DOI: https://doi.org/10.54393/pjhs.v7i2.3524

PAKISTAN JOURNAL OF HEALTH SCIENCES
(LAHORE)
https://thejas.com.pk/index.php/pjhs
ISSN (E): 2790-9352, (P): 2790-9344
Volume 7, Issue 02 (February 2026)

Original Article

OPEN ACCESS

Effectiveness of Holter Monitoring in the Detection of Atrial Fibrillation after Ischemic Stroke

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ARTICLE INFO

Keywords:
Atrial Fibrillation, Ischemic Stroke, Holter Monitoring, Paroxysmal Atrial Fibrillation

How to Cite:
Rahman, H. U., Hashmat, A., Mustafa, M., Rehman, W., Khan, T., & Tahir, F. (2026). Effectiveness of Holter Monitoring in the Detection of Atrial Fibrillation after Ischemic Stroke: Holter Monitoring in the Detection of Atrial Fibrillation after Ischemic Stroke. Pakistan Journal of Health Sciences, 7(2), 26-31. https://doi.org/10.54393/pjhs.v7i2.3524

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Received Date: 15th October, 2025
Revised Date: 2nd January, 2026
Acceptance Date: 9th January, 2026
Published Date: 28th February, 2026

ABSTRACT

Atrial fibrillation (AF) is an important but often hidden cause of recurrent ischemic stroke, requiring early detection for timely anticoagulation. This study assessed the effectiveness of 72-hour Holter monitoring in identifying previously undiagnosed AF in acute ischemic stroke patients, particularly in resource-limited settings. **Objectives:** To determine the effectiveness of 72-hour Holter monitoring in identifying previously undiagnosed AF in acute ischemic stroke patients. **Methods:** This analytical cross-sectional study was conducted at the Department of Neurology, Pak Emirates Military Hospital, Rawalpindi, from May to September 2025, enrolling 256 patients with neuroimaging-confirmed ischemic stroke. Holter monitoring was initiated within 2 hours of admission and continued for 72-hours, accompanied by 8-hourly pulse checks and symptom logs to identify AF episodes lasting ≥30 seconds. Chi-square or Fisher's exact tests were used, keeping p≤0.05 statistically significant. **Results:** The mean age was 65.4±11.2 years; 59.4% were male. AF was detected in 17 patients (6.6%), with 72-hour Holter yielding significantly higher detection than baseline ECG (17(6.6%) vs.5(2.0%), p=0.002, with diagnostic accuracy of 95.3%. Cumulative detection increased over time: 29.4% within 24 hours, 70.6% by 48 hours, and 100% by 72 hours. AF was significantly associated with age ≥65 years (p=0.008), hypertension (p=0.047), and diabetes (p=0.029). **Conclusions:** 72-hour Holter monitoring is a useful non-invasive method of correctly detecting occult AF in patients after acute ischemic stroke, with superior diagnostic yield over baseline ECG. These results favor routine use of 72-hour Holter monitoring as part of post-stroke protocols.

INTRODUCTION

Ischemic stroke continues to be a major cause of morbidity and mortality globally, with atrial fibrillation (AF) recognized as an important modifiable risk factor in about 20-30% of cases [1]. AF, particularly paroxysmal forms, often goes undetected prior to stroke events, underscoring the need for effective post-stroke cardiac rhythm monitoring to guide anticoagulant therapy and prevent recurrence [2]. Holter monitoring, an ambulatory electrocardiography that is not invasive, has become a vital diagnostic tool for occult AF detection in this group, with longer durations having the potential to increase yield compared to standard 24-hour monitoring [3]. The AF detection background after ischemic stroke outlines how difficult subclinical or paroxysmal occurrence is to detect, sometimes not shown on routine electrocardiograms (ECGs) [4]. Current European Stroke Organization guidelines suggest monitoring of at least 48-72 hours in selected patients, but optimal duration and timing are controversial [5]. Detection rates have been shown to vary according to the length of monitoring and the characteristics of the patient in studies. For example, 7-day outpatient cardiac rhythm monitoring has identified new AF in 6.4 % of patients with ischemic stroke or transient ischemic attack (TIA) of undetermined etiology, with increased yield in diabetic or older patients [6]. In a similar way, 7-day wearable devices revealed an 8.7%

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detection rate in AF patients without a previous history of AF, beating traditional 7-day Holter in certain cohorts by facilitating earlier detection and treatment [7]. Long-term strategies, including insertable cardiac monitors, achieve better long-term detection versus short-term Holter (e.g., 24-48 hours), reducing stroke recurrence with timely anticoagulation, though at greater invasiveness [8]. Timing also matters; early inpatient 48-hour Holter recordings in patients with embolic stroke of undetermined source (ESUS) identify a 20% detection rate for previously undiagnosed AF, much higher than with delayed outpatient monitoring (5%), emphasizing the importance of early evaluation [9]. This study favors the use of extended Holter but underlines the necessity for context-dependent data, especially in resource-poor environments. This study addresses the critical gap in detecting AF, a major modifiable risk factor for ischemic stroke, which is often missed on routine ECG. Extended 72-hour Holter monitoring has shown superior diagnostic yield internationally, but local data are lacking, particularly in resource-limited hospital settings.

Despite guideline recommendations and growing evidence supporting extended cardiac rhythm monitoring, a substantial proportion of atrial fibrillation cases after ischemic stroke remain undetected when relying on routine ECG or short-duration Holter monitoring. There is a paucity of local, context-specific evidence evaluating the diagnostic yield of prolonged (72-hour) Holter monitoring for AF detection in post-stroke patients, particularly within resource-limited hospital settings. This study aimed to evaluate the diagnostic yield of prolonged Holter monitoring in detecting previously unrecognized AF after ischemic stroke, providing critical data to guide clinical decision-making and reduce recurrent stroke risk in the local population.

METHODS

This analytical cross-sectional study was carried out at the Department of Neurology, Pak Emirates Military Hospital, Rawalpindi, Pakistan, from May to September 2025. Ethical approval was obtained from the hospital under reference number A/28/ERC/03/2025. The Sample size was determined to be 256 patients, through OpenEpi sample size software as n = $DFFF.N.p(1\text{-}p) / d^2/Z^2_{1-\alpha/2}. (N\text{-}1) + p(1\text{-}p)$, keeping anticipated frequency of AF among ischemic stroke patients as 6.4% [6], confidence level of 95%, and 3% margin of error. The inclusion criteria were patients aged 18-85 years of either gender diagnosed with acute ischemic stroke through clinical evaluation and neuroimaging (computed tomography or magnetic resonance imaging) and no previously known history of AF. Patients with contraindications for Holter monitoring (e.g., skin conditions prohibiting electrode application), patients with severe comorbidities that would interfere with study participation (e.g., advanced cancers or terminal diseases), and patients with established pre-existing AF were excluded. All eligible patients after written consent underwent a standard 12-lead electrocardiogram (ECG) on admission, within 2 hours of hospital presentation, using a GE MAC 5500 ECG system (GE Healthcare, USA). ECGs were recorded at a paper speed of 25 mm/s and an amplitude of 10 mm/mV. A cardiologist interpreted all baseline ECGs for the presence of AF or other arrhythmias. Baseline ECG parameters, including rhythm classification (sinus rhythm or AF) and heart rate, were documented for each patient. Following baseline ECG, patients underwent continuous 72-hour Holter monitoring (initiated within 2 hours of admission) using the GE SEER 12 Holter system (GE Healthcare, USA). Recordings were obtained with three-channel ECG leads (V1, V3, V5) placed according to the modified Mason-Likar configuration, at a sampling rate of 200 Hz. AF episodes were defined as irregular R-R intervals without distinct P waves lasting ≥30 seconds, consistent with established guidelines [10]. All recordings were analyzed with GE MARS 8.1 Holter analysis software, with automatic detection confirmed by a cardiologist. Standard artifact rejection, filtering, and detection thresholds were applied according to manufacturer guidelines to ensure data reproducibility. During the monitoring interval, pulse rhythm was manually checked every 8 hours by neurology residents, and patients recorded any cardiac complaints (e.g., palpitations, presyncope) or hemodynamic instability (e.g., systolic BP variations >40 mmHg) in hourly symptom logs. All clinical observations were time-stamped and correlated with Holter recordings. The effectiveness of 72-hour Holter monitoring was defined as its ability to detect previously unrecognized AF compared to baseline ECG and clinical monitoring. Effectiveness was quantified by the number of newly detected AF cases or additional AF cases identified beyond baseline ECG, and diagnostic accuracy. Demographic and clinical data, including age, gender, and comorbidities (diabetes mellitus, hypertension, and ischemic heart disease), were collected through structured interviews and clinical records. Data were analyzed using IBM SPSS version 27.0. Continuous data like age and monitoring time were reported as mean ± standard deviation after normality was checked by the Shapiro-Wilk test. Categorical data like gender, comorbidities, Holter initiation delay, and AF detection rate were reported as frequencies and percentages. Potential modifiers of effect (gender, age, comorbidities, and delay in Holter monitoring) were adjusted by stratification. Post-stratification was compared by the Chi-square test or Fisher's exact test as deemed appropriate, with a p-value ≤0.05 being statistically significant.

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RESULTS

This study included 256 ischemic stroke patients with a mean age of 65.4 ± 11.2 years (range: 32–85), of whom 152 (59.4%) were male. Hypertension was the most common comorbidity (70.3%, n=180), followed by diabetes mellitus (39.8%, n=102) and ischemic heart disease (25.0%, n=64). The mean time from presentation to Holter initiation was 2.8 ± 0.9 hours (Table 1).

Table 1: Baseline Characteristics of Study Participants (n=256)

Variables		Mean ± SD, n (%)
Age	Years	65.4 ± 11.2
Gender	Male	152 (59.4%)
	Female	104 (40.6%)
Comorbidities	Hypertension	180 (70.3%)
	Diabetes	102 (39.8%)
	Ischemic Heart Disease	64 (25.0%)
Time to Holter Initiation	Hours	2.8 ± 0.9

The effectiveness of 72-hour Holter monitoring was evaluated by its ability to detect previously unrecognized AF in acute ischemic stroke patients. Baseline ECG identified AF in 5 (2.0%) patients, whereas 72-hour Holter monitoring detected AF in 17 (6.6%) patients, uncovering 12 (4.7%) additional cases that were missed initially. McNemar's test showed a statistically significant difference between the two diagnostic methods (p = 0.002), confirming that extended Holter monitoring has a superior diagnostic yield for detecting previously unrecognized AF. Most AF episodes (82.4%, n=14) lasted 30 seconds to 5 minutes, while 3 exceeded 5 minutes. The diagnostic accuracy of the 72-hour Holter was 95.3%, indicating that prolonged monitoring is a reliable tool for identifying new-onset AF in acute ischemic stroke patients (Table 2).

Table 2: Newly Diagnosed Atrial Fibrillation on Baseline ECG vs 72-Hour Holter Monitoring (n=256)

AF Detection Method	n (%)	p-value (McNemar Test) for ECG vs Holter
Baseline ECG	5 (2.0%)	0.002*
72-Hour Holter Monitoring	17 (6.6%)	
Additional AF Cases Identified by Holter	12 (4.7%)	–
Diagnostic Accuracy of 72-Hour Holter Monitoring	95.3%	–

*p-value= 0.002<0.05 is significant, calculated through the McNemar test

5 (29.4%) AF cases were detected within 24 hours, 7 (41.2%) between 24–48 hours, and 5 (29.4%) between 48–72 hours. Nearly 70% of AF cases would have been missed with only 24-hour monitoring, highlighting the value of prolonged assessment (Figure 1).

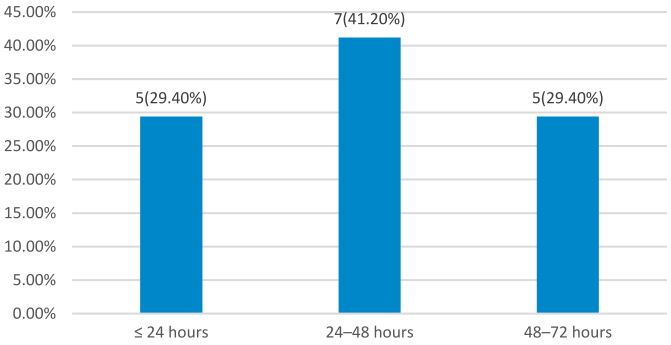

Figure 1: Percentage of Detection of Atrial Fibrillation Over 72-Hour Holter Monitoring

AF was significantly associated with patients aged ≥65 years, 14/120 (11.7%) (p=0.008). Hypertensive patients 15/180 (8.3%), and diabetic patients AF detection (6/64, 9.4% vs 11/192, 5.7%, p=0.029). No significant associations were observed with gender (p=0.661), ischemic heart disease (p=0.299), or delay in Holter initiation >2 hours (p=0.802) (Table 3).

Table 3: Association of Atrial Fibrillation Detection with Clinical and Demographic Characteristics (n=256)

Stratification Variables		AF Detected, n (%)	No AF, n (%)	p-value
Age	<65 Years (n=136)	3 (2.2%)	133 (97.8%)	0.008[a*]
	≥65 Years (n=120)	14 (11.7%)	106 (88.3%)	
Gender	Male (n=152)	11 (7.%2)	141 (92.8%)	0.661[a]
	Female (n=104)	6 (5.8%)	98 (94.2%)	
Hypertension	Yes (n=180)	15 (8.3%)	165 (91.7%)	0.047[b*]
	No (n=76)	2 (2.6%)	74 (97.4%)	
Diabetes Mellitus	Yes (n=64)	6 (9.4%)	58 (90.6%)	0.029[a*]
	No (n=192)	11 (5.7%)	181 (94.3%)	
Ischemic Heart Disease	Yes (n=64)	6 (9.4%)	58 (90.6%)	0.299[a]
	No (n=192)	11 (5.7%)	181 (94.3%)	
Delay in Holter (>2 Hours)	Yes (n=112)	8 (7.1%)	104 (92.9%)	0.802[a]
	No (n=144)	9 (6.3%)	135 (93.7%)	

[a]Chi-square test, [b]Fisher's exact test, as appropriate; * p-value ≤0.05 considered statistically significant

DISCUSSION

This study demonstrated that 72-hour Holter monitoring is an effective tool for detecting AF in patients with acute ischemic stroke (6.6% of cases). This detection rate is consistent with prior studies, such as a systematic review reporting a 6.27% prevalence of AF among stroke patients, with higher yields linked to prolonged monitoring [11]. Similarly, Bisson et al. observed new-onset AF in 5.9% of patients without prior AF after stroke, underscoring the importance of early cardiac rhythm evaluation [12]. Our higher detection rate compared to certain cohorts may relate to the early initiation of Holter monitoring within 4 hours of admission. The incremental diagnostic advantage of prolonged Holter monitoring over baseline ECG in our study (6.6% vs. 2.0%, p=0.002) highlights the value of

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extended surveillance for paroxysmal AF episodes. Comparable evidence shows that extending monitoring beyond 24 hours substantially improves detection rates. For instance, AF was identified in 4.5% of patients after 48 hours of Holter monitoring, while smartphone-based monitoring yielded even higher rates of 8.3% [13]. Dussault *et al.* similarly reported a three-fold increase in AF detection with extended monitoring compared to routine 24-hour assessment. Meta-analytic evidence also supports this, showing AF detection of 5.1% with ≤72 hours monitoring compared to 15% with ≥7 days [14]. Our findings align with this growing body of evidence that short-term ECG alone is insufficient and prolonged monitoring strategies are warranted. The temporal pattern of AF detection in our cohort further underscores the shortcomings of 24-hour monitoring. Only 29.4% of AF cases were detected in the first 24 hours, while 70.6% required the full 72 hours, consistent with prior work highlighting the incremental benefit of prolonged observation [15]. Enhanced monitoring approaches, such as 10-day Holter ECG or patch-type devices, have been shown to increase detection rates to 13.5% within six months [16]. Kwon *et al.* also reported that 72-hour adhesive patch monitoring increased AF detection by 1.6-fold compared with 24-hour Holter, particularly improving paroxysmal AF detection [17]. This study also identified significant associations between AF detection and clinical risk factors. Older age, hypertension, and diabetes mellitus were strongly linked to higher AF prevalence, in line with prior studies. For instance, Uhe *et al.* reported that AF detection rates rose from 6% in patients under 60 years to as high as 65% in those over 80 years using implantable monitors [18]. Similarly, Halimi *et al.* demonstrated that older age and hypertension were significantly associated with AF during 14-day continuous monitoring [19]. Diabetes and increasing comorbidity burden have also been identified as independent predictors of AF [6]. The clinical implications of these findings are significant. Continuous monitoring strategies, including wearable patches and implantable cardiac monitors, have demonstrated meaningful impacts on patient management, including the initiation of anticoagulation therapy and reductions in recurrent stroke risk [20]. These study findings support the incorporation of routine 72-hour Holter monitoring into post-stroke care, particularly in resource-constrained settings where longer-term or invasive monitoring is less feasible. Evidence also suggests that quality improvement initiatives using prolonged monitoring can increase AF detection and lead to more timely interventions [21].

Despite these strengths, our study has limitations. Being a single-center, and cross-sectional study limited its generalizability. The absence of long-term follow-up precludes assessment of recurrent stroke or the effectiveness of anticoagulation therapy. Furthermore, although 72-hour monitoring improves detection, very brief or late paroxysmal AF episodes may still be missed, as longer-term monitoring or implantable devices provide higher yields.

CONCLUSIONS

Seventy-two-hour Holter monitoring is a useful non-invasive method of correctly detecting occult AF in patients after acute ischemic stroke, with superior diagnostic yield over baseline ECG. These results favor routine use of 72-hour Holter monitoring as part of post-stroke protocols, especially in settings with limited resources, for early anticoagulant therapy initiation and prevention of recurrent stroke.

Authors' Contribution

Conceptualization: AH
Methodology: HUR, AH
Formal Analysis: AH, TK
Writing and Drafting: AH, MM, WR, FT
Review and Editing: HUR, AH, MM, WR, TK, FT

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.

Source of Funding

The author received no financial support for the research, authorship and/or publication of this article.

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