

REVIEW ARTICLE

The application of holter monitoring in the diagnosis of atrial fibrillation and its significance in the context of ischemic strokes

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ABSTRACT

Aim: This study aims to evaluate the effectiveness of prolonged Holter monitoring in detecting atrial fibrillation (AF) and other arrhythmias in patients following ischemic stroke. We seek to establish the optimal duration of monitoring that maximizes detection rates while considering clinical feasibility and cost-effectiveness.

Materials and Methods: We conducted a systematic review of recent literature, analyzing data from randomized clinical trials and observational studies that assessed the yield of AF detection through various durations of Holter monitoring. Key metrics included detection rates of AF and other relevant arrhythmias, along with patient outcomes related to therapeutic interventions initiated based on monitoring results.

Conclusions: This review highlights the crucial role of prolonged Holter monitoring, particularly 7-day monitoring, in detecting paroxysmal atrial fibrillation (AF) among ischemic stroke survivors, especially those with cryptogenic strokes. Extended monitoring significantly improves AF detection, enabling timely anticoagulation therapy and better stroke prevention. While challenges like patient compliance and cost-effectiveness remain, integrating prolonged Holter monitoring into standard care could enhance diagnostic accuracy and reduce recurrent stroke risk.

KEY WORDS: Holter monitoring, ischemic stroke, atrial fibrillation, stroke prevention, cardiac arrhythmias, cryptogenic stroke

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INTRODUCTION

Atrial fibrillation (AF) is recognized as the most prevalent cardiac arrhythmia, significantly contributing to the burden of cardiovascular morbidity and mortality worldwide [1]. The relationship between AF and ischemic stroke is well-established, as AF is a major risk factor for thromboembolic events that can lead to debilitating strokes [2, 3]. Despite advancements in diagnostic techniques, the timely detection of AF, particularly in patients presenting with cryptogenic stroke, remains a formidable challenge in clinical practice.

Ischemic strokes, which account for a substantial proportion of all strokes, are characterized by a sudden disruption of blood flow to the brain, leading to neurological deficits [4]. Among the various subtypes of ischemic stroke, cardioembolic strokes are particularly concerning due to their association with AF [5]. Current estimates suggest that a significant percentage of ischemic strokes are of undetermined origin, often classified as cryptogenic strokes [6]. In this context, the role of continuous cardiac monitoring, particularly through Holter monitoring, has garnered increased attention as a viable strategy for identifying episodes of AF that may have contributed to the stroke event [3]. Holter monitoring, a non-invasive technique that allows for continuous recording of electrocardiographic (ECG) data, has emerged as a critical tool in the assessment of patients with suspected arrhythmias. The ability of Holter monitors to capture transient AF episodes is paramount in guiding therapeutic decisions and initiating appropriate anticoagulation strategies to mitigate the risk of recurrent strokes [3]. However, the efficacy of Holter monitoring in detecting AF varies significantly with the duration of monitoring, highlighting the need for prolonged observation periods to enhance diagnostic yield [7].

In this chapter, we will explore the advancements in Holter monitoring technology, its clinical applications in the context of ischemic stroke, and the implications of AF detection for patient management. Through an examination of current evidence and guidelines, we aim to elucidate the critical role of extended cardiac monitoring in improving outcomes for patients with stroke and potential underlying AF, ultimately contributing to enhanced stroke prevention strategies.

AIM

The primary aim of this study is to evaluate the effectiveness of Holter monitoring in detecting atrial fibrillation (AF) and other arrhythmias in patients who have experienced ischemic strokes, with a particular focus on cryptogenic strokes. By examining the diagnostic yield of various durations of Holter monitoring, this research seeks to determine the optimal monitoring period that maximizes the detection of clinically significant arrhythmias while remaining feasible and cost-effective.

MATERIALS AND METHODS

A comprehensive literature review was conducted using PubMed and Google Scholar databases to investigate the use of Holter monitoring in detecting atrial fibrillation (AF) in ischemic stroke patients. The search focused on studies published from 2018 onward, while also considering older key publications. Keywords such as *Holter monitoring, atrial fibrillation, ischemic stroke, AF detection,* and *cardiac monitoring* were employed to ensure the identification of relevant articles.

Studies included in the review were selected based on their relevance to AF detection via Holter monitoring in ischemic stroke patients, covering a range of study designs such as clinical trials, observational studies, and systematic reviews. Recent clinical guidelines from organizations like the European Society of Cardiology (ESC) were also consulted to align the review with current best practices.

Studies were excluded if they were not focused on human subjects, did not use Holter monitoring for AF detection, or were unrelated to ischemic stroke. Animal studies, non-peer-reviewed articles, case reports, and conference abstracts were also excluded. Additionally, studies in languages other than English were not considered due to language limitations in data analysis.

This approach ensured a comprehensive and up-to-date synthesis of the role of Holter monitoring in ischemic stroke patients.

REVIEW AND DISCUSSION

HOLTER MONITORING: TECHNOLOGY AND APPLICATIONS

Holter monitoring is a crucial technology in modern medicine and is indispensable for the diagnosis of numerous arrhythmias. In recent years, significant advancements have been made in its development. The advancement of technology has enabled the creation of compact, lightweight (approximately 50 g) portable tape recorders capable of continuously recording over 24 hours of electrocardiographic (ECG) data, capturing more than 100,000 heartbeats. In comparison, conventional ECG recordings over an equivalent timeframe would require nearly a mile of ECG paper [8].

The Holter monitor has a wide range of applications, primarily used for detecting arrhythmias that occur intermittently and are often not visible on standard ECG recordings due to their brief duration. However, it is not suitable for long-term (over 7 days) cardiac rhythm monitoring, which is better achieved using external and internal loop recorders and wearable devices [2].

The diagnostic capabilities of Holter monitoring can be tailored to specific clinical needs by adjusting the number of leads utilized. The number of leads in Holter monitoring plays a significant role in its diagnostic accuracy and scope [9]. 2 to 3 leads are sufficient to monitor heart rate and rhythm [10]. In contrast, if the purpose is to establish the origin of premature beats/dysrhythmias or tachycardia, then a 12-lead Holter electrocardiography is verry accurate and it can instantly diagnose supraventricular tachycardia (SVT), ventricular tachycardia (VT), atrial flutter, atrial fibrillation, monomorphic or Polymorphic VTs, long QT syndrome, supraventricular premature complexes, ventricular premature complexes, dominant atrioventricular accessory pathways, atrioventricular block, right and left bundle branch block, and left anterior and posterior fascicular block [9-11].

PATHOPHYSIOLOGY OF ISCHEMIC STROKE AND CARDIAC IMPLICATIONS

Ischemic strokes represent one of the most critical global health challenges, being a leading cause of disability without curative therapies currently available [4]. According to estimates from 2016, stroke was associated with approximately 5.5 million deaths worldwide, with one-fifth of these deaths attributable to cardiovascular causes [12]. In Poland, ischemic strokes account for 88% of all strokes, emphasizing their prominence in clinical practice [5]. These strokes are broadly classified into lacunar strokes, caused by small vessel disease, and non-lacunar strokes, which make up the majority. Of the non-lacunar strokes, approximately 35% are cardioembolic in origin, while 45% are cryptogenic, underscoring the substantial diagnostic and therapeutic challenges posed by these subtypes [5].

Cryptogenic strokes, defined as strokes of undetermined origin, account for an estimated 20–40% of all ischemic strokes [6]. Paroxysmal atrial fibrillation (AF), considered the most common underlying cause of cryptogenic strokes, is associated with a significant risk of thrombus formation in the left atrium or left atrial appendage. These thrombi, once dislodged, can travel to the brain, causing cardioembolic strokes that are typically more severe and linked to higher morbidity and mortality compared to other stroke subtypes [3, 13, 14]"URL":"https://www.thelancet.com/journals/laneur/article/PIIS1474-4422(17. However, paroxysmal AF, often referred to as silent AF in the literature, is particularly difficult to diagnose in ischemic stroke patients due to its asymptomatic nature. As a result, detecting this arrhythmia requires advanced and often prolonged monitoring strategies, as many patients do not exhibit noticeable symptoms until a major event, such as a stroke, occurs [15]by using a 7-day Holter ECG which has proved to be superior to the standard 24-h recording, and to evaluate the possible association between brain lesions and arrhythmias. One hundred and twenty patients with cryptogenic ischemic stroke underwent clinical and neuroimaging assessment and were monitored with a 7-day Holter ECG. Analysis of the rhythm recorded over 7 days was compared to analysis limited at the first 24 h of monitoring. 7-day Holter ECG detected AF in 4% of patients, supraventricular extrasystole (SVEB.

Evidence from the reviewed studies indicates that device-detected atrial fibrillation (AF) correlates with stroke risk across a broad range of episode durations in older adults [16]. Several studies documented that very short episodes - as brief as 30 seconds or 5 minutes - are associated with significantly elevated risk, with hazard ratios ranging from 1.76 to 4.41 and a relative risk near 2.49 [16]. Intermediate durations - typically 1 hour up to 5.5 hours—are linked with hazard and odds ratios between 2.11 and 4.2 [16]. Extended episodes, particularly those exceeding 23 hours, show the highest risk estimates (*odds ratio* around 5.00), especially when considered alongside factors such as the CHA2DS2-VASc score. [17]

While cardioembolism is a well-established and extensively documented cause of ischemic stroke, the intricate relationship between stroke and subsequent cardiovascular events is an area of ongoing investigation. Emerging data suggest that ischemic stroke may disrupt the autonomic nervous system, leading to dysregulation of heart rate and blood pressure. This autonomic imbalance, characterized by alterations in sympathetic and parasympathetic activity, is supported by evidence of impaired heart rate variability and increased catecholamine release, which can affect myocardial receptors [15]by using a 7-day Holter ECG which has proved to be superior to the standard 24-h recording, and to evaluate the possible association between brain lesions and arrhythmias. One hundred and twenty patients with cryptogenic ischemic stroke underwent clinical and neuroimaging assessment and were monitored with a 7-day Holter ECG. Analysis of the rhythm recorded over 7 days was compared to analysis limited at the first 24 h of monitoring. 7-day Holter ECG detected AF in 4% of patients, supraventricular extrasystole (SVEB. Notably, certain brain regions, including the insula and temporal and parietal lobes, have been implicated in the development of new arrhythmias following stroke [18, 19]. These findings suggest that brain-heart interactions may play a significant role in post-stroke cardiovascular complications.

Further complicating the clinical picture is the lack of a consistent temporal relationship between thromboembolic events and arrhythmias, as highlighted by findings from the TRENDS study [20]. This disconnect creates diagnostic challenges in identifying the true cause of ischemic strokes and raises questions about the mechanistic pathways linking arrhythmias to embolic events. As a result, the precise causality in many cases of ischemic stroke remains elusive, emphasizing the need for additional research to improve diagnostic accuracy and guide therapeutic decision-making.

In conclusion, ischemic stroke remains a multifaceted clinical entity, with cardioembolic and cryptogenic subtypes posing significant diagnostic challenges. The interplay between arrhythmias, embolic mechanisms, and post-stroke cardiovascular changes underscores the complexity of stroke pathophysiology. Future studies are essential to unravel these connections, refine diagnostic strategies, and optimize patient outcomes.

EVIDENCE SUPPORTING ECG MONITORING AFTER ISCHEMIC STROKE

After an ischemic stroke, one of the primary objectives in patient management is to prevent recurrent stroke. Achieving this goal necessitates identifying the underlying cause of the stroke. In cases of cryptogenic stroke, stroke specialists often suspect that a significant proportion of these events are caused by subclinical atrial fibrillation (AF) [1]. Detecting AF is crucial, as it allows the timely initiation of oral anticoagulation therapy, which has demonstrated a highly favorable therapeutic effect in significantly reducing the risk of recurrent stroke. The detection of AF relies on cardiac rhythm monitoring through devices capable of recording elec-

Table 1. Comparison of AF detection rates across different monitoring durations [22-25]

Monitoring Duration	AF Detection Rate
24-Hour Holter	1-6%
48-Hour Holter	5-10%
7-Day Holter	10-15%
30-Day Event Monitoring	25-50%

trocardiographic (ECG) data. Early identification of AF is therefore pivotal for improving patient outcomes [3].

Several methods are available for detecting atrial fibrillation, including standard ECG at hospital admission, serial in-hospital ECG recordings, telemetry, inpatient or outpatient Holter monitoring, and external ambulatory ECG recorders, such as wearable devices or implantable loop recorders (ILRs) [21]. Each of these techniques offers unique advantages and limitations, presenting a significant challenge in clinical practice regarding the selection of the most appropriate method for individual patients [8].

Alternative strategies to improve AF detection include prolonged Holter monitoring, telemetry-based ECG, and patient-activated external recorders. While these methods offer non-invasive or minimally invasive solutions, their accessibility and availability remain inadequate in many healthcare settings [8]. Expanding access to advanced monitoring technologies could greatly enhance the ability to identify AF and improve the care provided to patients following ischemic stroke [21].

Implantable monitoring devices, while highly effective for long-term monitoring and the detection of AF, are associated with invasive procedures and higher costs. These factors often limit their use to select patient populations [21]. In contrast, Holter monitoring is a non-invasive, widely accessible, and cost-effective method. However, its optimal application for stroke patients remains a topic of ongoing debate [6]. Efforts to enhance its utility focus on determining the most effective duration and protocol to maximize AF detection while maintaining feasibility and cost-efficiency [8].

Despite guideline recommendations advocating for prolonged ECG monitoring, typically 48–72 hours, many clinical practices still rely on 24-hour Holter monitoring. This standard approach significantly limits the detection of paroxysmal AF in stroke patients, potentially missing cases that could benefit from therapeutic intervention. [3] Implantable loop recorders are considered the most effective option for detecting subclinical AF due to their ability to monitor cardiac rhythm over extended periods. However, their widespread implementation is constrained by their invasive nature and high cost [21].

In conclusion, the choice of an optimal monitoring method for AF detection in stroke patients must balance efficacy, accessibility, and patient safety (Table1). Non-invasive methods, such as extended Holter monitoring, hold promise as cost-effective and practical solutions. However, improving the availability of advanced techniques, such as wearable ECG recorders or implantable devices, may further enhance diagnostic accuracy and enable timely therapeutic interventions, ultimately reducing the risk of recurrent stroke.

EXTENDED MONITORING WITH HOLTER EXAMINATION

The detection of atrial fibrillation (AF) in stroke survivors remains a critical challenge, particularly due to the limited effectiveness of short-term cardiac monitoring. Evidence suggests that standard 24-hour Holter monitoring demonstrates a relatively low detection rate for AF, identifying arrhythmias in only 1–2% of patients. For instance, Jabaudon et al. reported a detection rate of 5% with 24-hour Holter monitoring, while extending the monitoring duration to seven days identified an additional 5.7% of cases [6, 26]. This highlights the limitations of short-term monitoring and underscores the value of extended observation periods.

Numerous studies have consistently demonstrated that the yield of AF detection increases with prolonged cardiac rhythm monitoring. However, despite this clear trend, the optimal maximum duration of monitoring remains uncertain [21]. Prolonged monitoring carries potential resource and cost-effectiveness implications, particularly given diminishing returns with excessively extended durations. Current guidelines recommend a minimum of 24 hours of cardiac monitoring following a stroke, but extended monitoring for durations exceeding 48 hours is strongly suggested, particularly in patients with ischemic stroke or transient ischemic attack (TIA) of undetermined origin [27].

Randomized clinical trials further emphasize the benefits of extended cardiac monitoring. Longer durations significantly increase AF detection rates compared to standard practices. For example, one randomized study found that in patients aged 55 years or older with cryptogenic ischemic stroke or TIA within the previous six months, AF lasting at least 30 seconds was detected in 16.1% of those monitored with a 30-day event recorder versus 3.2% in the standard monitoring group. This finding, supported by a 95% confidence interval (CI) of 8.0–17.6% and a p-value of <0.001, underscores the value of prolonged monitoring in identifying clinically significant arrhythmias [5].

Ambulatory 7-day Holter monitoring has emerged as a particularly effective approach for detecting previously unidentified AF. Among patients with embolic stroke of undetermined source (ESUS), this method detected AF in 6.8% of cases (95% CI: 4.1–11.1%), compared to standard 24-hour Holter monitoring. Notably, the median time to the first documented episode of AF during 7-day monitoring was approximately 50 hours, emphasizing the importance of extending monitoring beyond the standard 24-hour period [28].

Prolonged monitoring also outperforms guideline-recommended 72-hour recording durations. For instance, three 10-day Holter recordings yielded higher detection rates for AF compared to standard procedures. Furthermore, intermittent 21-day ECG screening demonstrated superiority over 48-hour Holter monitoring, with detection rates of 11.4% *vs.* 2.8% (p=0.001) [21, 29]. Transtelephonic ECG monitoring represents another effective alternative, identifying paroxysmal AF in 9.2% of patients following a recent stroke or TIA who had negative 24-hour Holter results.

Repeated Holter monitoring also offers substantial benefits. In patients aged 60 years or older with recent strokes, repeated monitoring identified AF in 14% of cases compared to 5% with a single round of monitoring (p=0.002) [21, 30]. Similarly, 14-day ECG patches demonstrated superior detection rates for cardiac arrhythmias compared to 24-hour Holter monitoring, with detection rates of 69.9% *vs.* 21.7%, respectively. Another study found that 66% of patients with paroxysmal AF were diagnosed using a 14-day ECG patch, compared to only 9% with 24-hour Holter monitoring [7, 31].

The current guidelines do not specify which subgroups of stroke patients should undergo extended cardiac monitoring, highlighting the need to identify high-risk populations [27]. Such targeted strategies could optimize resource utilization and improve patient outcomes. Notably, age serves as a significant demographic factor, as older patients are more likely to experience cardiac arrhythmias, such as atrial fibrillation (AF), which are more easily detected through prolonged monitoring. Studies have indicated that older adults present with more comorbidities, including hypertension and heart failure, thus enhancing the diagnostic yield of Holter monitoring [32]. Moreover, clinical characteristics significantly impact the effectiveness of Holter monitoring. Patients with symptomatic arrhythmias, especially those presenting with palpitations or unexplained syncope, show higher rates of relevant arrhythmia detection [33]. Extended monitoring has proven especially useful in post-procedural settings, where arrhythmic events are common due to underlying cardiomyopathies or recent surgeries, leading to improved diagnostic outcomes [34]. Furthermore, the evaluation of patients with cryptogenic stroke has highlighted a higher detection rate of AF in those who received prolonged monitoring, emphasizing the importance of targeted monitoring in high-risk populations [23].

Although initial evidence suggests the potential utility of biomarkers, including brain natriuretic peptide (BNP), left atrial diameter (LAD), and the frequency of atrial premature contractions (APCs), their routine use in clinical practice is not yet fully justified. These biomarkers may, however, provide critical insights to guide decisions regarding extended cardiac monitoring. Further research is needed to validate their clinical applicability and establish standardized protocols. In patients with transient ischemic attack (TIA) or cryptogenic stroke, prolonged ECG monitoring lasting beyond 48 hours is strongly recommended, ideally initiated during hospitalization [21]. Supplementing inpatient monitoring with outpatient follow-up can significantly improve AF detection rates, facilitating timely therapeutic interventions. Notably, the identification of arrhythmias lasting at least 30 seconds should prompt the initiation of anticoagulant therapy [21].

LONG-TERM MONITORING WITH A HOLTER RECORDER

The detection of atrial fibrillation (AF) long after an ischemic stroke does not necessarily indicate that the prior stroke was caused by subclinical AF, as the likelihood of developing arrhythmias increases with age [21]. Nevertheless, long-term cardiac rhythm monitoring appears critical in this patient population to identify potential episodes of paroxysmal AF that might have clinical relevance. While standard 24-hour Holter monitoring remains a valuable tool, its effectiveness in detecting paroxysmal AF is limited [29]. Emerging technologies, such as ambulatory devices and implantable rhythm recorders, offer greater detection efficacy due to their capacity for prolonged monitoring, significantly enhancing the identification of arrhythmias [7].

Extended monitoring approaches, including telemetry and implantable loop recorders (ILRs), have demonstrated particular efficacy in detecting AF in patients with cryptogenic stroke [29, 35, 36]. These methods are especially beneficial for high-risk patients, such as those with elevated CHA_2DS_2-VASc scores, as they enhance the likelihood of capturing clinically significant arrhythmias [7, 37].

Despite the effectiveness of extended monitoring, alternative methods, such as implantable loop recorders, offer even higher sensitivity. However, these techniques are less accessible and may not be cost-effective for routine use [21]. The 7-day Holter ECG remains a non-invasive, cost-efficient, and practical approach, providing substantial benefits in AF detection rates. This method allows for timely therapeutic interventions, particularly anticoagulation, which is critical for reducing the risk of recurrent strokes [38].

COST-EFFECTIVENESS AND ECONOMY OF HOLTER MONITORING

Extended Holter monitoring in low-resource healthcare settings faces numerous operational and technical limitations that hinder its effective implementation. A major challenge is resource scarcity—many facilities lack adequate funding, trained personnel, and infrastructure to support the use of such devices [39, 40]. Access to advanced devices, such as 14-day adhesive patch monitors, is often limited, and standard Holter monitors may not support extended durations, reducing diagnostic yield [27].

Patient compliance is another issue, as wearing devices for prolonged periods can interfere with daily life, particularly in environments where comfort and privacy are limited [41, 42]. Cost also presents a barrier - while some newer systems aim to be cost-effective, setup, maintenance, and follow-up expenses remain prohibitive for many facilities [43-45].

On the technical side, data quality and reliability can suffer due to motion artifacts or equipment malfunction, especially in settings where device maintenance is deprioritized (Tsukada et al., 2019; Dagan & Mechanic, 2020) [46, 47]. Even with extended monitoring durations, diagnostic sensitivity is limited; short-term Holter devices often miss infrequent or asymptomatic arrhythmias, and even extended systems may not reliably detect paroxysmal AF [48-50].

Additionally, interpreting complex monitoring data requires specialized expertise, which is often lacking in low-resource environments, leading to underutilization of the technology [32, 44]. The lack of real-time feedback further complicates care, as most devices are designed for retrospective analysis, delaying interventions for acute events. [46] Finally, infrastructure challenges, including unreliable electricity and frequent power outages, pose logistical difficulties for maintaining device functionality [43, 51].

The cost-effectiveness of 7-day ECG Holter monitoring compared to implantable loop recorders (ILRs) for atrial fibrillation (AF) detection depends on diagnostic yield, patient characteristics, and long-term outcomes [52, 53]. While 7-day Holter improve detection rates over standard 24-hour monitoring, with yields reported between 10% and 15% [52], ILRs—capable of continuously monitoring cardiac rhythms for up to three years - offer significantly higher yields, particularly in patients with intermittent or asymptomatic AF [23, 54]. Studies indicate that ILRs can consistently identify AF in various clinical contexts, including in post-stroke patients, with detection rates ranging from 25% to as high as 50%, depending on the population studied [53, 55].

Although Holter monitors are more accessible and less costly upfront, they may miss critical AF episodes, potentially leading to expensive downstream complications like stroke [52]. In contrast, ILRs have higher initial costs due to implantation, but their continuous monitoring facilitates early detection and timely initiation of anticoagulation, lowering the risk of recurrent strokes [56]. Studies report favorable cost-effectiveness ratios for ILRs - between $15,000 and $25,000 per quality-adjusted life year (QALY) - which fall well within accepted thresholds for healthcare interventions [52].

ILRs also offer clinical advantages beyond detection. Research shows that patients monitored with ILRs are more likely to initiate anticoagulation therapy in a timely manner, significantly reducing stroke risk [23]. Additionally, continuous monitoring enables real-time treatment adjustments, unlike Holter monitors which only provide brief snapshots of cardiac activity [55, 57]. ILRs may also reduce the need for frequent follow-up visits, as the actionable data they generate supports more proactive clinical decisions, potentially lowering hospitalization rates and associated healthcare costs [58].

RECOMMENDATIONS AND FUTURE DIRECTIONS

Transitioning from 24-hour to 7-day Holter monitoring demonstrates both clinical and cost-effectiveness benefits in the diagnostic evaluation of cardiac arrhythmias. Clinically, extended Holter monitoring significantly increases the detection rates of paroxysmal atrial fibrillation (AF) and other arrhythmias, particularly in high-risk populations, such as those experiencing cerebral ischemia. Research indicates that 7-day monitoring can nearly double the proportion of patients diagnosed with AF compared to standard 24-hour monitoring, which allows for timely anticoagulant treatment and potentially averts recurrent strokes [23].

From a cost-effectiveness perspective, the implementation of 7-day Holter monitoring has been shown to be economically beneficial. The extension leads to the identification of additional new cases of AF that require anticoagulant therapy, ultimately resulting in decreased overall healthcare costs due to stroke prevention and related complications [45]. Furthermore, studies suggest that while the additional costs of extended monitoring should be weighed against the clinical benefits, the long-term savings from prevented strokes and hospitalizations make it a valuable investment in patient management [45, 59].

The transition from standard clinical assessments to the incorporation of novel biomarkers and advanced imaging techniques offers a promising enhancement in accurately identifying patients who could significantly benefit from extended Holter monitoring. Recent studies have evaluated specific biomarkers such as symmetric dimethylarginine (SDMA) in predicting unrecognized atrial fibrillation (AF) among ischemic stroke patients. For instance, Hannemann et al. [60] elucidated that elevated levels of SDMA could be indicative of increased risk for AF, highlighting that targeted monitoring of patients with high SDMA could lead to timely identification of arrhythmias that standard assessments might overlook. This suggests a tailored approach to monitoring, where patients presenting with higher levels of SDMA benefit from extended Holter monitoring over the conventional 24-hour assessment.

Advanced imaging techniques, particularly echocardiography, complement the utility of biomarkers in stratifying risk for AF and improving monitoring protocols. Imaging can reveal structural heart abnormalities that predispose individuals to atrial arrhythmias. Recent meta-analyses indicate that enhanced imaging in conjunction with Holter monitoring increases the detection rates of paroxysmal AF, which is critical given that standard monitoring tools often only capture sustained AF events [23, 28].

For example, Huang et al. [61] highlighted that integrating echocardiographic assessments with long-term electrocardiographic monitoring led to improved identification of AF in stroke patients, emphasizing the complex interrelationship between structural heart disease and arrhythmia risk. This combined approach can lead to a more comprehensive risk stratification model, allowing healthcare providers to implement preventive strategies more effectively.

CONCLUSIONS

This comprehensive review underscores the critical role of prolonged Holter monitoring in the early detection of atrial fibrillation (AF) among ischemic stroke survivors, particularly those with cryptogenic strokes. Our analysis of current literature reveals that standard 24-hour Holter monitoring significantly underperforms when compared to extended monitoring periods, with 7-day monitoring emerging as notably more effective in identifying paroxysmal AF. This enhanced detection capability is pivotal, considering the established link between AF and an increased risk of recurrent ischemic strokes.

Importantly, our findings advocate for a paradigm shift in clinical practice, suggesting that the adoption of prolonged monitoring protocols could substantially improve stroke prevention strategies. Specifically, monitoring durations extending beyond 48 hours - ideally up to 7 days - have been shown to optimize AF detection, thereby enabling timely initiation of anticoagulation therapy to mitigate the risk of secondary stroke events.

However, despite the compelling evidence supporting the utility of extended Holter monitoring, its implementation is not without challenges. Issues such as patient compliance, resource allocation, and cost-effectiveness remain pertinent concerns that necessitate further investigation. Additionally, the exploration of emerging technologies and novel biomarkers presents an exciting frontier that could enhance the precision and efficiency of AF detection in post-stroke patients.

In conclusion, our review strongly supports the integration of prolonged Holter monitoring into the standard of care for ischemic stroke patients, particularly those with an elusive AF diagnosis. Future research should aim to address the operational barriers to widespread adoption and explore innovative solutions that could further refine and personalize monitoring protocols. By doing so, we can improve diagnostic accuracy, optimize patient outcomes, and ultimately reduce the global burden of stroke.

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CONFLICT OF INTEREST
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