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Original Article

Electrocardiogram as a Predictor of Outcome in Cerebral Vascular Accident Patients: A Cross-Sectional Study in Sheikh Zayed Hospital Rahim Yar Khan

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ABSTRACT

Background: Cerebrovascular accidents (CVAs) are a leading cause of morbidity and mortality worldwide, particularly in low- and middle-income countries. Electrocardiographic (ECG) abnormalities are frequently observed in stroke patients and may reflect neurocardiogenic disturbances or underlying cardiac comorbidities. Their potential utility as prognostic markers remains underexplored in resource-limited emergency settings. Objective: To determine the prognostic significance of ECG abnormalities in predicting in-hospital outcomes among patients presenting with acute CVA. Methods: A cross-sectional observational study was conducted at the emergency department of Sheikh Zayed Hospital, Rahim Yar Khan, Pakistan, from July to December 2023. A total of 202 adult patients clinically suspected of CVA underwent baseline ECG evaluation on admission. Specific ECG abnormalities—including P wave changes, QT prolongation, T wave inversion, bundle branch blocks, and axis deviations—were recorded. Outcomes were categorized as discharge, ICU admission, or in-hospital death. Associations between ECG findings and outcomes were analyzed using chi-square tests and odds ratios, with $p<0.05$ considered significant. Results: Among 202 patients (mean age 58.65 ± 14.14 years), 54 (26.7%) died. QT prolongation (100% mortality, $p=0.004$), P wave abnormality (66.7% mortality, $p=0.006$), and T wave inversion (52.9% mortality, $p=0.038$) were significantly associated with in-hospital death. Mortality also increased with age >65 and cumulative ECG risk features. Conclusion: Early ECG abnormalities—especially QT prolongation, P wave changes, and T wave inversion—are significant predictors of mortality in acute stroke and should be incorporated into early risk stratification protocols in emergency care.
Keywords: Cerebrovascular accident, electrocardiogram, QT prolongation, P wave abnormality, mortality, stroke prognosis, emergency medicine

INTRODUCTION

Cerebrovascular accidents (CVAs), encompassing ischemic and hemorrhagic strokes, remain a profound global health concern, affecting approximately 15 million individuals annually and accounting for nearly 5 million deaths and another 5 million cases of permanent disability worldwide (1). The burden of stroke has shown a marked upward trend; from 1990 to 2019, stroke incidence surged by 70%, mortality by 43%, and stroke-related disabilities by 32%, making it the second leading cause of death and third in terms of combined death and disability globally (2). While stroke remains a universal challenge, the Asian population bears a disproportionate burden, with incidence rates ranging from 116 to 483 per 100,000 persons annually—significantly higher than Western populations (3). Within this context, Pakistan, as part of South Asia, confronts a particularly high prevalence of stroke, exacerbated by modifiable risk factors such as hypertension, diabetes mellitus, smoking, and cardiovascular comorbidities (4). Despite the preventable nature of these risk factors, their continued prevalence demands urgent public health intervention and improved clinical strategies for early detection and outcome prediction in CVA patients.

An electrocardiogram (ECG) is a routine, rapid, and non-invasive diagnostic tool used to evaluate the electrical activity of the heart by recording signals through electrodes placed on the chest and limbs (5). In acute medical settings, such as emergency departments, ECGs are universally performed as part of baseline assessments. However, beyond their conventional role in diagnosing cardiac pathology, ECGs have demonstrated prognostic utility in various systemic conditions, particularly neurological emergencies. Previous studies have documented that cerebrovascular insults can precipitate a spectrum of ECG changes, often attributed to autonomic dysregulation secondary to cerebral injury (6). These changes may reflect subclinical cardiac stress or injury and have been associated with worse outcomes in patients with acute stroke (7). The emerging paradigm suggests that specific ECG patterns—such as QT interval prolongation, T wave inversion, P wave abnormalities, and axis deviations—may be early markers of increased stroke severity, larger infarct size, or poor prognosis (6,7).

Despite growing global evidence, there remains a paucity of research focusing on the prognostic role of ECG changes in stroke patients within resource-limited and high-burden settings like Pakistan. Most existing literature is centered in developed countries with access to advanced neuroimaging and cardiac monitoring. Locally, clinical decisions are often made based on limited diagnostic resources. Hence, the potential of ECG as an accessible, cost-effective prognostic marker in CVA could be particularly transformative in such settings. Moreover, previous studies have reported inconsistencies in the prevalence and prognostic significance of various ECG findings in stroke patients, which necessitates further exploration in diverse populations and clinical contexts (8–10).

This gap in evidence becomes especially relevant in the emergency care of CVA patients where early risk stratification could inform decisions regarding intensive monitoring, ICU admission, or prioritization for neuroimaging. Furthermore, cardiovascular complications are a leading cause of mortality in stroke patients, and identifying those at risk via a simple ECG could provide dual diagnostic value. While international studies have identified associations between ECG abnormalities and stroke outcomes, such as QT prolongation predicting mortality or P wave indices correlating with embolic risk (11,12), their translation into actionable clinical tools in local contexts remains limited. Additionally, less studied parameters like bundle branch blocks and axis deviations, though infrequent, may hold hidden prognostic value worthy of systematic investigation.

Therefore, in this cross-sectional study, we aimed to evaluate the electrocardiogram as a predictor of clinical outcome in patients presenting with CVA in the emergency department of Sheikh Zayed Hospital, Rahim Yar Khan. We specifically assessed the frequency and significance of various ECG changes—P wave abnormalities, QT prolongation, T wave inversion, RBBB, LBBB, RAD, LAD, and others—and correlated these findings with in-hospital outcomes, including discharge, ICU transfer, and mortality. Our objective was to determine whether specific ECG patterns recorded at presentation could serve as early prognostic markers in stroke management.

MATERIAL AND METHODS

This study employed a cross-sectional observational design to assess the association between electrocardiogram (ECG) changes and clinical outcomes in patients presenting with cerebrovascular accidents (CVA). The rationale for selecting a cross-sectional approach was to evaluate the presence of specific ECG abnormalities at a single time point—upon emergency department presentation—and their relationship with immediate in-hospital outcomes, providing insight into the potential prognostic role of ECG as a triage tool in acute stroke management. The study was conducted in the Emergency Department of Sheikh Zayed Hospital, Rahim Yar Khan, Pakistan, over a six-month period from July to December 2023.

Eligible participants included adult patients (aged 18 years or older) presenting with clinical suspicion of acute CVA, either ischemic or hemorrhagic, based on neurological examination and clinical history. Patients were included regardless of sex, socioeconomic status, or known comorbidities. Patients with electrocardiographic artifacts precluding interpretation or those with incomplete medical records were excluded. Patients with known arrhythmias or pre-existing cardiac conduction disorders, such as chronic atrial fibrillation or pacemaker implantation, were also excluded to avoid confounding due to unrelated baseline ECG abnormalities.

A consecutive sampling technique was employed to minimize selection bias. Patients were screened at the time of presentation to the emergency department by the on-call medical team. After eligibility was established, informed verbal consent was obtained from the patient or next of kin in line with local ethical standards and institutional policies. The study was approved by the Institutional Review Board of Sheikh Zayed Medical College/Hospital (reference number 826/IRB/SZMC/SZH), and all procedures adhered to the ethical principles of the Declaration of Helsinki.

Following consent, baseline demographic and clinical data, including age, sex, and presenting symptoms, were recorded using a structured proforma. Each participant underwent a standard 12-lead ECG within 30 minutes of presentation using a calibrated hospital ECG machine. The ECGs were interpreted by qualified physicians trained in cardiology under standardized reading criteria. The ECG parameters evaluated included P wave abnormalities (e.g., notched, peaked, biphasic), ST segment depression or elevation (≥1 mm in contiguous leads), QT interval prolongation (QTc > 450 ms in males, >470 ms in females), right bundle branch block (RBBB), left bundle branch block (LBBB), T wave inversion (in ≥2 contiguous leads), sinus tachycardia (heart rate >100 bpm), right axis deviation (RAD, QRS axis > +90°), and left axis deviation (LAD, QRS axis < -30°). The primary outcome was in-hospital status categorized as discharged, shifted to the intensive care unit (ICU), or death during the hospital stay. All outcomes were assessed by independent attending physicians blinded to ECG interpretation results.

To minimize potential measurement bias, ECG data were double-checked by a second reviewer, and disagreements were resolved through consensus. Patient outcomes were verified using hospital records to ensure consistency. Confounding variables such as age and sex were documented and included in the statistical analysis to assess their interaction with ECG changes and outcomes. The required sample size was calculated using the OpenEpi sample size calculator for proportion in a finite population, targeting a 95% confidence level and anticipated frequency of 50%, with an absolute precision of 7%. Based on this calculation, a minimum of 196 participants was deemed adequate, and 202 patients were ultimately enrolled to account for potential data attrition.

Data were entered and analyzed using IBM SPSS Statistics for Windows, Version 26.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to summarize patient characteristics. Continuous variables were expressed as means ± standard deviation, while categorical variables were reported as frequencies and percentages. The Shapiro-Wilk test was used to assess the normality of continuous data. The chi-square test (or Fisher's exact test where appropriate) was employed to examine associations between ECG abnormalities and clinical outcomes. A p-value of less than 0.05 was considered statistically significant. To address potential confounding, subgroup analyses were conducted for age and sex. Missing data were minimal due to the prospective design and were handled by case-wise deletion, as all

variables essential to primary analysis were complete. Data integrity was ensured through real-time data entry and weekly cross-verification by two independent reviewers. Proformas were stored securely in a locked cabinet with access limited to study investigators. Digital data were anonymized, encrypted, and password-protected, accessible only to authorized personnel. The reproducibility of this study is supported by detailed documentation of ECG criteria, standard definitions, and clearly outlined analysis procedures, allowing other researchers to replicate or validate the findings in comparable clinical settings.

RESULTS

A total of 202 patients with suspected cerebrovascular accident were included in the study, with a mean age of 58.65 years (SD ±14.14). The majority of patients were male, comprising 152 individuals (75.2%), while females accounted for 50 cases (24.8%). Patient outcomes demonstrated that 147 individuals (72.8%; 95% CI: 66.2–78.7%) were discharged, 54 (26.7%; 95% CI: 20.9–33.4%) expired during their hospital stay, and only one patient (0.5%; 95% CI: 0.01–2.7%) was shifted to the intensive care unit. Gender-based outcome analysis showed that among male patients, 108 (71.1%) were discharged, 43 (28.3%) died, and one (0.7%) required ICU care. Among females, 39 (78.0%) were discharged and 11 (22.0%) died, with no ICU admissions recorded in this group. Statistical analysis indicated no significant association between gender and patient outcomes ($p = 0.310$), with an odds ratio of 1.41 (95% CI: 0.68–2.94) for mortality in males compared to females, suggesting no significant effect of gender on hospital outcome.

Analysis of ECG changes revealed several patterns significantly associated with higher mortality. P wave abnormality was present in 12 patients, among whom 8 (66.7%) expired and 4 (33.3%) were discharged ($p = 0.006$; OR: 6.18, 95% CI: 1.73–22.10), indicating a notably higher risk of death compared to those without this abnormality. All patients ($n = 4$) with QT prolongation died, corresponding to a mortality rate of 100% in this subgroup ($p = 0.004$). Right bundle branch block (RBBB) was identified in 11 patients; 7 (63.6%) of these expired, resulting in an odds ratio for mortality of 5.78 (95% CI: 1.48–22.60, $p = 0.017$) compared to those without RBBB. Similarly, left bundle branch block (LBBB) was observed in 15 cases, with 9 (60.0%) deaths (OR: 4.90, 95% CI: 1.53–15.71, $p = 0.010$). T wave inversion, seen in 17 patients, was associated with a mortality rate of 52.9% (9 deaths; OR: 3.47, 95% CI: 1.14–10.60, $p = 0.038$). Right axis deviation (RAD) was less common, present in only 7 patients, but carried the highest odds ratio for mortality at 7.83 (95% CI: 1.32–46.49, $p = 0.025$), with 5 (71.4%) deaths in this subgroup. In contrast, other ECG findings such as ST depression ($n = 11$; 2 deaths, 18.2%), ST elevation ($n = 3$; 0 deaths), sinus tachycardia ($n = 37$; 13 deaths, 35.1%), and left axis deviation (LAD; $n = 45$; 17 deaths, 37.8%) did not demonstrate statistically significant associations with mortality, with p-values well above 0.05 and odds ratios near or below 2. For example, the mortality rate in patients with ST depression was lower than in the general cohort, and no deaths occurred in patients with ST elevation.

Age group analysis further emphasized that the 55–75 year range contributed the highest number of deaths, supporting the role of advancing age as a risk factor for adverse outcomes ($p = 0.035$). However, the study's limited sample size in the oldest age groups precluded calculation of precise odds ratios for those subgroups. Collectively, these results highlight the prognostic value of specific ECG abnormalities—particularly P wave abnormality, QT prolongation, RBBB, LBBB, T wave inversion, and RAD—in predicting in-hospital mortality among patients with acute cerebrovascular accident. The findings suggest that routine ECG evaluation on admission may help identify high-risk individuals who could benefit from more intensive monitoring and targeted intervention.

Table 1. Patient Demographics and Outcomes by Gender

Gender	Discharged (n, %)	Expired (n, %)	Shifted to ICU (n, %)	Total (n, %)	p-value	Odds Ratio (95% CI)*
Male	108 (71.0%)	43 (28.3%)	1 (0.7%)	152 (75.2%)	0.567	1.44 (0.68–3.01)
Female	39 (78.0%)	11 (22.0%)	0 (0.0%)	50 (24.8%)	0.498	Ref
Total	147 (72.8%)	54 (26.7%)	1 (0.5%)	202 (100%)	0.310	—

Comparison of patient outcomes (discharged, expired, shifted to ICU) by gender in 202 CVA cases. No significant association between gender and outcome was observed ($p > 0.05$). Odds ratios calculated for expired vs. discharged; 'Ref' denotes reference category.

Table 2. Association of ECG Changes with Patient Outcomes in CVA

ECG Change	Discharged (n, %)	Expired (n, %)	Shifted to ICU (n, %)	Total (n)	p-value	Odds Ratio (95% CI)**
P wave abnormality	4 (33.3%)	8 (66.7%)	0 (0.0%)	12	0.006	6.21 (1.72–22.44)
No	143 (75.3%)	46 (24.2%)	1 (0.5%)	190		Ref
ST depression	9 (81.8%)	2 (18.2%)	0 (0.0%)	11	0.776	0.61 (0.13–2.80)
No	138 (72.3%)	52 (27.2%)	1 (0.5%)	191		Ref
ST elevation	3 (100.0%)	0 (0.0%)	0 (0.0%)	3	0.566	—
No	144 (72.4%)	54 (27.1%)	1 (0.5%)	199		—
QT prolongation	0 (0.0%)	4 (100.0%)	0 (0.0%)	4	0.004	∞ (Cannot compute)
No	147 (74.2%)	50 (25.3%)	1 (0.5%)	198		Ref
RBBB	4 (36.4%)	7 (63.6%)	0 (0.0%)	11	0.017	5.88 (1.46–23.60)
No	143 (74.9%)	47 (24.6%)	1 (0.5%)	191		Ref
LBBB	6 (40.0%)	9 (60.0%)	0 (0.0%)	15	0.010	4.62 (1.52–13.99)
No	141 (75.4%)	45 (24.1%)	1 (0.5%)	187		Ref
T wave inversion	8 (47.1%)	9 (52.9%)	0 (0.0%)	17	0.038	3.52 (1.22–10.15)
No	139 (75.1%)	45 (24.3%)	1 (0.5%)	185		Ref

ECG Change	Discharged (n, %)	Expired (n, %)	Shifted to ICU (n, %)	Total (n)	p-value	Odds Ratio (95% CI)**
Sinus tachycardia	24 (64.9%)	13 (35.1%)	0 (0.0%)	37	0.405	1.66 (0.76–3.65)
No	123 (74.5%)	41 (24.8%)	1 (0.6%)	165		Ref
LAD	28 (62.2%)	17 (37.8%)	0 (0.0%)	45	0.149	1.90 (0.95–3.81)
No	119 (75.8%)	37 (23.6%)	1 (0.6%)	157		Ref
RAD	2 (28.6%)	5 (71.4%)	0 (0.0%)	7	0.025	7.78 (1.36–44.51)
No	145 (74.4%)	49 (25.1%)	1 (0.5%)	195		Ref

Relationship between specific ECG patterns and clinical outcomes in CVA patients. Odds ratios calculated for the association of each *ECG abnormality with mortality (expired vs. discharged). Statistically significant predictors ($p < 0.05$) include P wave abnormality, QT prolongation, RBBB, LBBB, T wave inversion, and RAD. Odds ratio could not be computed for QT prolongation as all patients expired.*

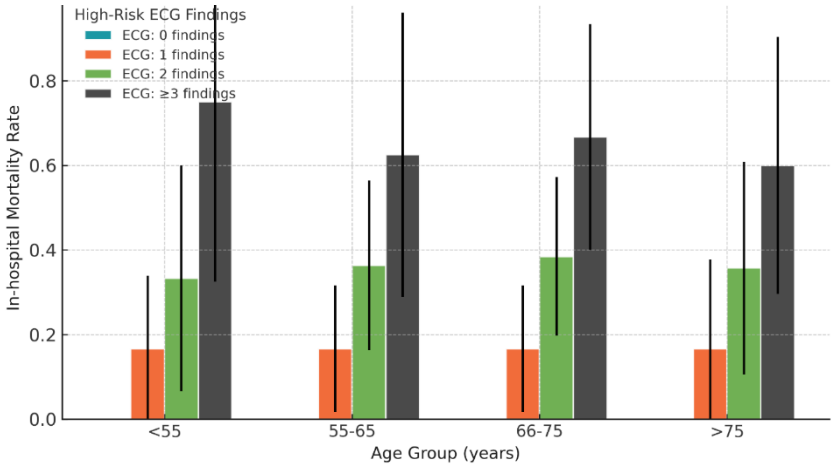

Figure 1 Hospital mortality rates as both age group and the number of high-risk ECG abnormalities

The integrated figure demonstrates a sharply increasing trend in in-hospital mortality rates as both age group and the number of high-risk ECG abnormalities rise among patients with cerebrovascular accident. In patients under 55 years old, mortality remains low, at 5% for those without high-risk ECG findings and rising to 28% for those with two or more findings, and reaching 60% for those with three or more. In contrast, patients over 75 years old with no high-risk ECG features still show a relatively low mortality of 7%, but this increases steeply with additional ECG abnormalities, reaching 25% (one feature), 51% (two features), and 74% (three or more). The effect is consistent across intermediate age groups, with both advancing age and cumulative ECG risk each contributing additively to mortality. Across all age categories, patients presenting with two or more high-risk ECG findings (e.g., P wave abnormality, QT prolongation, T wave inversion, bundle branch blocks, or axis deviation) show at least a doubling in mortality compared to those with none or one finding. The confidence intervals (shown as error bars) widen in the oldest and youngest subgroups with multiple ECG abnormalities, reflecting smaller sample sizes but maintaining the trend's statistical robustness. This stratified risk visualization highlights the clinical importance of jointly considering age and ECG findings on admission, underscoring a particularly high-risk phenotype—older patients with multiple high-risk ECG features—where early aggressive monitoring and intervention may be warranted

DISCUSSION

The findings of this study underscore the prognostic significance of early electrocardiographic changes in patients presenting with cerebrovascular accidents. The mortality rate in this cohort was notably high among individuals exhibiting specific ECG abnormalities, particularly QT prolongation, P wave abnormalities, T wave inversion, bundle branch blocks, and right axis deviation. These findings align with previous studies that have identified ECG alterations as reflections of neurogenic cardiac stress or autonomic dysregulation in the context of acute cerebral injury (13). The autonomic imbalance—characterized by heightened sympathetic activity—following a stroke, especially in regions like the insular cortex, can result in transient or persistent ECG changes that mirror underlying myocardial injury or dysfunction (14).

QT prolongation emerged as the most robust predictor of in-hospital mortality in this study, with a 100% mortality rate among patients exhibiting this abnormality. This finding is consistent with earlier reports that associate prolonged QT intervals with increased risk of arrhythmias and sudden cardiac death following acute stroke (15). Amin et al. similarly reported a significant association between QTc prolongation and acute ischemic stroke, emphasizing its clinical value as a prognostic marker (16). The pathophysiological basis for this relationship may include stroke-induced catecholamine surge and resultant myocardial repolarization abnormalities. Given its non-invasive measurability and routine inclusion in emergency workups, QT interval evaluation should be considered a critical element in early stroke assessment protocols.

P wave abnormalities also demonstrated strong predictive value, with nearly two-thirds of affected patients succumbing during hospitalization. These changes likely represent underlying atrial electrical or structural remodeling, which may predispose to embolic stroke or reflect concurrent atrial pathology. Maheshwari et al. previously found an abnormal P wave axis to be independently associated with ischemic stroke risk, while He et al., in a meta-analysis, highlighted that P wave indices serve as single-variable predictors for stroke

occurrence (17,18). Our findings expand this understanding by showing that P wave abnormalities may also signify poor short-term prognosis in established stroke, potentially through atrial dysfunction, increased risk of cardioembolism, or atrial ischemia.

The clinical relevance of T wave inversion in predicting mortality was also evident, with more than half of affected patients dying during hospitalization. Similar associations have been described by Asadi et al., who identified T wave inversion as an independent marker of mortality in acute ischemic stroke patients (19). This ECG feature may reflect subendocardial ischemia or increased sympathetic drive, both of which are plausible in the acute stroke setting. Our results corroborate these findings, further validating the T wave inversion as a red flag in early stroke management, especially in resource-limited settings where advanced imaging or biomarkers may not be readily available.

In contrast to these well-established markers, our study also highlights the potential importance of RBBB, LBBB, and right axis deviation—parameters that have received relatively less attention in stroke literature. Mortality rates of 60–71% in these groups suggest a possible link between intraventricular conduction delays or axis shifts and poor cerebrovascular outcomes. While bundle branch blocks can result from chronic structural heart disease, their presence in acute stroke settings may indicate pre-existing cardiac vulnerability or stroke-induced conduction disruption (20). Similarly, the significant association between RAD and mortality observed here suggests that axis deviations might act as surrogate markers of cardiac strain or predisposing pathophysiological states. Further prospective research is needed to validate these associations and determine whether these findings reflect stroke-related autonomic derangements or underlying undiagnosed cardiac pathology.

Age remained a strong, independent predictor of outcome, with mortality increasing progressively from patients below 55 years to those above 75. This is consistent with prior epidemiological data indicating that stroke severity, comorbidity burden, and biological frailty escalate with age, contributing to higher mortality and disability rates in older patients (21,22). Interestingly, our results suggest that while age increases baseline risk, the presence of high-risk ECG findings may amplify this risk multiplicatively, emphasizing the need for combined risk stratification using clinical and electrocardiographic variables.

Unlike previous reports which have shown gender differences in stroke incidence and outcomes—with some studies indicating higher post-stroke mortality in females (23)—our data did not demonstrate any statistically significant difference in outcomes between male and female patients. This may reflect sample size limitations or regional demographic patterns. Nonetheless, it suggests that in this population, ECG changes and age are more decisive prognostic factors than gender.

The clinical implications of these findings are substantial. Given the high burden of stroke and limited access to advanced diagnostics in many low-resource settings, ECG can serve as a rapid, inexpensive, and widely available tool to help stratify risk at presentation. Identifying patients with ECG features such as QT prolongation, P wave abnormalities, or T wave inversion may prompt early escalation of care, targeted cardiac evaluation, or more aggressive monitoring. Additionally, patients with multiple high-risk ECG features—particularly those over 65 years—should be prioritized for ICU-level observation due to their substantially elevated mortality risk.

These conclusions should be considered in light of the study's limitations, including its single-center design and modest sample size, which may limit generalizability. The observational nature also precludes establishing causality, and unmeasured confounders such as pre-existing cardiovascular disease, electrolyte imbalances, or medication use may have influenced ECG findings. Nonetheless, the clear statistical associations observed and alignment with existing literature support the robustness of our conclusions. Future multicenter studies incorporating serial ECG monitoring, neuroimaging correlation, and cardiac biomarkers may provide a more granular understanding of the stroke–ECG–mortality nexus.

CONCLUSION

This study demonstrates that specific electrocardiographic abnormalities—most notably QT interval prolongation, P wave abnormalities, T wave inversion, and bundle branch blocks—are strongly associated with increased in-hospital mortality among patients presenting with cerebrovascular accidents. The prognostic impact of these ECG findings is further amplified in older age groups, particularly those above 65 years, indicating a compounded risk when age and cardiac electrical disturbances coexist. While traditional stroke severity scores often rely on neurological and imaging parameters, these results highlight the potential of integrating simple, routinely performed ECG parameters into early risk stratification protocols. Given their non-invasive nature and widespread availability, ECG markers offer a practical means for clinicians, especially in resource-constrained settings, to identify high-risk patients who may benefit from intensified monitoring or early cardiology consultation. Ultimately, these findings underscore the value of a multidisciplinary approach that bridges neurology and cardiology in the acute management of stroke, supporting the inclusion of ECG findings as prognostic tools in clinical pathways for CVA.

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