke seizures are relatively frequent but may not be strongly predicted by basic demographic or subtype variables alone. The observed incidence underscores the importance of structured surveillance during both the acute and subacute phases of stroke recovery. Future multicenter studies incorporating detailed neuroimaging parameters, stroke severity assessment, and routine electroencephalographic monitoring are warranted to better define seizure risk profiles and improve post-stroke neurological care strategies.

Authors' Contribution

Conceptualization: SJ, AU
Methodology: ZUK, SK, SFK
Formal analysis: ZUK, SK, AU, SFK. JK
Writing and Drafting: SJ, JK
Review and Editing: SJ, ZUK, SK, AU, SFK, JK

All authors approved the final manuscript and take responsibility for the integrity of the work

Conflicts of Interest

All the authors declare no conflict of interest.

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