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LONG-TERM ARRHYTHMIA DETECTION USING PORTABLE ECG PATCHES IN STROKE PATIENTS: A CASE SERIES

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ABSTRACT

Cardiac arrhythmias are common following ischemic stroke and can lead to severe complications, such as recurrent strokes. Early identification is important, and continuous electrocardiography (ECG) monitoring provides a possible solution. This prospective observational case series assessed the efficacy of a portable ECG patch in detecting arrhythmias in post-stroke patients and their role in informing treatment decisions. This study was carried out between May and November 2023 in the neurology ward of a local hospital in Meerut, India. A total of 10 adult patients were included in this case series after applying the inclusion and exclusion criteria. They were continuously observed up to 80 hours with two alternate portable ECG patches after a baseline smartphone-based ECG (Spandan 12-lead ECG). The portable ECG patches detected several arrhythmias, such as transient and potentially lethal conditions like atrial fibrillation and ventricular tachycardia, which the initial baseline smartphone-based ECG failed to record. A cardiologist validated all the episodes of arrhythmia. The use of real-time data transmission facilitated timely clinical intervention, which aided in improved patient management and outcomes. This case series emphasizes the benefits of continuous portable ECG patch monitoring compared to single-time-point smartphone-based ECG in identifying intermittent arrhythmias in stroke patients. The results favour the incorporation of portable ECG patches into standard post-stroke management for early diagnosis, risk reduction, and enhanced therapeutic decision-making.

KEYWORDS

Stroke, cardiac arrhythmia, ECG monitoring, Holter monitor, patch

LEARNING POINTS

- Continuous electrocardiography (ECG) monitoring detects arrhythmias missed by baseline ECG, including transient and potentially life-threatening events like atrial fibrillation and ventricular tachycardia.
- Portable ECG patches are an effective tool for long-term cardiac monitoring in stroke patients, supporting early diagnosis and informed treatment decisions.

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INTRODUCTION

Stroke is a major global health issue, ranking as the fourth leading cause of death and fifth leading cause of disability in India[1]. In 2020, global cases of acute ischemic stroke (AIS) reached 68.16 million[2]. Cardiac arrhythmias, including atrial fibrillation (AF), ventricular tachycardia (VT), and others, are common during acute stroke and can lead to serious complications[3].

Accurate diagnosis and treatment of arrhythmias are essential to prevent complications like recurrent embolic events and sudden cardiac death, especially after stroke or myocardial infarction[4,5]. While conventional 24-hour Holter monitors have been widely used, their bulkiness often leads to poor patient compliance[6]. Additionally, detecting paroxysmal AF, which has a low burden, requires prolonged monitoring[7]. Recently, compact and more comfortable patch electrocardiography (ECG) devices have emerged as promising tools for extended and effective arrhythmia detection.

One such device is the portable ECG patch, a prototype developed using Spandan ECG hardware platform by Sunfox Technologies Private Limited, Dehradun, India, which is being designed to comply with IEC 60601-2-27 standards for ECG monitoring equipment. It has been established for continuous monitoring of cardiac arrhythmias over 48 hours *(Fig. 1)*. This patch uses the latest sensor technology in conjunction with signal processing algorithms to detect and classify the various arrhythmic events

We conducted a comprehensive study where the performance of this portable ECG patch in detecting arrhythmias among stroke patients was evaluated with known or suspected cardiac conditions. Each case presented in this study has a certain clinical scenario in which a portable ECG patch detected various arrhythmias. The main findings of this study emphasize the potential value of the portable ECG patch for continuous arrhythmia monitoring, offering useful insights from the cardiac rhythm patterns and leading to the detection of life-threatening episodic arrhythmias.

CASE DESCRIPTION

This prospective observational case series was conducted in the neurology ward of a local hospital in Meerut, India from May to November 2023. The study aimed to evaluate the efficacy of a portable ECG patch in detecting arrhythmias among patients with imaging-confirmed thrombotic stroke. A total of 10 adult patients were included in this case series. The inclusion criteria were patients aged ≥18 years, with a Glasgow Coma Scale (GCS) score ≥9 and expected survival >1 year, and the exclusion criteria were patients with haemorrhagic stroke, significant comorbidities, or those already on anticoagulants for other indications. The portable ECG patch is easy to use and can be applied at home without any medical training. This lightweight adhesive patch, which has electrodes, attaches directly to the chest, usually over the sternum or on the left side of the chest if there is excessive hair over the sternum. Once it is on, it continuously records

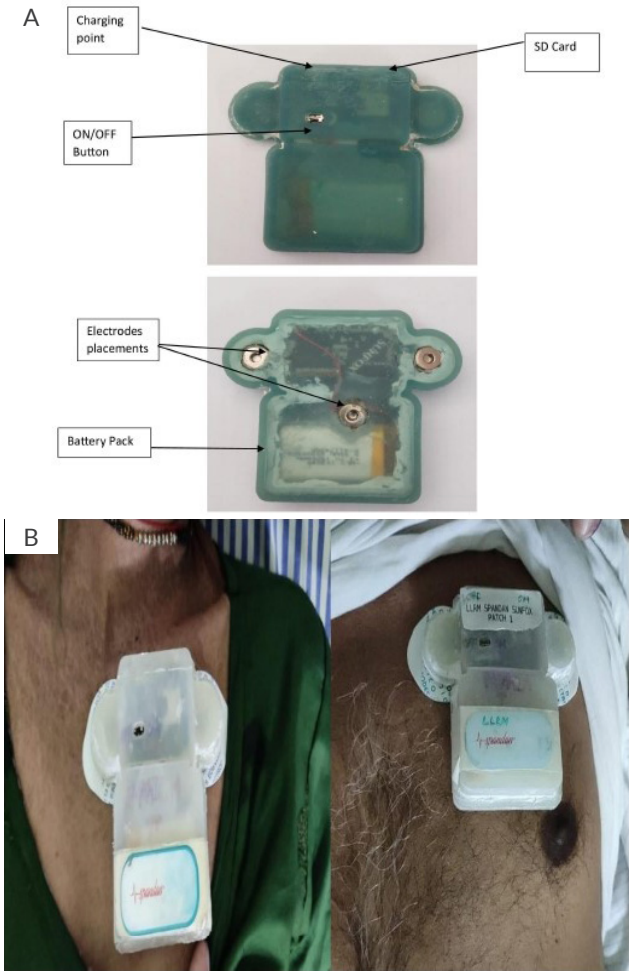


Figure 1. Portable Spandan ECG patch developed by Sunfox Technologies Pvt. Ltd. A) Patch device – a portable ECG patch for lead II arrhythmia monitoring. The SD card slot is only for optional storage; the device provides real-time ECG acquisition and display via a smartphone app using a wireless Bluetooth protocol, with data optionally stored or transmitted for clinical review. B) Electrode placement – Illustration of electrode positioning for male and female patients using the Spandan ECG patch.

ECG signals for up to 48 hours and connects wirelessly to a smartphone via Bluetooth through the companion app. The app shows live ECG readings, detects arrhythmias with built-in algorithms, and sends alerts for any abnormal rhythms. To avoid losing data, the device also has optional SD card storage for secure backup. The recorded information can be shared safely with healthcare providers for remote monitoring. Comfortable enough to wear during daily activities, the patch helps detect cardiac events reliably and early, even outside of hospital settings.

Baseline ECGs were performed using the smartphone-based ECG (Spandan 12-lead ECG) device. Following this, participants received continuous ECG monitoring for up to 80 hours using a portable patch ECG device. Two portable ECG patches were alternated to ensure uninterrupted data acquisition, allowing for real-time wireless transmission without hindering patient mobility.

Collected data included patient symptoms, ECG intervals, and types of arrhythmias. All episodes of arrhythmia

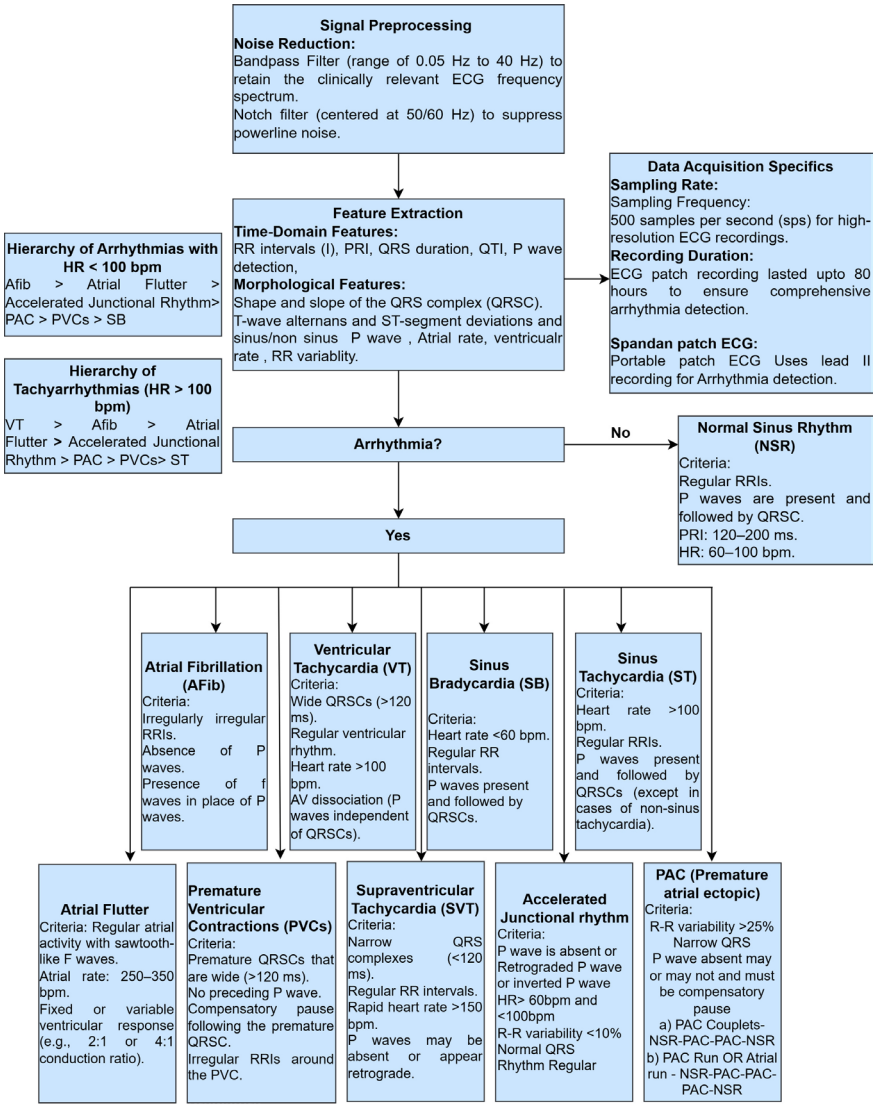


Figure 2. Portable Spandan ECG patch algorithm for arrhythmia detection.

detected by the patch device were reviewed and confirmed by a cardiologist. ECG data were analysed using MATLAB software for rhythm classification and comparison with baseline smartphone-based ECG results to assess the detection accuracy and clinical relevance of the portable patch monitor. A description of the algorithms utilized by the portable ECG patch for arrhythmia detection, as outlined in *Figure 2*, was applied for analysis.

Table 1 summarizes the findings in 10 patients, showing variations between smartphone-based ECG and portable ECG patch recordings, with the patch detecting additional arrhythmias and rhythm transitions. Notably, cases 1, 2, and 3 are detailed separately below for in-depth explanation.

Case 1: A 75-year-old male with a left middle cerebral artery infarct and haemorrhagic transformation, a history of VT/AF, type 2 diabetes, and smoking. He was on atorvastatin (20 mg) + aspirin (150 mg), metformin 500 mg, and glimepiride, and underwent an ECG evaluation. Smartphone-based ECG showed sinus arrhythmia with premature atrial contractions (PACs). Continuous 30-hour portable ECG patch monitoring demonstrated dynamic rhythm alterations: initial VT, later AF with rapid ventricular response, eventually reverting to VT *(Fig. 3)*. These recurrent arrhythmias underscore the patient's high cardiac risk. The case emphasizes the need for prolonged ECG monitoring in patients with AIS and a history of arrhythmia to facilitate timely, individualized therapy and avoid deterioration.

Case 2: A 61-year-old male with a bilateral cerebellar infarct, bilateral posterior circulation stroke, type 2 diabetes, and hypertension. He was taking atorvastatin (20 mg) + aspirin (150 mg) and metformin 500 mg, with a history of alcohol and tobacco abuse, and had a blood pressure of 137/72 mmHg. Smartphone-based ECG revealed sinus bradycardia, T-wave inversions (II, III, aVL, aVF, V5, V6), and myocardial ischemia, with baseline wandering due to electrical interference. After portable ECG patch placement, sinus rhythm with ST depression indicated persistent myocardial stress *(Fig. 4A)*. Several hours later, there was transient VT, which was only recorded on continuous monitoring *(Fig. 4B)*. This case highlights the value of prolonged ECG patch monitoring for the detection of arrhythmias at an early stage and the appropriate management in stroke patients.

Case 3: A 44-year-old male was diagnosed with an AIS involving the left middle cerebral artery, leading to right-sided hemiparesis. The patient's past medical history included significant risk factors for smoking. The patient's

Patient	Patient details	12-lead ECG	ECG patch
Case 1	75-year-old male with left MCA infarct, haemorrhagic transformation, history of VT/AF, T2DM, smoker	Sinus arrhythmia, PACs	VT to AF to VT
Case 2	61-year-old male patient with bilateral cerebellar infarct, bilateral posterior circulation stroke, history of T2DM, and hypertension	Sinus bradycardia, myocardial ischemia, T-wave inversion in lead II, III, AVI, AVF, V5, and V6, baseline wandering	Sinus rhythm with ST depression to VT
Case 3	44-year-old male with acute ischemic stroke (left MCA infarct) causing right-sided hemiparesis, history of smoking	Sinus arrhythmia	Atrial flutter with PVC to sinus rhythm with PVC
Case 4	57-year-old female patient with an acute infarct, history of VT, and diabetes	Sinus tachycardia	Sinus rhythm with PAC converted to VT
Case 5	55-year-old male with T2DM, hypertension, prior cerebrovascular accident, altered sensorium, multiple infarcts, aspiration pneumonitis, smoking history, and uncontrolled. hypertension (BP 138/100 mmHg)	Sinus rhythm, atrial couplets in lead II, III, avF, ST depression in V5, baseline wandering	Accelerated junctional rhythm
Case 6	65-year-old female with an ACA infarct, history of diabetes mellitus	Atrial tachycardia, PVC, ischemia	Sinus tachycardia with PVC and PVC couplet
Case 7	49-year-old female with left MCA infarction, severe ischemic stroke affecting the left hemisphere, with the history of smoking and alcohol intake	Sinus rhythm, ischemia, ST depression in V4, V5, V6, avL, II	VT
Case 8	A 50-year-old male with a left MCA infarct complicating his clinical condition, with a history of smoking and alcohol intake	Sinus rhythm, J-point elevation in V1, V2, and baseline wandering	Sinus rhythm with PVC
Case 9	61-year-old male clinically diagnosed with right MCA infarct, representing an ischemic stroke, with history of smoking and alcohol intake	Normal ECG	Sinus rhythm with interpolated PVC
Case 10	40-year-old male clinically diagnosed with a known or suspected seizure disorder, presenting with postictal confusion and possible CVA associated with respiratory failure; history of treated pulmonary tuberculosis	Sinus tachycardia	Sinus tachycardia with PVC

Abbreviations: ECG, electrocardiography; MCA, middle cerebral artery; VT, ventricular tachycardia; AF, atrial fibrillation; T2DM, type 2 diabetes mellitus; PACs, premature atrial contractions; PVC, premature ventricular contraction; BP, blood pressure; ACA, anterior cerebral artery; CVA, cerebrovascular accident.

Table 1. Comparison of smartphone-Based ECG and portable ECG patch recordings in acute ischaemic stroke patients.

blood pressure was 126/80 mmHg, and his medications included aspirin 150 mg and telmisartan 40 mg.

The smartphone-based ECG was sinus arrhythmia. Episodes of atrial flutter were demonstrated during the portable ECG patch monitoring of 40 hours. The patient also had PVCs during these episodes, as shown in *Figure 5*. These findings underscore the importance of continuous ECG monitoring in detecting intermittent arrhythmias that may influence stroke prognosis and secondary prevention.

DISCUSSION

This study examined the efficacy of a portable ECG patch in detecting arrhythmias in stroke patients. The portable ECG patch proved to be effective in detecting various types of cardiac arrhythmias, such as sinus tachycardia, sinus bradycardia, PACs, VT, AF, and ventricular fibrillation. Continuous ECG patch monitoring up to 80 hours allowed detection of transient arrhythmias that might have been missed with smartphone-based ECG methods. Key findings include that patients who developed a broad range of arrhythmias, showing that cardiac events after stroke are highly variable and continuous long-term monitoring is required. The ECG patch provided real-time data transmission that enabled immediate review and intervention, thus enhancing clinical decision-making.

Several studies have been conducted to explore alternative methods of cardiac monitoring in patients who have had a stroke in a bid to detect arrhythmia, particularly AF. Traditionally, Holter monitoring has been used for this purpose. This study by Onder H et al. demonstrated that 24 to 72 hours of Holter monitoring could diagnose AF in approximately 4.6% of patients with stroke[8]. However, our study showed that these portable ECG patches with continuous portable ECG patch monitoring up to 80 hours can detect a much wider spectrum of arrhythmia, such as VT, AF and atrial flutter, that might go undiagnosed on shorter monitoring times.

Kim et al. assessed the 11-day adhesive ECG patch for drug-

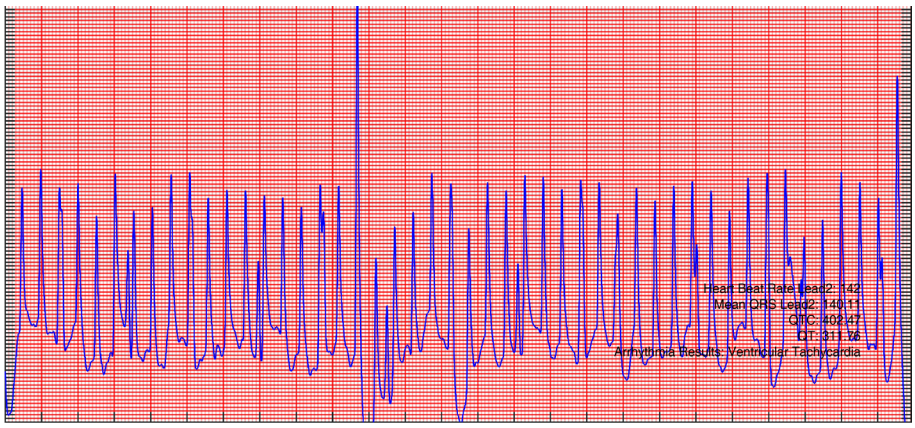


Figure 3. Patient's portable ECG patch report confirming ventricular tachycardia.



Figure 4. Patient's portable ECG patch report shows A) sinus rhythm with ST depression and B) ventricular tachycardia.



Figure 5. Patient's Spandan ECG patch report confirming atrial flutter with premature ventricular contraction (PVC).

refractory paroxysmal AF detection. The result was superior when compared to the traditional 24-hour Holter test, with the detection of AF or atrial tachycardia in 47.5% of the patients compared to 13.6% detected by the Holter test[9]. Our study results are similarly aligned with the principle that longer and more sensitive monitoring, even up to 80 hours, can greatly increase detection rates of arrhythmias in stroke patients and encourage timely clinical interventions.

Ha et al. conducted a randomized clinical trial on post-cardiac surgery continuous ECG monitoring and showed significantly higher detection rates of AF as compared to intermittent methods. This correlates with our findings in concluding that this kind of monitoring using a portable device is indeed helpful for the early diagnosis of arrhythmias for early therapeutic intervention before recurrent strokes[10].

Our study adds valuable insights to the current literature as it demonstrates both the feasibility and the effectiveness of using a portable ECG patch in the monitoring of stroke patients with arrhythmias. Holter monitoring, of course, remains the first standard diagnosis. However, the portability, ease of use, non-invasive nature, and prolonged monitoring capability of ECG patches offer distinct advantages, particularly in the acute and post-acute phases of stroke care.

In contrast to traditional hospital-based ECG systems such as Holter monitors, the portable ECG patch is lightweight, smartphone-integrated, and offers real-time rhythm display through a mobile app. All these enable flexible deployment not

just within hospital settings but within home and community environments as well, without the need for medical training. Even though the device remains in prototype form and the ultimate cost has yet to be established, it is being designed with affordability as an objective. Its anticipated low cost compared to traditional Holter monitors or other ECG patch systems makes it particularly promising for use in resource-limited environments, where financial and infrastructural constraints often hinder access to extended arrhythmia monitoring.

The limitations of this study are that it did not include patients with haemorrhagic stroke, those with severe comorbidities, or those on anticoagulation therapy, which limits the study's ability to explore the full spectrum of stroke patients. A comparative study between the patch device and Holter monitor should be done for better, more accurate validation of the patch's effectiveness.

CONCLUSION

This pilot study showed that the portable ECG patch is feasible for continuous arrhythmia monitoring in stroke patients. Our results highlight the fact that long-term ECG patch monitoring is efficient in detecting transient and life-threatening arrhythmias, which the routine 12-lead methods of short-term ECG may miss. The patch device's real-time data transmission, lightweight and non-invasive nature, also contribute to better patient compliance and enhance clinical decision-making, making it more appropriate for long-term use outside of the hospital setting than traditional Holter monitors.

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