RESEARCH PAPER

Assessment of Cardiac Rhythm Abnormalities among Adult Patients with Acute Stroke Using Holter Monitoring: A Hospital Based Cross Sectional Study

[1]Dr. Aviral Meshram and [2]Dr. Aralikatte Onkarappa Saroja

[1]Senior Resident, Department Of Neurology, Jawaharlal Nehru Medical college and KLES Dr. Prabhakar Kore Hospital and Medical Research Centre, Nehru Nagar, Belagavi, Karnataka, India
[2]Professor and Head, Department Of Neurology, Jawaharlal Nehru Medical College and KLES Dr. Prabhakar Kore Hospital and Medical Research Center , Nehru Nagar, Belagavi, Karnataka, India
[1]aviralmeshram@gmail.com and [2] sarojaao2002@yahoo.com

Received: 10th July, 2026; Revised: 10th August 2026; Accepted: 1st September, 2026; Available Online: 6th September ,2026

ABSTRACT

Background: Stroke is a leading cause of mortality and disability worldwide. Cardiac rhythm abnormalities frequently occur after acute stroke due to autonomic dysfunction, catecholamine excess, or underlying cardiovascular disease. Many remain undetected on routine electrocardiography (ECG), making continuous cardiac monitoring important for diagnosis and secondary stroke prevention.

Objectives: To determine the prevalence of cardiac conduction defects and rhythm abnormalities using 24-hour Holter monitoring in adults with acute stroke and evaluate their association with stroke characteristics, severity, and functional outcome.

Methods: This hospital-based cross-sectional observational study included 100 consecutive adults with radiologically confirmed acute stroke admitted to a tertiary care center. All patients underwent clinical evaluation, neuroimaging, 12-lead ECG, echocardiography, and 24-hour Holter monitoring. Stroke severity was assessed using the National Institutes of Health Stroke Scale (NIHSS) and Glasgow Coma Scale (GCS), while functional outcome at discharge was evaluated using the modified Rankin Scale (mRS).

Results: The mean age was 60.1 ± 14.1 years, and 66% were male. Ischaemic stroke accounted for 95% of cases. Hypertension (57%) and diabetes mellitus (31%) were the most common risk factors. Baseline ECG was normal in 98% of patients, whereas Holter monitoring detected rhythm abnormalities in 33%. Ventricular premature complexes were the commonest findings, followed by atrial fibrillation, paroxysmal atrial fibrillation, atrial premature complexes, sinus tachycardia, ventricular bigeminy, non-sustained ventricular tachycardia, sinus pauses, and sinus node dysfunction. NIHSS ($p<0.001$) and GCS ($p=0.001$) were significantly associated with discharge outcome, while Holter-detected abnormalities showed no significant association with stroke subtype, lesion characteristics, or short-term functional outcome.

Conclusions: Twenty-four-hour Holter monitoring substantially improves detection of occult cardiac rhythm abnormalities compared with routine ECG in acute stroke. Although these abnormalities were not associated with short-term functional outcome, Holter monitoring may facilitate identification of clinically important arrhythmias, particularly occult atrial fibrillation, thereby supporting appropriate secondary stroke prevention.

Keywords: *Stroke; Holter monitoring; Cardiac arrhythmias; Atrial fibrillation; Electrocardiography; Stroke-heart syndrome.*

How to cite this article: Meshram A, Saroja AO, Assessment of Cardiac Rhythm Abnormalities among Adult Patients with Acute Stroke Using Holter Monitoring: A Hospital Based Cross Sectional Study. Int J Drug Deliv Technol. 2026;16(80s): 1268-1272; DOI: 10.25258/ijddt.16.80s.159
Source of support: Nil.
Conflict of interest: None

INTRODUCTION

Stroke is a major global health problem and remains one of the leading causes of mortality and long-term disability worldwide. The World Health Organization (WHO) defines stroke as the rapid development of focal or global neurological dysfunction of vascular origin lasting more than 24 hours or resulting in death.[1] More recently, the American Stroke Association expanded this definition to include pathological or imaging evidence of permanent infarction in the brain, spinal cord, or retina due to vascular causes, irrespective of clinical symptoms. Despite advances in prevention and treatment, stroke continues to impose a substantial healthcare burden, particularly in

**Author for Correspondence: aviralmeshram@gmail.com*

developing countries where ageing populations and increasing prevalence of vascular risk factors are expected to further increase its incidence.[2]

Acute stroke is frequently associated with cardiovascular complications due to disruption of central autonomic regulation. Injury to cortical and subcortical autonomic centers, particularly the insular cortex, produces an imbalance between sympathetic and parasympathetic activity, resulting in excessive catecholamine release, myocardial injury, electrocardiographic (ECG) abnormalities, cardiac arrhythmias, and, in severe cases, sudden cardiac death. Cardiac abnormalities have been reported in 60–70% of patients following acute stroke. Right insular lesions have been associated with supraventricular tachyarrhythmias and sudden death, whereas left parieto-insular infarcts are linked to an increased risk of new-onset atrial fibrillation.[3]

Electrocardiographic abnormalities are observed in up to 90% of patients with acute ischemic stroke. Common findings include QT interval prolongation, ST-segment depression, T-wave inversion, U waves, sinus tachycardia, premature atrial and ventricular complexes, and atrial fibrillation (AF). Among these, AF is of particular clinical importance because it is responsible for approximately 10% of all strokes and nearly half of cardioembolic strokes. However, AF often remains undiagnosed because it may be asymptomatic or paroxysmal, making it difficult to detect on a single standard ECG. Moreover, cardiac rhythm disturbances may occur as a consequence of acute neurological injury, further complicating the distinction between pre-existing and stroke-induced arrhythmias.[4]

Continuous cardiac rhythm monitoring has therefore become an important component of the evaluation of patients with acute stroke. Twenty-four-hour Holter monitoring provides a higher diagnostic yield than routine ECG by detecting intermittent arrhythmias and conduction abnormalities that may otherwise remain unrecognized. It is particularly valuable in identifying occult AF in patients with embolic stroke of undetermined source (ESUS) and cryptogenic stroke, facilitating timely initiation of anticoagulation and other secondary prevention strategies. In addition, Holter monitoring may help identify clinically significant ventricular arrhythmias and conduction disturbances that contribute to adverse cardiovascular outcomes.[5]

Given the high prevalence of occult rhythm abnormalities and their potential therapeutic implications, this study was undertaken to determine the prevalence of cardiac conduction defects and rhythm abnormalities detected by 24-hour Holter monitoring in patients with acute stroke and to evaluate their association with stroke characteristics, severity, and short-term functional outcome.

MATERIALS AND METHODS

This hospital-based cross-sectional observational study was conducted in the Department of Neurology, over a period of one year after obtaining approval from the Institutional Ethics Committee. The study population comprised adult patients admitted with radiologically confirmed acute stroke. The sample size was calculated using the prevalence reported by Kairi et al.[6] for Holter-detected cardiac rhythm abnormalities in acute ischemic stroke (p=60%), employing the formula $n = Z^2pq/d^2$, which yielded a minimum sample size of 93. To account for possible attrition and incomplete data, 100 consecutive eligible patients were enrolled.

Patients aged >18 years with acute ischemic or haemorrhagic stroke confirmed by computed tomography (CT) or magnetic resonance imaging (MRI), presenting within 24 hours of symptom onset and able to undergo Holter monitoring, were included after obtaining written informed consent. Patients with known atrial fibrillation, previously diagnosed cardiac rhythm disorders, permanent pacemakers, or severe structural heart disease were excluded.

After enrolment, detailed demographic and clinical data, including age, sex, presenting symptoms, vascular risk factors, previous stroke or transient ischemic attack, hypertension, diabetes mellitus, smoking, tobacco use, and alcohol consumption, were recorded. Neurological evaluation was performed using the National Institutes of Health Stroke Scale (NIHSS) and Glasgow Coma Scale (GCS). Neuroimaging findings were reviewed to determine stroke subtype, lesion side, and vascular territory involved.

All patients underwent a comprehensive cardiac evaluation comprising a standard 12-lead electrocardiogram (ECG), two-dimensional echocardiography, and 24-hour Holter monitoring to detect cardiac conduction defects and rhythm abnormalities. Functional outcome at discharge was assessed using the modified Rankin Scale (mRS), with scores of 0–2 considered a good outcome and scores of 3–5 considered a poor outcome.

Data were entered into Microsoft Excel and analysed using SPSS version 26 and STATA version 10.1. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. Comparisons between categorical variables were performed using the Chi-square test or Fisher's exact test, as appropriate. A p-value <0.05 was considered statistically significant. Institutional Ethics Committee approval and written informed consent were obtained before study commencement, and patient confidentiality was maintained throughout the study.

RESULTS

A total of 100 consecutive patients with acute stroke were included in the study. The mean age was **60.1 ± 14.1 years** (range 27–85 years), and **66% were male**. Ischemic stroke accounted for **95%** of cases, while **5%** had hemorrhagic stroke. Hypertension (57%) and diabetes mellitus (31%) were the most common vascular risk factors. Baseline electrocardiography was normal in **98%** of patients.

Table 1. Baseline demographic and clinical characteristics (N=100)

Variable	n (%)
Mean age (years)	60.1 ± 14.1
Male sex	66 (66.0)
Ischemic stroke	95 (95.0)
Hemorrhagic stroke	5 (5.0)
Presented within 4.5 h	20 (20.0)
Hypertension	57 (57.0)
Diabetes mellitus	31 (31.0)
Previous stroke	5 (5.0)
Previous TIA	4 (4.0)

The study population predominantly consisted of older males with ischemic stroke. Hypertension and diabetes were the most common vascular risk factors, while only one-fifth of patients presented within the thrombolytic window.

Table 2- Stroke Severity, Neurological Assessment and Functional Outcome at Discharge

Assessment	Category	n (%)
NIHSS	0–4	34 (34.0)
	5–15	53 (53.0)
	16–20	8 (8.0)
	21–42	4 (4.0)
	Not assessable	1 (1.0)
GCS	13–15	88 (88.0)
	9–12	10 (10.0)
	4–8	2 (2.0)
mRS at discharge	0	17 (17.0)
	1	30 (30.0)
	2	15 (15.0)
	3	15 (15.0)
	4	18 (18.0)
	5	5 (5.0)

Among the 100 patients, NIHSS scores indicated that the majority had mild to moderate neurological impairment, with 34.0% having a score of 0–4 and 53.0% having a score of 5–15. Severe stroke, defined by an NIHSS score of ≥16, was observed in 12.0% of patients, while 1.0% were not assessable. On assessment of consciousness using the GCS, 88.0% had a score of 13–15, indicating preserved or near-normal consciousness, whereas 10.0% had scores of 9–12 and 2.0% had scores of 4–8. At discharge, functional outcome assessed using the modified Rankin Scale (mRS) showed that 62.0% of patients had a favourable functional outcome (mRS 0–2). Among these, 17.0% were completely independent (mRS 0), 30.0% had slight disability (mRS 1), and 15.0% had mild disability (mRS 2). Moderate to severe disability (mRS 3–5) was present in 38.0% of patients, including 15.0% with mRS 3, 18.0% with mRS 4, and 5.0% with mRS 5. Overall, the findings demonstrate that most patients presented with relatively preserved consciousness and mild-to-moderate stroke severity, with nearly two-thirds achieving a favourable functional status at discharge.

Table 3. Investigation and Twenty-four-hour Holter monitoring findings

Observation/Investigation	Findings n (%)
ECG/ECHO	
Normal baseline ECG	98 (98.0%)
Sinus bradycardia	1 (1.0%)
Sinus tachycardia	1 (1.0%)
Diastolic dysfunction (ECHO)	96 (96.0%)
Concentric LVH	42 (42.0%)
Mild pulmonary hypertension	33 (33.0%)
Holter finding	
No arrhythmia	67 (67.0%)
Occasional ventricular premature complexes (VPCs)	14 (14.0%)
Frequent VPCs	6 (6.0%)
Sinus tachycardia	3 (3.0%)
Occasional atrial premature complexes	2 (2.0%)
Atrial fibrillation	1 (1.0%)
Paroxysmal atrial fibrillation	1 (1.0%)
Short run of AF	1 (1.0%)
Non-sustained ventricular tachycardia	1 (1.0%)
Ventricular bigeminy	1 (1.0%)
Significant sinus pause	1 (1.0%)
Sinus node dysfunction	1 (1.0%)

Cardiac evaluation revealed that 98.0% of patients had a normal baseline ECG, while sinus bradycardia and sinus tachycardia were each observed in 1.0% of patients. In contrast, echocardiography demonstrated a high prevalence of structural and functional abnormalities, with diastolic dysfunction present in 96.0%, concentric left ventricular hypertrophy in 42.0%, and mild pulmonary hypertension in 33.0%. Twenty-four-hour Holter monitoring identified rhythm abnormalities in 33.0% of patients, with occasional ventricular premature complexes (14.0%) being the most frequent finding, followed by frequent VPCs (6.0%) and sinus tachycardia (3.0%). Occasional atrial premature complexes were detected in 2.0%, while atrial fibrillation, paroxysmal atrial fibrillation, short runs of AF, non-sustained ventricular tachycardia, ventricular bigeminy, significant sinus pauses, and sinus node dysfunction were each observed in 1.0% of patients. Overall, although routine ECG was largely normal, echocardiography and prolonged Holter monitoring revealed a substantial burden of subclinical structural, functional, and rhythm abnormalities, highlighting the value of comprehensive cardiac assessment.

Table 4. Association of clinical variables with functional outcome

Variable	p-value
NIHSS vs mRS	**<0.001**
GCS vs mRS	**0.001**
Baseline ECG vs mRS	0.535
Holter findings vs mRS	0.539
Holter findings vs stroke subtype	0.124
Holter findings vs vascular territory	0.844

Holter findings vs lesion side	0.729

Admission stroke severity measured by NIHSS and GCS was significantly associated with functional outcome at discharge. In contrast, Holter-detected rhythm abnormalities were not significantly associated with functional outcome, stroke subtype, vascular territory, or lesion laterality.

DISCUSSION

The present study evaluated the prevalence of cardiac conduction defects and rhythm abnormalities detected by 24-hour Holter monitoring in 100 patients with acute stroke and examined their association with stroke characteristics, severity, and short-term functional outcome. The study demonstrated that Holter monitoring identified cardiac rhythm abnormalities in one-third (33%) of patients despite normal baseline electrocardiography in 98%, highlighting the limited sensitivity of routine ECG for detecting intermittent arrhythmias. These findings support the role of continuous cardiac monitoring in the early evaluation of patients with acute stroke.

The study population had a mean age of 60.1 ± 14.1 years and was predominantly male (66%), consistent with previous studies reporting a higher burden of stroke among older adults and men. Hypertension (57%) and diabetes mellitus (31%) were the most prevalent vascular risk factors, similar to observations by Carrarini et al., Alriyami et al., Himmelreich et al., and Foo et al., who also identified hypertension as the commonest comorbidity among stroke patients. These findings reinforce the importance of aggressive control of vascular risk factors to reduce stroke incidence and recurrent cerebrovascular events. [7,8,9,10]

Most patients presented with mild-to-moderate neurological deficits, with 53% having NIHSS scores between 5 and 15 and 88% demonstrating preserved consciousness (GCS 13–15). Importantly, admission NIHSS and GCS showed significant associations with functional outcome at discharge ($p<0.001$ and $p=0.001$, respectively), indicating that stroke severity remains the strongest predictor of early disability. These observations are in agreement with previous studies demonstrating that higher NIHSS scores and reduced consciousness are associated with poorer neurological recovery and increased mortality following stroke.

Holter monitoring detected rhythm abnormalities in 33% of patients, with ventricular premature complexes representing the most frequent finding (20%), followed by sinus tachycardia, atrial premature complexes, atrial fibrillation, paroxysmal atrial fibrillation, ventricular bigeminy, sinus pauses, sinus node dysfunction, and non-sustained ventricular tachycardia. Although atrial fibrillation was identified in only a small proportion of patients, its detection is clinically important because previously unrecognized AF may alter secondary stroke prevention by prompting anticoagulation therapy. Similar studies by Alriyami et al., Carrarini et al., and Himmelreich et al. also demonstrated that prolonged cardiac monitoring detects occult atrial fibrillation and other intermittent arrhythmias that are frequently missed on routine ECG, with longer monitoring durations providing higher detection rates.[7,8,9]

Routine ECG was normal in nearly all patients, whereas Holter monitoring revealed clinically relevant rhythm abnormalities in one-third of the cohort, confirming the superior diagnostic yield of continuous monitoring. This finding supports previous evidence that intermittent arrhythmias, particularly paroxysmal atrial fibrillation, may remain undetected on a single ECG recording. Echocardiography demonstrated a high prevalence of diastolic dysfunction (96%) and concentric left ventricular hypertrophy (42%), reflecting the substantial burden of underlying cardiovascular disease among stroke patients. Comparable observations have been reported in earlier studies evaluating stroke-heart syndrome and cardiovascular complications after acute stroke.[11,12]

Despite the relatively high prevalence of Holter-detected rhythm abnormalities, no significant association was observed between arrhythmias and functional outcome ($p=0.539$), stroke subtype ($p=0.124$), vascular territory involvement ($p=0.844$), or lesion laterality ($p=0.729$). Although the distribution of specific arrhythmias varied according to lesion side, the overall presence of arrhythmias was similar across lesion locations. These findings suggest that while rhythm abnormalities are common after stroke, they do not independently predict short-term disability. Similar heterogeneous findings have been reported in previous literature, where the prognostic significance of post-stroke arrhythmias varies depending on study design, duration of monitoring, and patient characteristics.[13,14]

The present study has certain limitations. It was a single-center study with a relatively small sample size, particularly for haemorrhagic stroke, limiting subgroup analyses. Holter monitoring was restricted to 24 hours, and longer-duration monitoring may have detected additional cases of paroxysmal atrial fibrillation. Furthermore, only short-term outcomes at hospital discharge were assessed, precluding evaluation of long-term cardiovascular events and recurrent stroke.

Overall, the present study demonstrates that 24-hour Holter monitoring substantially increases the detection of occult cardiac rhythm abnormalities compared with routine ECG in patients with acute stroke. Ventricular premature complexes were the predominant arrhythmias, while previously undiagnosed atrial fibrillation and other clinically significant conduction abnormalities were also identified. Although these rhythm disturbances were not associated with short-term functional outcome, the findings support the incorporation of Holter monitoring into the routine evaluation of acute stroke patients to improve identification of cardioembolic sources and optimize secondary stroke prevention.

CONCLUSION

Twenty-four-hour Holter monitoring detected cardiac rhythm abnormalities in one-third of patients with acute stroke and demonstrated a substantially higher diagnostic yield than routine electrocardiography. Ventricular premature complexes were the most frequently identified arrhythmias, while previously undiagnosed atrial fibrillation, paroxysmal atrial fibrillation, and occasional conduction abnormalities such as sinus pauses and sinus node dysfunction were also detected, highlighting the value of continuous cardiac monitoring in identifying clinically significant occult rhythm disturbances. Stroke severity at presentation, assessed using the NIHSS and GCS, was a significant predictor of short-term functional outcome, whereas Holter-detected rhythm abnormalities showed no significant association with discharge functional status, stroke subtype, or vascular territory involvement. Overall, these findings support the use of 24-hour Holter monitoring as an important adjunctive investigation in the evaluation of patients with acute stroke to facilitate early detection of occult arrhythmias and guide appropriate secondary stroke prevention strategies.

BIBLIOGRAPHY

1. Donkor ES. Stroke in the 21st century: a snapshot of the burden, epidemiology, and quality of life. Stroke Res Treat. 2018 Nov 27;2018: 3238165
2. Elsheikh S, Almutairi AR, Alotaibi NM. Atrial fibrillation and stroke: state-of-the-art and future directions. J Cardiovasc Med (Hagerstown). 2024;25(2):101–110.
3. Algra A, Gates PC, Fox AJ, Hachinski V, Barnett HJM. Side of Brain Infarction and Long-Term Risk of Sudden Death in Patients with Symptomatic Carotid Disease. Stroke. 2003 Dec;34(12):2871–5.
4. Goldstein DS. The electrocardiogram in stroke: relationship to pathophysiological type and comparison with prior tracings. Stroke. 1979 May;10(3):253–9.
5. LAVY S, YAAR I, MELAMED E, STERN S. The Effect of Acute Stroke on Cardiac Functions as Observed in an Intensive Stroke Care Unit. Stroke. 1974 Nov;5(6):775–80.
6. Kairi SK, Chakrabarti D, Chakraborty D. Spectrum of Cardiac Rhythm Disturbance after Acute Ischemic Stroke using 24 Hours Holter Monitoring. International Journal of Pharmaceutical and Clinical Research Original Research Article [Internet]. 2022;14(10):482–91. Available from: www.ijpcr.com
7. Carrarini C, Di Stefano V, Russo M, Dono F, Di Pietro M, Furia N, et al. ECG monitoring of post-stroke occurring arrhythmias: an observational study using 7-day Holter ECG. Sci Rep. 2022;12:228.
8. Alriyami WB, Sadiq MA, Al Rawahi M, Ahmed S, Al Kindi FA, Khatri MA. The role of 24-hour Holter electrocardiogram in the early detection of atrial fibrillation in newly diagnosed acute ischemic stroke patients. Cureus. 2023;15(11):e48556.
9. Himmelreich JCL, Lucassen WAM, Coutinho JM, Harskamp RE, de Groot JR, van Weert HCPM. 14-day Holter monitoring for atrial fibrillation after ischemic stroke: the yield of guideline-recommended monitoring duration. Cerebrovasc Dis. 2019;47(5-6):285–291.
10. Foo DHP, Fong AYY, Almahmeed W. Detection of atrial fibrillation in patients admitted with ischaemic stroke: a non-systematic review of the Asian population. Open Heart. 2021;8(2):e001697.
11. Scheitz JF, Nolte CH, Doehner W, Hachinski V, Endres M. Stroke-heart syndrome: clinical presentation and underlying mechanisms. Lancet Neurol. 2018 Dec;17(12):1109–1120.
12. Chen Z, Venkat P, Seyfried D, Chopp M, Yan T, Chen J. Brain-heart interaction: cardiac complications after stroke. Circ Res. 2017 Aug 18;121(4):451–468.
13. Wang L, Ma L, Ren C, Zhao W, Ji X, Liu Z, Li S. Stroke–heart syndrome: current progress and future outlook. J Neurol. 2024;271(8):4813-4825
14. Hassan MS, Waberi MM, Sidow NO, Hassan MO, Akyüz H, Abdi IA, et al. Analysis of echocardiographic findings of patients with acute ischemic stroke admitted to a tertiary care hospital in Mogadishu, Somalia. Int J Gen Med. 2023; 16:2887-2895